IntechOpen

IntechOpen Series
Education and Human Development,
Volume 17

Metacognition in Learning
New Perspectives

Edited by Murat Tezer

Metacognition in Learning - New Perspectives

Edited by Murat Tezer

Published in London, United Kingdom

Metacognition in Learning - New Perspectives
http://dx.doi.org/10.5772/intechopen.107819
Edited by Murat Tezer

Contributors
Ali Albalhareth, Amanda Joe, Awelani V. Mudau, Bulelwa Makena, Helen Burns, Jill Castek, Jogymol K. Alex, Lisa DeTora, Lungiswa Nqoma, Manasseh Ternenge Adi, Motsi Qoyi, Muhammad Naeem Butt, Murat Tezer, Nida Ayaz, Nomaroma Kumanda, Nomxolisi Mtsi, Orit Avidov-Ungar, Parlan Parlan, Pretty Thandiswa Mpiti, Rosamma Philip, Sabrina G. Sobel, Sara Zamir, Sarmishtha Ghosh, Sayyeda Jawerya Ayaz, Shakespear M. Chiphambo, Sunder Kala Negi, Tavonga Tawanda, Wen Wen, Zanele Ginyigazi, Zikhona Seleke

© The Editor(s) and the Author(s) 2024
The rights of the editor(s) and the author(s) have been asserted in accordance with the Copyright, Designs and Patents Act 1988. All rights to the book as a whole are reserved by INTECHOPEN LIMITED. The book as a whole (compilation) cannot be reproduced, distributed or used for commercial or non-commercial purposes without INTECHOPEN LIMITED's written permission. Enquiries concerning the use of the book should be directed to INTECHOPEN LIMITED rights and permissions department (permissions@intechopen.com).
Violations are liable to prosecution under the governing Copyright Law.

Individual chapters of this publication are distributed under the terms of the Creative Commons Attribution 3.0 Unported License which permits commercial use, distribution and reproduction of the individual chapters, provided the original author(s) and source publication are appropriately acknowledged. If so indicated, certain images may not be included under the Creative Commons license. In such cases users will need to obtain permission from the license holder to reproduce the material. More details and guidelines concerning content reuse and adaptation can be found at http://www.intechopen.com/copyright-policy.html.

Notice
Statements and opinions expressed in the chapters are these of the individual contributors and not necessarily those of the editors or publisher. No responsibility is accepted for the accuracy of information contained in the published chapters. The publisher assumes no responsibility for any damage or injury to persons or property arising out of the use of any materials, instructions, methods or ideas contained in the book.

First published in London, United Kingdom, 2024 by IntechOpen
IntechOpen is the global imprint of INTECHOPEN LIMITED, registered in England and Wales, registration number: 11086078, 167-169 Great Portland Street, London, W1W 5PF, United Kingdom

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library

Additional hard and PDF copies can be obtained from orders@intechopen.com

Metacognition in Learning - New Perspectives
Edited by Murat Tezer
p. cm.

This title is part of the Education and Human Development Book Series, Volume 17
Topic: Education
Series Editor: Katherine K.M. Stavropoulos
Topic Editor: Delfín Ortega-Sánchez

Print ISBN 978-0-85014-162-7
Online ISBN 978-0-85014-163-4
eBook (PDF) ISBN 978-0-85014-164-1
ISSN 2755-9513

We are IntechOpen,
the world's leading publisher of
Open Access books
Built by scientists, for scientists

7,000+
Open access books available

188,000+
International authors and editors

205M+
Downloads

156
Countries delivered to

Our authors are among the
Top 1%
most cited scientists

12.2%
Contributors from top 500 universities

WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com

IntechOpen Book Series

Education and Human Development

Volume 17

Aims and Scope of the Series

Education and Human Development is an interdisciplinary research area that aims to shed light on topics related to both learning and development. This Series is intended for researchers, practitioners, and students who are interested in understanding more about these fields and their applications.

Meet the Series Editor

Katherine Stavropoulos received her BA in Psychology from Trinity College, in Connecticut, USA and her Ph.D. in Experimental Psychology from the University of California, San Diego. She completed her postdoctoral work at the Yale Child Study Center with Dr. James McPartland. Dr. Stavropoulos' doctoral dissertation explored neural correlates of reward anticipation to social versus nonsocial stimuli in children with and without autism spectrum disorders (ASD). She has been a faculty member at the University of California, Riverside in the School of Education since 2016. Her research focuses on translational studies to explore the reward system in ASD, as well as how anxiety contributes to social challenges in ASD. She also investigates how behavioral interventions affect neural activity, behavior, and school performance in children with ASD. She is also involved in the diagnosis of children with ASD and is a licensed clinical psychologist in California. She is the Assistant Director of the SEARCH Center at UCR and is a faculty member in the Graduate Program in Neuroscience.

Meet the Volume Editor

Murat Tezer was born in Nicosia in 1972. He earned a Ph.D. in applied mathematics and computer science at Eastern Mediterranean University in 2003. He worked as a project advisor at many schools under the grant program supported by the European Union. He has written more than 100 research publications and books or chapters about mathematics education, which have been published and cited in many publications in international publishing houses. He has directed more than 40 master's or doctoral theses as an advisor. He worked as vice head of computer education and instructional technology. In 2008, he became the head of the Department of Elementary and Secondary Mathematics Education between the years 2009 and 2018. He worked as vice-dean of the Education Faculty of Near East University between the years 2013 and 2018, and then he became a professor of mathematics education. In addition, he is an executive board member of the Cyprus Educational Sciences Association.

Contents

Preface

Metacognition is an individual's ability to manage their own learning process. That is, it can be stated as the ability of a person to plan, monitor, organize, and evaluate how they will learn. Metacognition also helps the individual determine learning goals, develop learning strategies, use resources effectively, and evaluate their progress in the learning process. In addition, this skill enables the person to be more effective and efficient in the learning process.

Understanding how cognitive processes affect people's thinking and how the learning process takes place is a very important issue today. The complex structure and functioning of the human brain is one of the main features that distinguishes us from other living things. At this point, the concepts of metacognition, cognition, and cognitive learning come to the fore.

This book aims to provide a comprehensive overview of metacognition, cognition, and cognitive learning. It examines topics such as how the human brain works, thinking and decision-making processes, problem-solving skills, and learning methods and is aimed at helping the reader understand cognitive processes more deeply.

In the first section of the book, the concept of metacognition in learning is discussed. In the first chapter, the concepts of cognition, metacognition, metacognitive strategy, and metacognitive skill are examined within a theoretical framework and the place of these concepts in education is discussed. Additionally, examples of metacognition are given and its importance is revealed.

In the second chapter, metacognitive strategies and their types are given definitions. In addition, the connection between 21st-century skills, metacognition, self-regulated learning, collaborative, creative thinking, and metacognition is revealed.

The third chapter introduces the idea of metacognition to any reader interested in learning more about it. The chapter opens with a broad explanation of the topic at hand. The ability to reflect on and analyze one's cognitive functioning is known as metacognition. Also, social metacognition and the self-concept, social metacognition and stereotypes, and social metacognition and attitude are all discussed.

In the fourth chapter, important aspects of teaching metacognition are explained. Learning that helps develop and use the student's metacognition promotes meaningful learning and provides better learning outcomes. It is emphasized that the PDCA—namely preparing (P), doing (D), checking (C), and evaluating and following up (A)—metacognitive learning strategy was developed as an alternative to metacognitive learning.

The fifth assesses how effectively metacognitive knowledge contributes to various facets of personality development. Also, this chapter highlights the significance of using metacognitive knowledge for comprehensive learner development and emphasizes the vital role of teachers in imparting metacognitive skills, thereby guiding learners toward personal growth. The findings underscore the potential of metacognitive knowledge in molding individuals into well-rounded personalities, with significant implications for educational practices.

In the sixth chapter, research, findings, and discussion emerging from a theoretical exploration of imagination as cognition and metacognition are presented. The researcher took a pragmatic stance in addressing a problem encountered in education practice: that an articulated understanding of "imagination "is largely absent, and its likely relationship with metacognition is little articulated, despite these being essential components of learning. This chapter is largely concerned with the model of imagination and metacognition that emerged through this process.

In the second section of the book, cognition and human psychology are discussed.

In the seventh chapter, information is provided that personalization in education in response to individual needs not only facilitates students to learn better by using different strategies but also meets the teaching needs of teachers in designing various teaching platforms. Moreover, while this chapter emphasizes that personalized learning using computers and mobile devices is one of the latest trends that has a global impact and promises to offer new methods that improve and stimulate learning, the effects of using technologies without taking into account pedagogical theories and models are emphasized.

The eighth chapter explores the MetaFlex framework, a novel approach that combines metacognition and psychological flexibility to foster personal growth and enhance psychological well-being. The MetaFlex framework focuses on the integration of metacognitive strategies and techniques to enhance self-awareness, cognitive flexibility, and adaptive thinking.

In the ninth chapter, the impact of teacher workload on students' academic excellence and metacognition is investigated to find measures to inform appropriate teacher workload. While it has been previously revealed that excessive workload can cause stress and prevent teachers from completing the curriculum on time, this chapter shows how it affects students' metacognition and academic excellence, and recommendations are given.

In the third section of the book, metacognition, transformative learning, and ICT are discussed.

In Chapter 10, transformation and motivation through the application of awareness and metacognition are emphasized. This chapter describes metacognition, the value of metacognitive awareness, and how it can be used to improve student learning and academic performance. In addition, while the effects of metacognition on learning are focused on in this chapter, the importance of awareness and use of metacognition in education is also emphasized, as it enables students to think big.

Chapter 11 examines students' perspectives on transformational learning experiences. Inspired by Mezirow's ten-stage transformative learning theory, the theoretical framework for understanding and analyzing students' impressions of transformative learning activities is also introduced. This theory places a strong emphasis on the important teaching and learning opportunities that are linked to students' previous experiences, and the importance of critical thinking and revision that can result in a transformation in students' knowledge is also emphasized in this chapter.

Chapter 12 explores educators' and students' perceptions of transformative learning through technology in rural schools. Transformative learning theory and the Technology Readiness Index model form the basis of this chapter. This chapter also reveals why most educators and students are optimistic about the use of information and communication t (ICT) to support teaching and learning, as well as what challenges they face and what methods they prefer to manage the situation.

Chapter 13 examines how students' collaboration processes have different characteristics that serve as peer scaffolding to support their learning. This chapter emphasizes how students collaborate with their peers, allowing each student to express and speak their ideas, but also how they have the chance to develop the ideas of others by listening to and incorporating the collaborator's suggestions. Constructive feedback provided by peers and how they help refine and enhance each other's understanding and learning products are the highlights of this chapter.

Chapter 14 aims to explore the integration of information and communication technology (ICT) during teaching and learning encounters in a country. In this chapter, it is emphasized why schools should pay significant attention to ICT integration training, competence, and appropriate software and materials to enable a computer-integrated teaching and learning culture for their various needs.

In the fourth section of the book, metacognition in special education is discussed.

Chapter 15 discusses reading comprehension, prior knowledge, and vocabulary knowledge, specifically with individuals who are deaf and hard of hearing. Also, this chapter defines metacognition and other terms related to reading comprehension. Metacognitive strategies are critical for reading comprehension, and planning strategies, which are also defined as before reading strategies, are the most critical.

In the fifth section of the book, metacognition and cognition in science are discussed.

Chapter 16 explores how teachers apply case studies as a teaching method that encourages critical thinking in science learning. The study was informed by Vygotsky's social constructivism and Shulman's pedagogical content knowledge. Both theories align constructively with the study as they emphasize that knowledge is produced through active participation and that the subject should be guided using relevant pedagogy. This chapter also explains why teachers should collaborate with other science teachers and science cluster leaders to share knowledge.

Chapter 17 emphasizes how to communicate clearly in STEM fields, mastering discipline-specific vocabulary and writing style and citation norms, in addition to following general rules for quality writing. In addition, in this chapter, the role and application of metacognitive approaches in science and writing studies may differ, and different communication environments are discussed, in which metacognitive approaches taken from chemistry education and writing studies can be applied.

In Chapter 18, the role of teachers in chemistry metacognition, what metacognition and chemistry metacognition are, their importance in chemistry education, and how they can be taught or developed to science or chemistry students who find the subject challenging are discussed. The importance of using metacognition and chemistry metacognition skills, knowledge, and attitudes in modeling and scaffolding by science and chemistry teachers in order for students to observe and learn metacognition in practice is also emphasized in this chapter.

Finally, Chapter 19 aims to explore the use of the conceptual change approach to improve students' understanding of the quantitative aspects of chemical change. In this chapter, the reader is informed that the conceptual change framework is effective in changing students' misconceptions and facilitates greater conceptual understanding, and the study proposes a well-designed conceptual change teaching approach that leads to significantly better acquisition of scientific concepts.

This book aims to contribute to the understanding of cognitive processes and the development of learning skills. In addition to providing the reader with basic information about metacognition, cognition, and cognitive learning, it aims to provide a better understanding of the subject with practical applications and examples.

I hope this book will be a useful resource for you about cognitive processes and learning. I wish you a pleasant reading.

Kind regards,

Dr. Murat Tezer
Professor,
Primary Mathematics Education Department,
Near East University,
Nicosia, Northern Cyprus

Section 1

Metacognition in Learning

Chapter 1

Cognition and Metacognition in Education

Murat Tezer

Abstract

Metacognitive skills help students develop skills such as problem-solving, critical thinking, leadership, and responsibility. This chapter aims to examine the concepts of cognition, metacognition, metacognitive strategy, and metacognitive skill within a theoretical framework and to reveal the place of these concepts in education. In the research literature review method was used. In the light of the results obtained based on the research findings, it was determined that metacognitive strategies help students improve their cognitive skills during the learning process and are related to academic success. This research reveals the need to emphasize the importance and place of metacognitive skills in education, to teach students strategies, and to guide them when and where to use them. Additionally, students need to gain appropriate experiences and practice to develop their metacognitive skills. Metacognitive development begins at an early age and continues throughout the teaching process; therefore, it is very essential to carry out activities that support metacognition, especially at preschool and primary school levels. The general conclusion is that developing metacognitive skills increases students' cognitive competencies and makes them responsible for their learning, which in turn enables students to become more independent learners and increases their overall academic success.

Keywords: metacognition, cognition, metacognitive skill, strategy, awareness, metacognition in education

1. Introduction

Today, with the increase in knowledge, rapid changes and developments occur in social life, and many areas of human life are affected. With this effect, individuals' learning and information-processing skills improve. While it was previously considered sufficient to simply memorize and repeat information, now comprehension and interpretation skills have gained importance. Individuals can analyze the information they learn, establish relationships between different information, and associate this information with their own experiences [1]. In the fast-paced and ever-evolving world we live in today, it is not enough for students to simply access information. They also need to process information effectively and apply it in a variety of study areas. This includes the ability to synthesize information from different sources, think critically about complex problems, and communicate ideas effectively [2].

Learning to learn is a skill supported by the contemporary education system. It is thought that the individual who acquires the skill of learning to learn uses versatile thinking and questioning skills. The individual who uses questioning skills will carry out thinking activities on his/her behaviors and thoughts. As a result, the individual will be able to organize his metacognitive knowledge by thinking about his/her thoughts. Metacognition refers to the knowledge and awareness of an individual's thinking processes, the ability to reflect on and adjust an individual's thoughts, control this process, and use learning strategies consciously. This concept enables students to actively guide the learning process and achieve better results by using effective learning strategies [3]. As the individual's metacognitive awareness increases, his perception of himself and his environment will differ, and this awareness can contribute to the raising of conscious, questioning, and intellectual individuals. Efforts to raise conscious individuals in education have begun to progress rapidly on a more meaningful path with the emergence of the concept of metacognition and the studies carried out on this subject [4]. High-quality instruction not only teaches students domain-wide knowledge but also provides metacognitive knowledge. Metacognitive knowledge helps students understand their learning processes and enables them to use learning strategies more effectively. Students need to understand how they learn, what strategies are most effective for them, and how they can be better organized [5].

1.1 Cognition and metacognition in theory

According to the information processing approach, learning occurs through the flow of information within sensory recording, short-term memory and long-term memory elements. Executive processes have an important place in the process of ensuring and directing the flow of knowledge within mental processes. Executive processes; they are the memory system elements that monitor and direct what information will be processed in the learning-teaching process, how this information will be processed, and control the learning-teaching process order. It involves being aware of one's own thoughts, understanding how these thoughts influence learning, and making conscious efforts to regulate and control cognitive activities; it is the regulation and control of these processes to increase remembering. Metacognition includes the skills of (a) being aware of one's own learning and memory capacity, (b) knowing the qualities of the learning strategy to be used, (c) planning for the study to be done, (d) using effective learning strategies, and (e) monitoring and evaluating the learning situation [6].

The first words on the subject of metacognition and therefore the emergence of the concept of metacognition began to be put forward by Flavell in 1976, and this concept was used to describe the individual's own cognitive processes and knowledge and the knowledge that can keep cognitive processes under control. The subject of metacognition includes the individual's awareness of what he knows, that is, "metacognitive knowledge", the subjects that the individual can do, that is, "metacognitive skills", and what the individual knows about his cognitive ability, that is, "metacognitive experience". If we want to explain metacognition using the words Flavell first used, we would have to say that it is "cognition and knowledge about cognitive phenomena" [7]. Flavell [8] presented metacognition and cognitive monitoring in a model of stages. Cognitive monitoring takes place via "activities and interactions" between these four structures: (a) metacognitive knowledge, (b) metacognitive experiences, (c) goals (tasks), and (d) activities (strategies).

Another important part of Flavell's [8] model was metacognitive experiences that enable people to notice, direct, and evaluate their thought processes [8]. While these experiences help improve learning and problem-solving skills, they also contribute to a better understanding of one's mental processes. These metacognitive experiences can occur before, during, and after a cognitive activity [9]. Flavell's definition of metacognitive components states that metacognitive knowledge is one's information about his or her cognitive abilities, learning, and universal characteristics of learning. On the other hand, he considers metacognitive experiences as control and regulation processes, such as a person actively monitoring his cognitive process and his/her thinking consciousness.

While Flavell states that metacognition can sometimes be unconscious and emotionally charged, Brown et al. [10] have the opposite idea. They suggested that the management of cognition is a purposeful and emotion-free element. Brown [11] claimed that it involves "purposeful efforts toward learning and problem-solving and actions of predicting, controlling, monitoring, testing, coordinating." He divided the management of cognition into two main categories: (a) knowledge of cognition, which involves the individual thinking consciously about his cognitive abilities and actions, and (b) regulation of cognition, which are activities related to self-regulatory mechanisms in the learning or problem-solving process. Although he considered these two elements as two separate areas of research, he stated that they were "very closely related to each other" and constantly supported each other. Knowledge of cognition is what an individual knows about a particular sequence of events or a particular thing. The second element, regulation of cognition, involves the individual thinking about, monitoring, and controlling mental processes. It is the operational aspect of cognition management [10, 12]. Metacognition includes knowledge and regulations regarding cognitive activities during the individual's learning process [8]. Metacognition is defined as one's own awareness of his/her metacognitive processes and strategies [13].

Metacognition, which is related to the individual's self-reflective feature, draws attention to how individuals think and understand during the learning process and how he/she assimilates and understand information [14]. Thus, metacognition helps the individual develop the thinking mechanism to fully learn and understand. As Vygotsky [15] emphasized, when the student is aware of his thinking processes, he gains control over how he learns. A few terms have emerged related to the concept of metacognition, which we have used widely for years:

These are metacognitive beliefs (the capability to evaluate and question one's own beliefs and thoughts and manage them through a metacognitive approach), metacognitive awareness (the capability to recognize and consciously manage one's own mental processes, ideas, feelings, and beliefs), metacognitive experiences (the ability to notice, monitor, and evaluate one's own mental processes, thoughts, and perceptions), metacognitive knowledge (the capability to be conscious, knowledgeable about an individual's thoughts, beliefs, memory thinking processes, and learning strategies), feeling knowing, judging learning, theory of mind, meta-memory, metacognitive skills, higher-level skills, meta-components, monitoring by understanding, learning strategies, heuristic strategies (cognitive methods and approaches used to generate new and creative solutions), and self-regulation [16]. Veenman et al. [16] tried to explain these concepts by considering metacognitive knowledge and skills separately. They stated that metacognitive knowledge reflecting our learning process may be true or false and that this self-knowledge may be closed to changes. They emphasized that metacognitive skills have a feedback mechanism and are open to transformations.

Schraw and Moshman [7] further examined Brown's distinction between metacognition and the regulation of cognition in his model. Metacognition is discussed under two general headings: self-evaluation and self-management. Self-assessment parallels the structure called cognitive management knowledge by other researchers. This category includes the individual's personal opinions about his or her knowledge and abilities, such as memory abilities, problem-solving capacity, or other cognitive abilities. Self-management looks like the adjustment of cognition. It expresses the organizing of cognition in action. They are mental procedures that help organize the elements of problem-solving. These processes include plans made before starting a task, adjustments made while working, and reviewing the process afterward. These two elements of cognition management processes are interrelated [17].

Tobias and Everson [18] discussed cognitive management as a combination of knowledge and skills. This component can be examined in three main areas. Metacognitive knowledge is a kind of monitoring, which is one's learning processes and the controlling of these processes. A prerequisite for metacognitive processes is monitoring. Students intensively engage in monitoring activities in learning environments where they gain new knowledge. Information monitoring can be thought of as the capability to understand what is known by an individual and what is not known. Students who accurately analyze what they have already learned and what they have not yet learned perform better at focusing their interests and other cognitive sources on the material to be learned. As a result, they developed their model by adding information monitoring and control to the metacognition model consisting of three components [18].

1.2 Difference between cognition and metacognition

When the definitions of metacognition are examined, the expression cognition is often encountered. Therefore, some comparisons have been made to better understand the relationship between the concepts of cognition and metacognition. One of these comparisons is that the concept of cognition deals with the individual's ability to comprehend any situation by being aware of it, while metacognition is not only cognition but also being aware of how he comprehends this situation and thinking about how he learned [19]. According to another comparison, while cognition includes strategy and actual operations, metacognition includes what the individual knows about his cognitions and his ability to control these cognitions [20].

According to Yıldız [21], while cognition is the individual's knowledge of a situation, metacognition deals with the individual's awareness of his or her level of knowledge. To give an example, Gama [22] stated that the ability required to understand a text by reading it is different from understanding how much one can comprehend this text. The knowledge about solving a mathematical problem is cognitive, but the individual's ability to compare the ability to read the text with the ability to solve a mathematical question and determine which one is better is metacognition. Just as the definitions of cognition and metacognition are different, there are also differences in their functions. In this context, the function of cognition is to find cognitive solutions to solve problems and achieve the goal. The task of metacognition is to regulate the cognitive work of a person while solving problems or to manage the learning task [20].

1.3 Metacognitive awareness

Metacognitive awareness is the individual's awareness of his/her cognitive processes and the capability to control these processes. Thanks to this awareness, the student can understand how he learns, what strategies he uses, and when he needs help. Metacognitive awareness helps the student make the learning process more effective and enables them to develop learning strategies. Metacognitive awareness is the state in which the student has information about how much of the field knowledge he has mastered in the learning process, which personal learning strategy he should use and why he uses it, and what he has done and should do until he reaches his goal [23]. According to Demir and Doğanay [24], metacognitive awareness is expressed as planning the work to be done by focusing attention, being able to evaluate the stages in the learning process, and making arrangements, in short, learning to learn. In other words, metacognitive awareness is one's own awareness of his/her knowledge about what, how, and by what means he/she can learn in the learning process [25]. As can be understood from the definitions, metacognitive awareness can generally be expressed as thinking about one's work, structure, and knowledge of the cognitive system [26, 27]. In this context, it can be said that metacognitive awareness can be expressed as "cognition about cognition" [28].

1.4 Metacognitive knowledge

Pintrich et al. [29] stated that metacognition is divided into two basic structures, which are (1) metacognitive knowledge and (2) metacognitive control and regulation. Some researchers have stated that metacognitive control and metacognitive regulation are different structures. What is expressed here as metacognitive regulation is the concept of self-regulation. These concepts can be discussed together and separately in the literature. Conceptually metacognition, compared to self-regulation, has been introduced to the literature before, and studies have been carried out in this field [30]. Later, in the 1980s and 1990s, educational and developmental psychologists proposed that individuals have different ways of monitoring, controlling, and regulating their learning [31–33]. According to Pintrich et al. [29], under the metacognitive knowledge dimension, students' declarative, process, and situation-based knowledge is grouped as knowledge of cognition and cognitive strategies. Metacognitive knowledge can be expressed as one's knowledge about one's cognition and is located in long-term memory under a topic that has previously been learned in different ways; for example, it is a term related to awareness of learned information such as geography, mathematics, and physics. Metacognitive knowledge is a more static concept than monitoring and regulation and is the student's awareness of what he knows or does not know. Metacognitive knowledge; it also includes one's self-knowledge, task recognition, and strategy recognition, which are among the variables that affect cognition. Knowing oneself means being aware of one's attributes, but also knowing one's differences from other people.

2. The place of metacognition in education

2.1 Metacognitive teaching

One of the most important factors underlying teachers' ability to provide strong and effective teaching is their ability to develop students' metacognitive awareness. Metacognitive development is a complex process. As a result of the research, three basic rules have been put forward for successful metacognitive teaching: (1) giving metacognitive teaching by connecting it with the content, (2) informing students about the usefulness of metacognitive activities so that they spend more effort, (3) providing a long-term training for successful metacognitive activities. Provision of education. For teachers to provide metacognitive development in students, they must have three important teaching skills [34]. First, the teacher can give the student tasks or tasks that he can think about intensively. Secondly, it can provide a classroom environment where students can think and reason without fear and with mutual respect and are encouraged to do research. The third teaching skill is to give students time to express their thoughts about what they have learned. The teacher, who plays a central role in the metacognitive development process, encourages students to think and answer questions such as how and why during learning [14]. However, research shows that teachers and university academics have little knowledge about metacognition [35, 36].

2.2 Metacognition and measurement-evaluation

In education, in addition to summative assessment to measure learning outcomes, formative assessment that provides information about the learning-teaching process has become a necessity. With formative assessment, teachers enable students to engage with thought-provoking questions by providing a discussion environment and accelerating learning through various activities such as peer and self-assessment, observations, quizzes, and portfolios [37]. The formative assessment approach improves learning with five important features [38, 39]: (1) providing effective feedback to students, (2) enabling students to learn actively, (3) assessment to organize teaching according to the evaluation results, (4) to improve students' self-esteem and motivation, and (5) to allow students to evaluate themselves and understand how they develop. Formative assessment, which provides an opportunity for students to evaluate themselves and monitor their development, also implicitly helps the development of students' metacognitive awareness [40].

Sadler [41] emphasized that formative evaluation depends on two important factors. First, students need to understand the range between the learning goal and their current level. Second, students need to close this gap. Although the teacher activates this process and guides the student, learning must occur by the students [42]. In other words, students need to be active in the learning–teaching process. Students must take an active role during learning, teaching, and evaluation for the development of metacognitive awareness [43]. A learning-focused assessment-evaluation approach, in which the student plays an active role and provides feedback for learning, enables the student to learn more deeply and effectively [38]. Therefore, learning-oriented assessment and evaluation can ensure the metacognitive development of the student. For example, through self-assessment, which is one of the learning-oriented measurement-evaluation methods, the student reflects and creates feedback during the learning process. Thus, self-assessment helps students understand what they have learned more deeply and improve the teaching strategies they use, contributing to their metacognitive development and activities in future lessons [44].

Measuring metacognition is very difficult for many reasons: (1) metacognition is a complex structure, (2) metacognition cannot be observed directly, (3) metacognition can be a mixture of both verbal ability and memory capacity, and (4) existing measurements tend to be more narrowly focused and distant from learning [45]. For this reason, the assessment-evaluation practices that teachers will use when measuring metacognitive knowledge will tend to be informal rather than formal [46]. Pintrich suggested that when teachers measure metacognitive knowledge informally, they usually do so by listening to students' cognitions and what they have learned.

2.3 Metacognitive strategies

Hartman [47] compared cognitive skills to "workers" and metacognitive skills to "bosses" and stated that cognition brings about the mental activities decided by metacognition. Accordingly, while coding (recording information), inferring, comparing, and analyzing constitute cognitive strategies, planning, monitoring, and evaluation constitute metacognitive strategies. Metacognitive strategies include thinking about the learning process by consciously following one's cognitive strategies to achieve specific goals, planning learning, monitoring understanding as it occurs, and self-evaluating learning [48]. That is, these strategies consist of planning, monitoring, and evaluation [17, 32, 49–51].

The proper planning process includes selecting appropriate strategies and organizing resources. As you mentioned in the reading example, the student can make predictions and list strategies before starting to read. It can also achieve a more effective reading experience by selectively distributing time and attention. Planning helps the student better organize the learning process and achieve their goals [52]. In other words, it can be said that the individual's making arrangements for his learning before learning is within the scope of this strategy. The sentence "I prepare for the topic to be covered before the mathematics lesson" can be given as an example of planning [53]. The planning strategy is divided into four different sub-steps [50]: (1) advance organizers, (2) organizational planning, (3) selective attention, and (4) self-management. According to Zhang and Seepho [50], metacognitive strategies play an important role in the reading comprehension process. These strategies are used in three stages: preorganization, organizational planning, and selective attention.

In the advance organizers phase, the student understands the meaning and nature of reading, determines reading goals, and plans the purposes of secondary reading tasks. At this stage, the student also details the preliminary information about the reading task.

In the organizational planning phase, the student plans the content of each task, divides specific reading tasks into sections, plans strategies for completing the tasks, and details preliminary information about the reading tasks. In the selective attention stage, the student sorts strategies for completing tasks and selects appropriate reading strategies to focus on a particular task. These metacognitive strategies make the student's reading comprehension process more effective. The student uses reading strategies relevant to a particular task and adjusts those strategies to achieve his or her goals. This is an indicator of self-management because the student realizes, controls, and directs his cognitive processes [50].

Monitoring is a cognitive process that reflects progress in line with goals and feedback [54]. Lv and Chen [55] defined monitoring as being aware of what one is doing. According to Mahdavi [56], monitoring includes the self-testing capability necessary to organize learning and learning environment. It also refers to critical analysis of the validity of strategies or plans being implemented. Thus, this strategy allows the individual to evaluate learning demands and outcomes to inform the construction of a higher-level mental model [57]. Thus, learning is increased by monitoring cognition [30]. The monitoring strategy is divided into two different sub-steps [50]: (1) monitoring comprehension and (2) monitoring production. When using the monitoring strategy during reading, checking one's meaning, accuracy, and appropriateness of the reading process, as well as one's capabilities and difficulties in each reading task, helps to monitor comprehension; inspection by the teacher to see whether the reading strategies used in the classroom can solve comprehension problems, monitoring selected reading strategies, and adopting alternatives when they do not work also indicates monitoring production [50].

Evaluation mentions evaluating the efficiency and products of one's learning [52]. According to Mahdavi [56], evaluation refers to examining the progress made toward targets that will enable planning, monitoring, and evaluation. In other words, it is a review of the learning itself at the end of learning. In mathematics, the sentence "After studying the combination subject, I will give myself an exam on that subject" can be given as an example for evaluation [53]. The evaluation strategy is divided into three different sub-steps [50]. These are (1) self-monitoring, (2) self-evaluation, and (3) self-reflection. Accordingly, when using the evaluation strategy after reading, evaluating whether the reading target was successful or not is a self-control; self-assessment of how well one has learned to read and one's use of reading strategies; thinking about whether he needs to go back to understand better is also given as an example of self-reflection [50].

It has been stated that metacognitive strategies are related to success and learning in many disciplines, especially in reading, mathematics, and science [58]. The use of metacognitive strategies in the teaching process allows students to take ownership of their learning and become active participants in the evaluation and improvement of their knowledge and skills. By engaging in metacognitive activities, such as self-assessment and reflection, students can identify any gaps or misunderstandings in their understanding of the content. This self-evaluation process enables them to recognize their strengths and weaknesses and make necessary adjustments to their learning strategies. For instance, when a student completes a study session, they can employ metacognitive strategies to assess their comprehension of the topic. They may ask themselves questions like, "Can I explain this concept in my own words?" or "Can I solve problems related to this topic?" This self-checking process helps the student become aware of their level of understanding and identify areas that require further attention. If the student finds that they have a strong grasp of the material, they are likely to continue using the same learning strategies in future situations. This reinforces their confidence in their approach and enhances their learning efficiency. On the other hand, if the student realizes that they have not fully understood the topic, they are likely to reevaluate their learning strategies and make necessary changes. For example, they may decide to seek additional resources, ask for clarification from the teacher, or adjust their study techniques. The student must be aware of metacognitive strategies and use these strategies to control his learning and make adjustments when deemed necessary and to achieve the goal of learning. According to Avargil et al. [59], students' use of these strategies can also improve their learning strategies. Therefore, it is argued that metacognition has a big capability to enable students to become successful learners [60].

2.4 Development of metacognition

So, can students' metacognition levels be improved? According to Mahdavi [52], the answer to this question is definitely "yes". It is argued that metacognitive development, with individual differences, begins at an early age (5/7 years old) and develops during the teaching process [61, 62]. Because between these ages, children begin to have the awareness that they are thinking and learning as individuals [61]. Promoting metacognition; it starts with creating awareness among students that the existence of metacognition is different from cognition and that it develops academic achievement in an appositive way. The next stage is to teach the strategies and, more crucially, to answer students' needs to create clear information about determining the time and place of using strategies [63]. For all these, students need to gain some experiences regarding their metacognition.

According to Papaleontiou-Louca [64], metacognition, like everything else, develops with practice. According to Fouché and Lamport [65], for metacognition to be effective, classroom environments that support students' metacognitive expectations must be created. Because a metacognitive classroom environment supports thinking awareness [26]. In addition, metacognition should be included among the teaching objectives, as well as a suitable classroom environment to activate and develop the knowledge and strategies that students have but do not use. Using accurate, metacognitive strategies gives students a broader repertoire of strategies. Students have the opportunity to try and apply different learning strategies. These experiences help students determine which strategies are most effective and make them more likely to use those strategies in future learning situations [7]. Considering the period in which metacognition begins to develop, it is possible to say that it would be beneficial to enrich learning environments, especially at preschool and primary school levels, with activities aimed at developing metacognition.

2.5 Benefits of metacognition in education

It was stated in a study by Blakey and Spence [26] that metacognitive behavior or metacognitive behaviors come into play when faced with situations that cannot be solved with learned reactions. In these situations, when habitual responses are not successful, individuals need metacognitive skills. Metacognitive skills, if recognized and applied through guidance, help students successfully solve the problems they encounter. Considering that individuals in today's twenty-first century need to have skills such as problem-solving, critical thinking, leadership, and responsibility, the importance of metacognitive skills comes to the fore. In other words, metacognition is extremely important in the twenty-first century [26]. This situation makes it necessary for personal, social, cognitive, and metacognitive development to be included in the scope of learning goals, even though academic success comes to mind first when learning goals are mentioned [66].

Metacognition has the potential to empower students to take responsibility for their learning and increase the meaningfulness of their learning. With this feature, it gradually frees students from dependence on teachers who guide their learning [67]. In short, metacognition makes students responsible for their learning. In this case, it can be said that students with better metacognitive development will be more independent in the learning process.

The development of metacognition increases competencies in cognitive areas [62]. Because metacognition promotes the cognitive level by activating monitoring and control factors [68]. Therefore, metacognition helps children make the most of their mental resources [61]. With metacognition, students try to use their thinking skills not only for the information they will acquire but also for the learning process. For example, a student who aims to learn multiplication tables should think about how best to acquire this information rather than the information in this table, plan his learning, and evaluate the effectiveness of the strategy he uses. It requires much more mental skills than just acquiring the information in the table. Students' reflection on their learning helps them perform many academic tasks more effectively [69]. Because the student managed his/her learning process. In this way, students with metacognitive skills can manage the learning process more effectively. When determining learning goals, they can develop strategies that suit their own learning styles by taking a constructive approach [61]. In addition, Schraw [57] stated that students with metacognitive awareness are generally more convenient because they act more determinedly in the learning process, experience less anxiety, use more strategies, and attribute their success to controllable reasons.

3. Conclusion and recommendations

As a result, the place of metacognition in education is very important. Metacognitive skills help students develop skills such as problem-solving, critical thinking, leadership, and responsibility. Metacognition enables students to be more active by allowing them to take more responsibility in their learning and increases the meaningfulness of their learning. Additionally, the development of metacognition increases cognitive competencies and helps students make the best use of their mental resources. Students with metacognition can manage their learning processes, which increases their academic success. Therefore, the importance and place of metacognitive skills should be emphasized in education.

The following suggestions can be given to educators and students to improve metacognitive skills:

- Educators should use teaching strategies that focus on metacognitive skills. They should design and implement activities to improve students' problem-solving, critical thinking, and learning process management skills.

- Students must take responsibility for their learning and actively participate in learning. Students should be provided with opportunities to set learning goals and plan and evaluate their learning processes.

- Students should be provided with opportunities to develop their critical thinking skills. Students should be allowed to evaluate different perspectives and use evidence-based thinking and critical evaluation skills.

- Collaboration and communication skills play an important role in the development of metacognitive skills. Collaboration and communication skills should be developed by providing students with group work, project-based learning, or discussion opportunities.

- Educators should provide students with feedback on their learning and help them recognize their strengths and weaknesses in the learning process. Students should be guided to evaluate and improve their learning strategies.

- The school curriculum should be designed to support the development of metacognitive skills. Problem-solving, critical thinking, and leadership should be encouraged by offering students different learning experiences.

- Students should be made aware that metacognitive skills are tools they will use throughout their lives. It should be emphasized that these skills are related not only to academic success but also to personal and professional success.

As a result, various suggestions can be offered to educators and students to improve metacognitive skills. With these suggestions and guidance from educators, significant progress will be made in the development of students' skills such as problem-solving, critical thinking, leadership, and responsibility.

Acknowledgements

I would like to express my gratitude to my wife, children, and family for their support, patience, and encouragement while carrying out this study. I would also like to thank everyone who contributed to the success of the entire study.

Declarations

The author declares no conflict of interest.

Author details

Murat Tezer
Primary Mathematics Education Department, Near East University, Nicosia, Northern Cyprus

*Address all correspondence to: murat.tezer@neu.edu.tr

IntechOpen

© 2024 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

References

[1] Boran M. Üstün zekâlı ve yetenekli öğrencilerin algılanan problem çözme becerilerinin üstbilişsel farkındalıkları ve eleştirel düşünme eğilimleri açısından incelenmesi [master's theses]. Mersin: Mersin Üniversitesi, Eğitim Bilimleri Enstitüsü; 2016

[2] Debeş G, Şenol H. Öğrenmenin Kapsamı ve Etkileyen Faktörler. In: Namlı AK, editor. Eğitimin Kavramsal Temelleri -8. İstanbul: Efe Akademik Yayıncılık; 2023. pp. 203-216

[3] Schraw G, Dennison RS. Assessing metacognitive awareness. Contemporary Educational Psychology. 1994;**19**(4):460-475

[4] Özsoy G. Üstbiliş. Türk Eğitim Bilimleri Dergisi. 2008;**6**(4):713-740

[5] Schraw G. Promoting general metacognitive awareness. Instructional Science. 1998;**26**:113-125. DOI: 10.1023/A:1003044231033

[6] Öztürk B. Genel öğrenme stratejilerinin öğrenciler tarafından kullanılma durumları. Yayınlanmamış Doktora Tezi, Ankara: Gazi Üniversitesi Sosyal Bilimler Enstitüsü; 1995

[7] Schraw G, Moshman D. Metacognitive theories. Educational Psychology Review. 1995;7(4):351-371

[8] Flavell JH. Metacognitive & cognitive monitoring. American Psychologist. 1979;**34**(10):906-911

[9] Garner R. Metacognition and Reading Comprehension. Norwood, N.J.: Ablex Publishing; 1987

[10] Brown AL, Bransford J, Ferrara R, Campione J. Learning, remembering, and understanding. In: Mussen PH, Flavell J, Markman E, editors. Handbook of Child Psychology, Cognitive Development. Vol. 3. New York: Wiley; 1983. pp. 77-166

[11] Brown AL. Metacognitive development and reading. In: Spiro RJ, Bruce BB, Brewer WF, editors. Theoretical Issues in Reading Comprehension. Hillsdale, N.J: Lawrence Erlbaum Associates; 1980. pp. 453-481

[12] Brown A. Metacognition, executive control, self-control, and other mysterious mechanisms. In: Weinert F, Kluwe R, editors. Metacognition, Motivation, and Understanding. Hillsdale, NJ: Erlbaum; 1987. pp. 65-116

[13] Flavell JH, Green FL, Flavell ER. Development of children's awareness of their own thoughts. Journal of Cognition and Development. 2000;**1**(1):97-112

[14] Jones D. Speaking, listening, planning and assessing: The teacher's role in developing metacognitive awareness. Early Child Development and Care. 2007;**177**(6-7):569-579

[15] Vygotsky LS. Thought and Language. Cambridge: MA, MIT Press; 1962

[16] Veenman MVC, Van Hout-Wolters BHAM, Afflerbach P. Metacognition and learning: Conceptual and methodological considerations. Metacognition Learning. 2006;**1**:3-14

[17] Jacobs J, Paris S. Children's metacognition about reading: Issues in definition, measurement, and instruction. Educational Psychologist. 1987;**22**(3-4):255-278

[18] Tobias S, Everson HT. "Knowing What you Know, and What you don't

Know", College Board Report (2002-2004). New York: The College Entrance Examination Board; 2002

[19] Senemoğlu N. Gelişim, öğrenme ve öğretim: Kuramdan uygulamaya. Ankara: Gazi Kitabevi; 2004

[20] Akın A. Başarı amaç oryantastonları ile bilişötesi farkındalık, ebeveyn tutumları ve akademik başarı arasındaki ilişkiler [doctoral dissertation]. Turkey: Sakarya Universitesi; 2006

[21] Yıldız H. Üst Biliş Stratejilerinin Öğretmen Adaylarının Üst Bilişsel Farkındalıklarına ve Öz Yeterliklerine Etkisi [Ph.D. theses]. Malatya: İnönü Üniversitesi Eğitim Bilimleri Enstitüsü; 2012

[22] Gama CA. Integrating Metacognition Instruction in Interactive Learning Environments [Doctoral thesis]. Falmer: University of Sussex, Phill; 2004

[23] Leow MH, Razak RA. Malaysian elementary learners' self-regulation, motivational beliefs and learner control motivation when experiencing online tutorials. Turkish Online Journal of Distance Education. 2024;**25**(1):334-352

[24] Demir Ö, Doğanay A. Bilişsel farkındalık becerilerinin geliştirilmesinde bilişsel koçluk yaklaşımı. Kuram ve Uygulamada Eğitim Yönetimi. 2009;**15**(60):601-623

[25] Çakıroğlu A. Üst bilişsel Strateji Kullanımının Okuduğunu Anlama Düzeyi Düşük Öğrencilerde Erişi Artırımına Etkisi [Ph.D. theses]. Ankara: Gazi Üniversitesi Eğitim Bilimleri Enstitüsü; 2007

[26] Blakey E, Spence S. Developing Metacognition. Syracuse, NY: ERIC Clearinghouse on Information Resources; 1990

[27] Tuononen T, Hyytinen H, Räisänen M, Hailikari T, Parpala A. Metacognitive awareness in relation to university students' learning profiles. Metacognition and Learning. 2023;**18**(1):37-54

[28] Öztürk S. Sınıf öğretmeni adaylarının üstbilişsel farkındalıkları ile matematik öğretmeye yönelik kaygılarının incelenmesi [master's theses]. Kastamonu: Kastamonu Üniversitesi, Sosyal Bilimler Enstitüsü; 2019

[29] Pintrich PR, Walters C, Baxter GP. Assessing metacognition and self-regulated learning. In: Schraw G, Impara JC, editors. Issues in the Measurement of Metacognition. Lincoln, NE: Buros Institute of Mental Measurement; 2000. pp. 43-97

[30] Paris SG, Winograd P. Promoting metacognition and motivation of exceptional children. Remedial and Special Education. 1990;**11**(6):7-15

[31] Schunk DH, Zimmerman BJ. Self-regulation in education: Retrospect and prospect. In: Schunk DH, Zimmerman BJ, editors. Self-Regulation of Learning and Performance: Issues and Educational Applications. Lawrence Erlbaum, Routledge; 1994. pp. 305-314

[32] Zimmerman BJ, Martinez-Pons M. Development of a structured interview for assessing student use of self-regulated learning strategies. American Educational Research Journal. 1986;**23**(4):614-628

[33] Zimmerman BJ. Attaining self-regulation: A social cognitive perspective. In: Boekaerts M, Pintrich P, Zeidner M, editors. Handbook of Self-Regulation. San Diego: Academic Press; 2000. pp. 13-39

[34] Williams M. Letting talents shine: Developing oracy with gifted

and talented pupils. In: Jones D, Hodson P, editors. Unlocking Speaking and Listening. London: David Fulton; 2006

[35] Veenman MVJ, Kok R, Kuilenburg J. Intelligence and metacognitive skillfulness in secondary education. In: Oser F, Baets U, editors. 9th European Conference on Learning and Instruction, Abstract Volume. Mainz: Aachen; 2001. p. 166

[36] Tocco AJ, Mehrhoff LA, Osborn HM, McCartin LF, Jameson MM. Learning communities promote pedagogical metacognition in higher education faculty. To Improve the Academy: A Journal of Educational Development. 2023;**42**(1):224-254

[37] Şahin Ç, Karaman P. Sınıf öğretmeni adaylarının ölçme ve değerlendirmeye ilişkin inançları. Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, Hacettepe University. Journal of Education. 2013;**28**(2):394-407

[38] Black P, Wiliam D. Assessment and classroom learning. Assessment in Education. 1998;**5**(1):7-74

[39] Black PJ, Wiliam D. Developing the theory of formative assessment. Educational Assessment, Evaluation and Accountability. 2009;**21**(1):5-31

[40] Rocha FEMD, Oliveira TF, Aresi PZM, Souza MLD. Metacognition, self-perception, and self-awareness in children from 9 to 12 years old. Psicologia Escolar e Educacional. 2023;**27**:e249951

[41] Sadler DR. Formative assessment: Revisiting the territory. Assessment in Education. 1998;**5**(1):77-84

[42] Black P, Harrison C, Lee C, Marshall B, Wiliam D. Assessment for Learning: Putting it into Practice. Oxford, United Kingdom: Oxford University Press; 2003

[43] Rezai A, Ashkani P, Ismail SM. Effects of group-dynamic assessment and process-based instruction on EFL learners' metacognitive awareness and listening comprehension: A mixed-methods inquiry. Journal of Psycholinguistic Research. 2023:1-26

[44] Bosch E, Spinath B. What evidence-based learning activities help students acquire knowledge, correct confidence in their own knowledge, and accurate self-assessment? Learning and Individual Differences. 2023;**108**:102374

[45] Lai ER. Metacognition: A literature review. Always Learning: Pearson Research Report. 2011;**24**:1-40

[46] Pintrich PR. The role of metacognitive knowledge in learning, teaching, and assessing. Theory into Practice. 2002;**41**(4):219-225

[47] Hartman HJ. Metacognition in learning and instruction: Theory, research and practice. Dordrecht, The Netherlands: Kluwer Academic; 2001

[48] Flavell J. Cognitive monitoring. In: Dickson WP, editor. Children's Oral Communication Skills. New York: Academic Press; 1981. pp. 35-60

[49] Sternberg RJ. Metacognition, abilities, and developing expertise: What makes an expert student? In: Hartman HJ, editor. Metacognition in Learning and Instruction. Dordrecht, The Netherlands: Kluwer Academic; 2001. pp. 247-260

[50] Zhang L, Seepho S. Metacognitive strategy use and academic reading achievement: Insights from a Chinese context. Electronic Journal of Foreign Language Teaching. 2013;**10**(1):24-69

[51] Singh A, Diefes-Dux HA. Pairing self-evaluation activities with self-reflection to engage students deeply in multiple metacognition strategies. In: 2023 ASEE Annual Conference & Exposition, Baltimore. Jun 2023

[52] Schraw G. Promoting general metacognitive awareness. In: Hartman HJ, editor. Metacognition in Learning and Instruction. Dordrecht, The Netherlands: Springer; 2002. pp. 3-16

[53] Kaplan A, Duran M. Ortaokul öğrencilerine yönelik matematiksel üstbiliş farkındalık ölçeği: geçerlik ve güvenirlik çalışması. Atatürk Üniversitesi Kazım Karabekir Eğitim Fakültesi Dergisi. 2016;**32**:1-17

[54] Eker C. The effect of teaching practice conducted by using metacognition strategies on students' reading comprehension skills. International Online Journal of Educational Sciences. 2014;**6**(2):269-280. DOI: 10.15345/iojes.2014.02.002

[55] Lv F, Chen H. A study of metacognitive-strategies based writing instruction for vocational college students. English Language Teaching. 2010;**3**:136-144

[56] Mahdavi M. An overview: Metacognition in education. International Journal of Multidisciplinary and Current Research. 2014;**2**(6):529-535

[57] Schraw G, Gutierrez AP. Metacognitive strategy instruction that highlinghts the role of monitoring and control processes. In: Peña EA, editor. Metacognition: Fundaments, applications, and trends (pp. 3-15). Springer International; 2015. pp. 3-16

[58] Chan CT. European Journal of Mathematics and Science Education. Science Education. 2023;**4**(3):169-180

[59] Avargil S, Lavi R, Dori YJ. Students' metacognition and metacognitive strategies in science education. In: Dori YJ, Mevarech ZR, Baker DR, editors. Cognition, Metacognition, and Culture in STEM Education. Vol. 24. Springer International Publishing; 2018. pp. 33-64

[60] Perry J, Lundie D, Golder G. Metacognition in schools: What does the literature suggest about the effectiveness of teaching metacognition in schools? Educational Review. 2019;**71**(4):483-500. DOI: 10.1080/00131911.2018.1441127

[61] Fisher R. Thinking about thinking: Developing metacognition in children. Early Child Development and Care. 1998;**141**(1):1-15

[62] Hanten G, Dennis M, Zhang L, Barnes M, Roberson G, Archibald J, et al. Childhood head injury and metacognitive processes in language and memory. Developmental Neuropsychology. 2004;**25**(1-2):85-106. DOI: 10.1080/87565641.2004.9651923

[63] Çakıroğlu Ü, Betül ER. A model to develop activities for teaching programming through metacognitive strategies. Thinking Skills and Creativity. 2023;**48**:101279

[64] Papaleontiou-Louca E. The concept and instruction of metacognition. Teacher Development. 2003;**7**(1):9-30

[65] Fouché J, Lamport MA. Do metacognitive strategies improve student achievement in secondary science classrooms? Christian Perspectives in Education. 2011;**4**(2):1-25

[66] Woolfolk Hoy A. Educational psychology in teacher education. Educational Psychologist. 2000;**35**(4):257-270. DOI: 10.1207/S15326985EP3504_04

[67] Hashey AL, Foxworth LL, Di Cesare DM, Kaczorowski TL. Teach

cognitive and metacognitive strategies to support learning and independence. In: High Leverage Practices for Intensive Interventions. Routledge; 2023. pp. 204-215

[68] Kapa E. A metacognitive support during the process of problem solving in a computerized environment. Educational Studies in Mathematics. 2001;**47**:317-336

[69] Noë A. The Entanglement: How Art and Philosophy Make Us What We Are. Princeton: Princeton University Press; 2023

Chapter 2

Perspective Chapter: Metacognitive Strategies – Preparing Self-Regulated Learners in the Twenty-First Century

Sarmishtha Ghosh

Abstract

In the twenty-first century, with the enormous increase in volume of information, students suffer from the cognitive overload that has been seen to be associated with incidence of depression/burnout amongst students at various levels of the training phase. This eventually leads to poor performance and lack of confidence in the younger generation. Effective strategies for efficient learning need to be informed to the learners to make them understand the importance of learning and retrieval at appropriate time. One such strategy is educating individuals metacognitively where the students will be able to build strong content knowledge by responding to varying demands of disciplines by critically synthesizing different resources and valuing sound evidence. Teaching students to be metacognitively aware through different strategies is also a challenge for teachers. Teaching students to ask themselves self-reflective questions and assess where they are right now (thinking about what they already know), how they learn (what is working and what is not), and where they want to be. With the aid of metacognition, students will be able to solve problems more effectively and take charge of their learning as self- regulated learners, which is essential in the current time.

Keywords: twenty-first century skills, metacognition, self-regulated learning, collaborative, creative thinking

1. Introduction

The ubiquitous presence of technology in the current century has led to the development of a society that is primarily an information or knowledge society. With an explosion of information and the development of economic systems where ideas or knowledge function as commodities [1], society has developed numerous expectations from the current generation of professionals.

The extensive cognitive overload creates suffering for students, which is actually associated with an incidence of depression/burnout amongst them at various levels of the training phase. This eventually leads to poor performance and a lack of confidence in the younger generation.

Twenty-first century skills that have been identified as essential for survival include critical thinking and communication skills. Creativity, problem solving, perseverance, collaboration, information literacy, and technology skills [2, 3].

Out of these, collaboration is described as a *process* rather than an outcome of a group of activities, as it was earlier understood. There has emerged a need to differentiate collaboration from related activities such as cooperation and coordination. Gulati et al. [4] defined coordination as "the deliberate and orderly alignment or adjustment of partners' actions to achieve jointly determined goals," while they defined cooperation as the "joint pursuit of agreed-on goal(s) in a manner corresponding to a shared understanding about contributions and payoffs." Their definitions of coordination and cooperation seem closely related: both definitions refer to some action taken toward agreed-on, joint, or common goals.

Collaboration skills are both generic and content/context-specific in that the collaborative skills themselves do not typically vary across content areas.

Students can very well gather and transfer their skills, provided the content and context are relevant to the collaborative activity. When tasks involve offering resources, ideas, and efforts that are collaborative, students can contribute very effectively, considering that they have the relevant content knowledge. Collaboration is also intertwined with other cognitive, interpersonal, and intrapersonal competencies: effective collaboration requires communication skills, metacognition, self-direction, and so on.

Many tasks now require a specific level of comprehension of information [5]. Because of this, new competencies—often referred to as twenty-first century skills—are required. Additionally, young people today need to be educated for jobs that do not yet exist but will come into existence soon with comparable primary tasks [6]. Anderson [1] cited the following as essential skills: Knowledge construction, followed by adaptability, information management, locating, organizing, and retrieving information, critical thinking, and teamwork. These competencies are also referred to as lifelong learning capacities [7].

The greatest problem a student faces when moving from high school to a professional college is the transition from the memorization of declarative knowledge emphasized in high schools to more advanced thinking skills required in colleges, such as critical thinking. To be successful, they need to demonstrate some personal characteristics, one of which is self-regulated learning habits, and the other is metacognitive awareness. Self-regulated learning (SRL) and metacognitive strategies are closely related concepts that involve learners taking an active role in their learning process. This chapter aims to understand the two processes and their relationships in developing the students of the twenty-first century for their survival.

2. What is self-regulated learning (SRL)

Learning that is self-regulated is defined as the capacity of an individual to comprehend and manage his learning environment. Setting goals, self-monitoring, self-instruction, and self-reinforcement are all aspects of self-regulation [8].

Self-regulated learning refers to the ability of learners to set goals, monitor their learning progress, and regulate their cognitive processes, motivation, and behavior to achieve those goals effectively. It involves being aware of oneself as a learner and employing various strategies to control and optimize the learning experience.

Self-Regulated learning refers to a process that can be described through a self-oriented feedback loop'.

Components of self-regulated learning typically include:

Planning: setting goals, creating a study schedule, organizing resources, and managing time effectively. Monitoring: evaluating one's progress, noting strengths and faults, and determining which areas need more focus or improvement.

Control: managing distractions, controlling motivation, and applying focused effort to learning activities.

Reflection: engaging in self-reflection, performance evaluation, and the identification of successful or unsuccessful techniques.

These processes help the learners transform their mental abilities into skills [9] and habits through a developmental process, emerging from guided practice and feedback [10, 11].

This practice makes the learners proactive, seeking out opportunities to learn and adapting their strategies as needed. They take responsibility for their learning and are motivated to achieve their goals, thus developing into self-regulated lifelong learners (**Figure 1**) [12].

How to develop a classroom culture grounded in self-regulated learning - role of teachers

- Help students figure out where, in the SRL process, things are breaking down.
- Design instruction and assessment that will create opportunities for multiple cycles of regulation to unfold.
- Construct classroom tasks and make them contextual
- Create competency-based contextual assessment & feedback processes.
- Have regular interactions & develop safe and cordial relationships

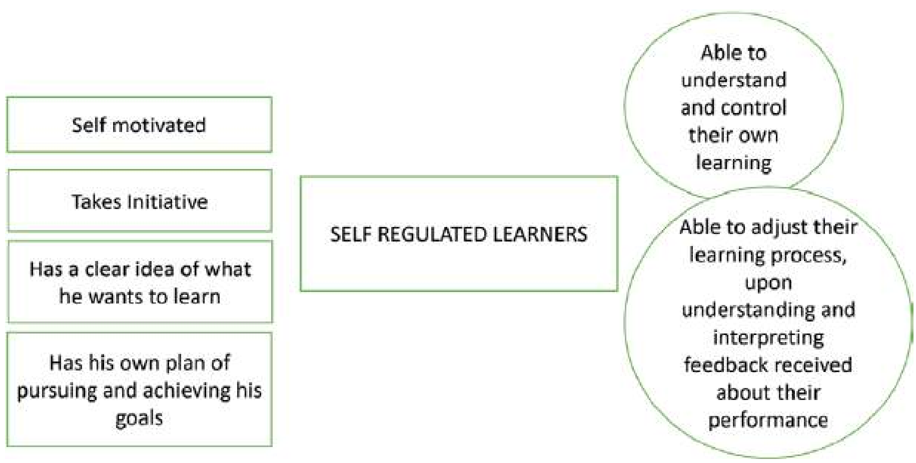

Figure 1.
Characteristics of self-regulated learners.

- Specify what should be the focus in a particular session- allow students to say, "My focus will be."
- Create safe spaces to make mistakes
- Create opportunities for students to learn from mistakes and be rewarded for that.

3. Metacognition and self-regulated learning

Metacognition is defined as "thinking about thinking" or "awareness and management of one's own thoughts." This encompasses two main components: knowledge about cognition and regulation of cognition [13]. This involves an understanding of one's cognitive processes and the ability to control and manage these processes effectively (**Figure 2**). Empirical studies suggest a strong correlation between metacognition and self-regulated learning [14]. Self-regulated learners employ metacognitive strategies to plan, monitor, and evaluate their learning. They are aware of their cognitive strengths and weaknesses, set realistic goals, select appropriate learning strategies, and reflect on their learning outcomes [9].

Recent developments in cognitive neuroscience have provided further insights into the neural basis of metacognition. Studies using functional Magnetic Resonance Imaging (fMRI) have revealed that metacognitive tasks activate the prefrontal cortex, a region associated with higher-order cognitive functions such as planning and decision-making [15]. This underscores the critical role of metacognition in self-regulated learning and decision-making processes.

Metacognitive abilities include things like thinking and studying techniques [16]. The capacity to apply such information to control one's learning is known as metacognition [17]. It involves three different types of knowledge:

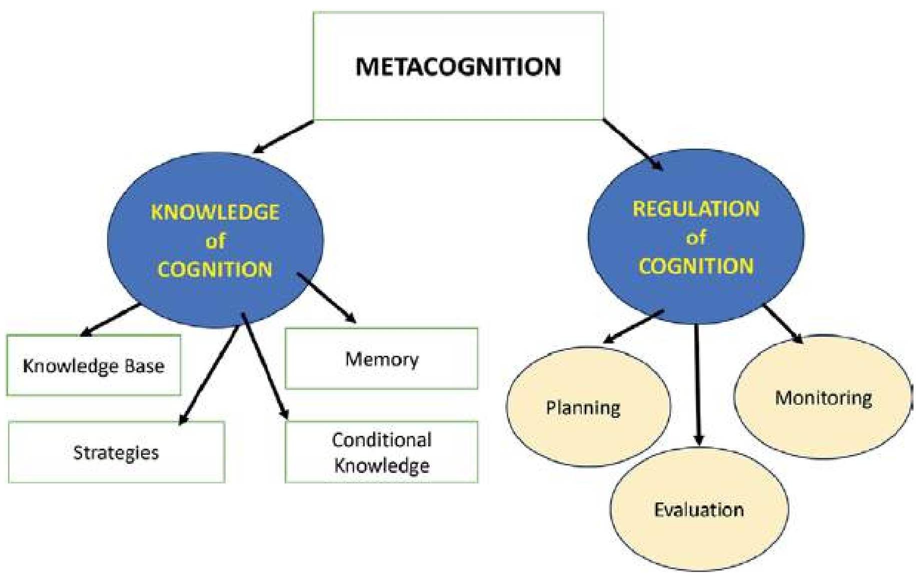

Figure 2.
Different types of metacognition.

- declarative knowledge that affects learning and memory,
- procedural knowledge or knowing how to use strategies, and
- self-regulatory knowledge that ensures task completion [18–20].

4. Metacognitive strategies

Metacognition refers to the ability to think about and have awareness of one's cognitive processes. Metacognitive strategies are techniques or approaches that learners use to plan, monitor, and evaluate their thinking and learning [21]. So, the common metacognitive strategies include:

Planning: This consists of setting clear goals, identifying appropriate learning strategies, and organizing information. This is the selection of appropriate strategies and the allocation of cognitive resources before the task. It includes asking questions like.

"How much time should I give to this particular task?",

"What are the strategies that I need to use"?

How should I start, and what resources should I gather?"

"What order should I follow while considering the task?"

"What should be skimmed, and what should be paid maximum attention to?

B. Monitoring: This comprises checking understanding during learning activities, identifying areas of confusion, and seeking clarification. Monitoring is the real-time awareness of how a person is doing in the relevant tasks by asking the following questions himself.

"how I am doing?"

"is this making sense"?

"Am I trying to go too fast?"

"Have I studied enough?"

"Do I need to study more and in a different manner?"

Evaluation: This involves making judgments about the processes and outcomes of thinking and learning by assessing performance after completing the task. This includes reflecting on the effectiveness of the strategies employed, checking the progress, and making appropriate adjustments. The questions normally asked are.

"Should I change strategies?

Should I get help?

Should I give up for now or should I continue?" [20].

These strategies make the learners more aware of their thinking processes, enabling them to effectively regulate their learning. By monitoring their understanding and evaluating their learning strategies, they can identify areas of weakness and eventually take steps to improve their learning outcomes.

5. How to teach students metacognitive skills to promote their learning abilities?

The twenty-first century offers learners an ever-changing learning landscape that appears to be rapidly evolving, which demands that students be able to regulate their learning processes. In the context of twenty-first century skills, metacognition plays a pivotal role in critical thinking and problem-solving. By understanding and regulating their cognitive processes, learners can approach problems more effectively and make informed decisions. Furthermore, metacognition is integral to lifelong learning, a key twenty-first century skill [22–24].

Another crucial area where metacognition plays a significant role is creativity. Successful creativity involves metacognitive skills such as recognizing the novelty and value of one's ideas and being able to persuade others of their worth. Metacognitive strategies can help learners refine their creative process by encouraging them to reflect on their ideas, evaluate their originality and effectiveness, and make necessary adjustments. In a study by Veenman et al. [25], a strong correlation was found between metacognitive skills and creativity amongst students. This finding further underscores the importance of metacognitive strategies in fostering not only self-regulated learning but also creative thinking, a key competency in the twenty-first century learning paradigm.

Metacognitive strategies help learners optimize their learning experiences. By employing techniques such as self-explanation, elaboration, and metacognitive questioning, learners actively engage with the material, improve comprehension, and consolidate knowledge. These strategies also aid in memory, consolidation, and long-term retention of information (**Table 1**).

Metacognition is monitoring and controlling what's in your head, while self-regulation is monitoring and controlling how you interact with your environment. Thus, self-regulated learning is the application of metacognition and self-regulation in learning.

Number	Strategy	Description
1.	Goal Setting	Encourage learners to set clear and achievable learning goals, both short-term and long-term. These goals provide direction, motivation, and a sense of purpose for their learning journey.
2.	Planning Organization:	Teach learners to create study plans and break down tasks into and manageable chunks, and effectively manage their time and This helps them stay organized, meet deadlines, and avoid procrastination.
3.	Monitoring Reflection:	Guide learners to regularly reflect on their learning progress, assess and their understanding, and identify areas of improvement. This reflective practice encourages self-awareness and enables learners to adjust their strategies for better results
4	Metacognitive Questioning:	Encourage learners to ask themselves questions that stimulate metacognition. Questions like "What do I already know?" and "How does this relate to what I've learned before?", and "What strategies can I use to approach this task?" prompt learners to think critically and develop their understanding.
5	Self-Explanation and Elaboration	Foster a learning environment where learners are encouraged to explain concepts in their own words, connect new information to prior knowledge, and engage in discussions. This process of self-explanation deepens understanding and promotes higher-order thinking.
6	Problem-Solving Strategies	Teach learners problem-solving techniques such as breaking complex problems, considering alternative perspectives, and brainstorming solutions, and evaluating different approaches. These strategies encourage learners to approach challenges systematically

Table 1.
The following table highlights some of the strategies.

6. Conclusion and recommendation

In the twenty-first century, fostering self-regulated learners is more critical than ever due to the fast-paced, information-saturated environment. Metacognitive strategies present an effective approach to cultivating these skills, with empirical and neuroscientific evidence substantiating their impact on learning. Therefore, educators should implement these strategies in their teaching practices to prepare learners for the challenges of the twenty-first century. The integration of metacognitive strategies in learning is paramount to preparing self-regulated learners for the twenty-first century. By fostering metacognitive skills, educators equip learners with the ability to take charge of their learning, adapt to novel situations, and solve problems effectively. As educators, it is our responsibility to create a metacognitive environment that encourages reflection, inquiry, and self-regulation, thereby empowering learners for life-long learning, shaping active rather than passive learners, promoting deep learning rather than superficial learning, and giving them a sense of control over learning and learning how to learn.

Author details

Sarmishtha Ghosh
Bhaikaka University, Karamsad, Gujarat, India

*Address all correspondence to: essjee63@gmail.com

IntechOpen

© 2024 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. (cc) BY

References

[1] Anderson R. Implications of the information and knowledge society for education. In: Voogt J, Knezek G, editors. International Handbook of Information Technology in Primary and Secondary Education. New York: Springer; 2008. pp. 5-22

[2] Kennedy TJ, Sundberg CW. 21st century skills. In: Akpan B, Kennedy TJ, editors. Science Education in Theory and Practice. Cham: Springer Texts in Education. Springer; 2020. DOI: 10.1007/978-3-030-43620-9_32

[3] Van Laar E, Van Deursen AJ, Van Dijk JA, De Haan J. The relation between 21st-century skills and digital skills: A systematic literature review. Computers in Human Behavior. 2017;**72**:577-588

[4] Gulati R, Wohlgezogen F, ZhelyazkovP.Thetwofacetsofcollaboration: Cooperationandcoordination in strategic alliances. Academy of Management Annals. 2012;**6**:531-583

[5] Levy F, Mundane RJ. How Computerized Work and Globalization Shape Human Skill Demands. USA: MIT, Department of Urban Studies and Planning & Harvard University, Graduate School of Education; 2006

[6] Fisch K, McLeod S. Did you Know? 3.0. 2009th ed. Available from: www.youtube.com/watch?v=PHmwZ96_Gos2009 [Accessed: May 15, 2009]

[7] Law N, Pelgrum WJ, Plomp T. Pedagogy and ICT Use in Schools around the World. Findings from the IEA SITES 2006 Study. CERC Studies in Comparative Education. Hong Kong: Comparative Education Research Centre, The University of Hong Kong, and Dordrecht. Springer; 2008

[8] Schraw G, Crippen K, Hartley K. Promoting self-regulation in science education: Metacognition as part of a broader perspective on learning. Research in Science Education. 2006;**36**:111-139

[9] Zimmerman BJ. Becoming a self-regulated learner: An overview. Theory Into Practice. 2002, May;**41**(2):64-70. DOI: 10.1207/s15430421tip4102_2

[10] Butler DL, Winne PH. Feedback and self-regulated learning: A theoretical synthesis. Review of Educational Research. 1995;**65**(3):245-281. DOI: 10.3102/00346543065003245

[11] Butler DL. Individualizing instruction in self-regulated learning. Theory Into Practice. 2002;**41**(2):81-92. DOI: 10.1207/s15430421tip4102_4

[12] Graham S, Harris KR, Reid R. Developing self-regulated learners. Focus on Exceptional Children. 1992;**24**(6):1-16 DOI: 10.17161/foec.v24i6.7539

[13] Flavell JH. Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry. American Psychologist. 1979;**34**(10):906-911. DOI: 10.1037/0003-066x.34.10.906

[14] Dinsmore DL, Alexander PA, Loughlin SM. Focusing the conceptual lens onmetacognition, self-regulation, and self-regulated learning. Educational Psychology Review. 2008;**20**(4):391-409

[15] Fleming SM, Dolan RJ. The neural basis of metacognitive ability. Philosophical Transactionsof the Royal Society B: Biological Sciences. 2012;**367**(1594):1338-1134

[16] Slavin RE. Educational Psychology: Theory and Practice. New Jersey: Pearson Education, Inc; 2009

[17] Fetsco T, McClure J. Educational Psychology: An Integrated Approach to Classroomdecisions. Boston: Pearson Education, Inc.; 2005

[18] Kluwe RH. Executive decisions and regulation of problem-solving behavior. In: Weinert FE, Kluwe RH, editors. Metacognition, Motivation, and Understanding. New Jersey: Lawrence Erlbaum Associates, Inc; 1987. pp. 31-64

[19] Schraw G, Moshman D. Metacognitive theories. Educational Psychology Review. 1995;**7**(4):351-371

[20] Woolfolk A. Educational Psychology. 20th ed. New Jersey: Pearson Education Inc.; 2013

[21] Swanson HL. Influence of metacognitive knowledge and aptitude on problemsolving. Journal of Educational Psychology. 1990;**82**(2):306-314

[22] Trilling B, Fadel C. 21st Century Skills: Learning for Life in our Times. Jossey-Bass; 2009

[23] Shannon SV. Using metacognitive strategies and learning styles to create self-directed learners. Institute for Learning Styles Journal. 2008;**1**:14-28

[24] Stankow L. Complexity, metacognition, and fluid intelligence. Intelligence. 2000;**28**(2):121-143

[25] Veenman MV, Wilhelm P, Beishuizen J. The relation between intellectual andmetacognitive skills from a developmental perspective. Learning and Instruction. 2004;**14**(1):89-109

Chapter 3

Demystifying Metacognition

Manasseh Ternenge Adi

Abstract

Dispelling the myths about different but related definitions of metacognition is presented. The author bases the discussion on an examination of the relevant literatures. Understanding the impact of culture is a key part of social metacognition. Examining unstated beliefs about oneself may reveal insights into one's social metacognition and sense of identity. It also clarifies the relationships between social metacognition, self-concept, and attitudes, as well as between social metacognition and prejudice and stereotyping. It focuses on studies conducted with nonhuman primates and other animals, such as chimpanzees, rhesus macaques, rats, pigeons, dogs, and dolphins. Strategies for fostering metacognition in the classroom are also covered; specifically, how this type of thinking helps students better evaluate and adjust their own methods of learning in order to gain a deeper comprehension of complex material. Teachers' professional approaches to metacognition are characterised as a process in which students take charge of their own learning; in turn, teachers are tasked with assisting students in acquiring the knowledge, understanding, and abilities necessary to do so. Teachers are urged to design lessons giving pupils opportunities to develop their own metacognitive skills. It concludes with a summary of the discussion and values of metacognition.

Keywords: demystification, education, students, teachers, metacognition

1. Introduction

Concepts are defined and approached differently. Concepts are abstract ideas that underpin principles, thoughts, and beliefs. Concepts affect many areas of cognition and are explored in linguistics, psychology, and others. These fields study logic and psychology of concepts and how they are put together to form thoughts and sentences. The study of concepts has served as an important flagship of an emerging interdisciplinary approach to cognitive sciences.

As such, this chapter's premise is the need to clarify the term "metacognition." Understanding one's own mental processes and their underlying patterns is one definition of metacognition. Meta means "beyond" or "on top of" in some contexts, which is how the phrase is understood by others. Meta is a form of self-reference. This signifies a greater degree of generalisation. Metadata, in the context of computer science, describes the categorised information about data stores [1, 2].

Metaphysics is the scientific study of nature itself, while metamorphoses are changes to a stable type of development; a morphing of morphing. Metalinguistics and metalanguage are, according to linguists, the words and phrases used to discuss or characterise language in general or a specific language. To build upon the work of other scholars, I will simply define metacognition as the process of being aware of one's own cognitive processes as they relate to the acquisition of new information and insight. The team metacognitive abilities are discussed as the best ways to approach learning. It manifests itself in a variety of ways, such as when students reflect on their own thought processes or when they apply certain techniques for addressing problems [3, 4]. Metacognition consists of two main parts: knowing how one's own mind works, and being able to control how one's mind works. A metacognitive model is unique among scientific models, in that its inventor typically includes a comparison definition as part of the model. While scientific models frequently exclude the observer from the equation, metacognitive models aim to centre the observer at every stage.

When talking about metacognition, it's useful to bring up similar concepts like metamemory. Understanding memory and how to memorise information which is known as metamemory is a type of metacognition.

Two books of the Greek philosopher Aristotle (384–322 BC) contain discussions of metacognition. In 1976, American developmental psychologist John H. Flavell used the term "metacognition" to describe a more advanced form of thinking [5–7].

Metacognition is knowledge of cognition and control of cognition, according to one of the earliest researchers, Flavell. When a person realises he/she is having more problems understanding topic A than topic B, or when he/she realises he/she should verify hypothesis C before committing to it, such person is engaging in metacognition [7, 8].

Thinking about thinking is called metacognition. In this context, metacognition meant approaching or referring to one's own thinking process, such as one's study habits, memory, and the ability to keep track of one's own progress in school. It then inferred that content education should be supplemented with instruction in metacognition. Understanding one's own cognitive processes and how to control them for optimal learning and decision-making constitutes metacognitive knowledge. Knowing when you have knowledge, when you do not, and what to do in either situation is essential. In other words, it necessitates constant self-evaluation and course correction [6].

Knowing yourself as a learner is an important part of the metacognition process. It is a measure of the student's self-awareness as a learner. A learner who can articulate his/her own abilities in terms of academic writing, testing, and other tasks demonstrates metacognitive awareness. It is important to note that metacognitive processes are used in every field and every type of learning and thinking situation. Metacognition is a crucial skill for lifelong learning and should be explicitly taught and discussed with students. Content knowledge, task knowledge, and strategic knowledge are all examples of metacognitive expertise [7, 8].

Content knowledge also called declarative knowledge means realising one's own potential. A student might think he/she is making use of content knowledge when he/she does an in-class self-assessment of his understanding of the material. This leads us to a different perspective, which shows that not all metacognitions are correct. According to research, when asked to evaluate their own knowledge and that of their peers, students frequently confuse laziness with lack of understanding. Another correlation between overconfidence in one's own performance and an inaccurate metacognitive evaluation of that performance is found.

Task knowledge also called procedural knowledge is one's subjective evaluation of the content, duration, and nature of an assignment in determining its perceived difficulty. The research cited in this section is concerned with how accurately judging the difficulty of a task affects one's overall performance on that activity. Again, the accuracy of this knowledge was skewed because students who thought their way were better, easier, and also seemed to perform poorly on evaluations, compared to students who were thoroughly and consistently examined and reported being less confident but yet doing better on initial evaluations.

Strategic knowledge also called conditional knowledge means the individual's aptitude for employing various methods in order to acquire knowledge. In this case, it is noted that young children struggle with this strategy. Students do not start to grasp the concept of efficient methods until they reach the upper grades of primary school.

Memory monitoring and self-regulation, meta-reasoning and awareness or consciousness are all subfields of metacognition. These skills are put to use when people strive to control their own minds and increase their capacity for rational thought, education, and assessment. As an added bonus, increased awareness can cut down on the time it takes to solve problems or finish activities by allowing you to react more quickly in the first place. This suggests that it is a mental operation.

An important distinction in metacognition (proposed by T. O. Nelson and L. Narens) in Experimental Psychology is between monitoring, which means making judgements about the strength of one's memories, and control, which means using those judgements to guide behaviour (in particular, to guide study choices). This distinction was discussed by Dunlosky, Serra, and Baker in Dunlosky and Bjork's (2008) Overview of Metamemory Research, which focused on the transferability of findings from this field [8–11]. This leads to the discussion of another approach of metacognition called social metacognition.

2. Social metacognition

An essential part of metacognition is social metacognition. As such, it is stereotypical. A group of false beliefs about a person or group of individuals is what we mean when we use the term "stereotype." Humans are portrayed here under the headings of social metacognition and stereotypes as having a wide range of beliefs, perspectives, and cultural practises. The cultural context in which we were raised greatly shapes our own perspectives. It is believed that metacognition studies should also investigate how our own cultural backgrounds shape our assumptions about the mental processes of others. These are the points of view of the expansionist theory, which argues that we cannot have a whole picture of metacognition unless we factor in the influence of contextual and cultural factors. Social metacognition is the fusion of social psychology with self-aware learning.

The field of study known as "social metacognition" examines how we think about thinking about how other people think. It entails making value judgements about the mental processes of others, such as their thoughts, feelings, and perceptions [12]. Since evaluating oneself is analogous to evaluating others, this can be quantified [12]. People's judgements of others tend to be more off-base when they have less information to go on, an effect known as the fundamental attribution mistake [12, 13]. Having members of a team or organisation who share similar worldviews might help mitigate this error and foster stronger bonds.

2.1 Social metacognition and the self-concept

Theoretical frameworks are developed to provide light on the connections between social metacognition and one's sense of identity. Examining implicit beliefs about one's own identity is an example of how social metacognition and self-concept interact with one another. While implicit theories explored many different aspects of the self's functioning, just two—entity theory and incrementalist theory—are of interest here [1, 13]. The incrementalist perspective contends that an individual's self-attributes and talents can be modified via effort and experience, while the entity theory maintains that these aspects of an individual are fixed and stable. As a result of believing that they have no power to alter their situation, entity theorists are more likely to succumb to learned helplessness and give up readily when faced with adversity. When faced with setbacks, incremental theorists respond in a unique manner, adopting a pattern that emphasises the pursuit of mastery. They ramp up their efforts while contemplating alternative strategies for completing the work at hand. This might also be influenced by cultural norms. For instance, if one's culture teaches that memory loss is inevitable with age, that person may avoid mentally taxing activities as they get older, hastening their cognitive decline [14]. Furthermore, it is argued that a woman's performance on mathematical ability tests or interest in mathematics may suffer if she is aware of the stereotype that women are not strong at mathematics [7, 15]. These cases illustrate how people's metacognitive beliefs—their understanding of their own thinking and how it affects their behaviour—can be passed down via families and cultures.

2.2 Attitudes as a function of social metacognition

The way we think about attitude greatly affects the way we behave. Metacognitions about attitudes influence how individuals act, especially how they interact with others [16].

Attitude's importance, certainty, and perceived knowledge are all metacognitive traits that have distinct influences on behaviour [16]. Individuals' information-seeking habits can often be anticipated based on their attitudes. Attitude importance, rather than clarity of attitude, is a stronger predictor of behaviour [16]. It is possible for someone to place a high value on voting as a civic duty but have little confidence in the outcome. This indicates they are committed to casting a ballot, regardless of their confidence in any particular candidate. On the other hand, someone who is set on a particular candidate but does not feel strongly about the issue might not bother to cast a ballot. The same holds true for interactions with other people. Even if someone knows a lot of good things about their family, they could not prioritise their relationships with them.

Attitude metacognitive features may be crucial to unravelling the mysteries of attitude shift. According to studies, the most important component in influencing one's attitude is the frequency with which one thinks either positively or negatively [17]. Even if one accepts the reality of climate change, one's attitude towards the issue may be unfavourable. In contrast to someone who holds more optimistic views on the same subject, this person is unlikely to alter their behaviours.

The possibility of a change in behaviour can be increased in another way: by changing the origin of the attitude. Attitude is significantly influenced by one's own thoughts and ideas as opposed to those of others [17]. People are more likely to adopt a healthier lifestyle when they believe the initiative came from within themselves, rather than from an outside source like a friend or family member. These ideas can be recast in a manner that highlights the value of the individual. It describes how one's outlook affects his or her actions.

2.3 Social metacognition and stereotypes

We also have secondary thoughts regarding whether our own stereotypical ideas are reasonable, fair, or acceptable in the eyes of others [18]. We are aware that making generalisations about people is not appropriate and we work hard to avoid doing so.

Even minute social cues might have an impact on one's best intentions. For instance, when people are tricked into thinking they are good at making snap judgements about other people, they revert back to using preconceived notions about them [19]. Stereotypes and other forms of social metacognitive assumption are influenced by people's cultural backgrounds. For instance, no age-related differences in memory performance have been found in societies where the myth that memory deteriorates with age is not widely held [15].

Implicit ideas regarding the stability versus malleability of human features predict variations in social stereotyping when it comes to making judgements about other people. When people have what is called "entity theory of traits," they are more likely to draw conclusions about individuals within a group based on superficial similarities. People who hold entity views of traits are more likely to make harsh trait judgements about novel groups, as well as to deploy stereotypes about existing groups based on those features [20]. Assumptions and implicit notions about a group can lead to more stereotyped judgements [21]. Metastereotypes refer to an individual's belief that others have a certain stereotype of them.

3. Animal metacognition

Animal metacognition needs to be addressed in this chapter for the sake of completeness. It will improve deduction and comparison, leading to a more complete knowledge of how animals and humans use metacognition. Chimpanzees, rhesus macaques, rats, pigeons, dogs, and dolphins are just some of the animals used in scientific studies.

Metacognition, the ability to reflect on one's own thought processes and modify one's conduct accordingly, has been observed in chimpanzees. Georgia State University (2015), Agnes Scott College, Wofford College, and the University at Buffalo, The State University of New York researchers [22] found that chimpanzees, like humans, have the ability to engage in metacognitive monitoring, which reflects a form of cognitive control essential to making intelligent decisions. Beran et al. found that chimpanzees demonstrated metacognitive monitoring in an information-seeking task [23], so this fits with their findings. Three chimpanzees were studied and asked to use a keyboard to name the food item in order to receive it. Either the food was in plain sight, or they had to approach the container to inspect its contents. Chimpanzees were more likely to open a container to see what was inside when the food inside was disguised, according to the research. However, when the chimpanzees could see what was in the container, they were more likely to approach the keyboard without first checking the container and report the food's identity. Their findings imply that chimpanzees are perceptive beings capable of successful information-seeking behaviours in the face of knowledge gaps.

Rhesus monkeys (*Macaca mulatta*) were tested by Rosati and Santos who investigated whether or not they engage in metacognitive inferences during a binary choice [24].

The four different circumstances that the monkeys were exposed to involved their seeing a human seem to conceal food rewards in either one or two tubes. When they saw a bailing event, the monkeys usually looked in the right place, but they did some fact-finding by peeking into the middle of the room where they could see both hiding sites. Furthermore, the study's findings give evidence that nonhumans demonstrate information-seeking reactions in contexts with which they are unfamiliar [24]. It also demonstrates that monkeys employ information about their own knowledge levels spontaneously to solve naturalistic foraging difficulties.

Metacognition was not just something that was seen in nonhuman primates. In a perceptual discrimination challenge, Foote and Crystal showed for the first time that rats had self-aware knowledge [25]. The rodents were asked to judge whether or not certain sounds were long or short. Sometimes it was hard to tell whether a noise was brief or long because of its duration. On some trials, the rats were given the chance to skip the test, but on others, they were coerced into answering questions. They could earn a lot of money if they took the test and answered properly, but nothing if they misclassified the sounds. However, the rats would be assured a reduced prize if they opted out of doing the exam. This suggests that rats know they do not have the correct answers and choose not to take the exam in order to earn the reward as the level of noise in the environment increases. The rats also performed better when given the option to skip trials they were unsure of, suggesting that they were able to make more informed decisions when given the option.

It is possible that they are keeping tabs on their mental states, which would explain their reaction pattern. It is also possible to account for their performance in the discrimination test on the basis of external cues, such as environmental cue associations. Over time, rats may have learned to respond negatively to intermediate stimuli by selecting the decline option. Tests can be declined on the basis of discriminative cues such as longer reaction latencies or qualities inherent to the stimulus. To determine whether or if rats are capable of metacognitive reacting adaptively [26], Templer et al. used an olfactory-based delayed match-to-sample (DMTS) memory challenge [26]. After being presented with a sample odour, rats were given the option of skipping the subsequent memory test or taking it. The rewards for making the right olfactory judgements were substantial, while those for making the wrong ones were none. There was some compensation for choosing the decline alternatives.

Some "no-sample" trials, in which no odour was presented to the participants prior to the memory test, were included in the second experiment. They reasoned that if rats were able to internally judge the strength of their memories, they would be less likely to choose the option where no sample odour was offered. However, the rats would be less likely to choose to refuse the test if external environmental signals were used to drive the decline option. Supporting the idea that rats can gauge their own memory strength, the data showed that rats were more likely to decline the test in no-sample trials compared to standard sample trials.

They also controlled memory strength by presenting the sampled odour twice and by changing the retention period between the learning and the test in order to rule out alternative possibilities. Rats that had been exposed to the sample twice were less likely to refuse the test, showing that their memory for these samples was strengthened. This was discovered by Templer and colleagues. As people's memories improved after the shorter delay, they were less likely to take the longer delayed sample test. Collectively, the results of their experiments showed that rats could tell the difference between remembering and forgetting and disproved the hypothesis that decreased use was influenced by environmental cues.

Studying whether pigeons (*Columba livia*) can exert behavioural control as a function of knowledge level on a 3-item sequence learning task, a reference memory task supposedly requiring fewer working memory resources [27], Iwasaki et al. conducted this research. In the study, participants were exposed to two lists with varying degrees of familiarity. The pigeons had seen the first one many times, but the second one changed with each training session. Primary reinforcement rates were reduced by 0.60 percentage points in the first test, and by 0.75 percentage points in the second test, when pigeons were given the option of selecting a trial with a hint. The study found that when given a choice between a familiar and a novel list, pigeons with cognitive abilities between 2 and 4 years old preferred the trial with a hint. In the very first sessions of both tests, one bird provided strong evidence. These findings indicate that pigeons may keep tabs on their long-term knowledge states before beginning to solve a problem, allowing them to exert some degree of influence on their surroundings. Pigeons were trained by Adams and Santi to recognise differences in lighting for a perceptual discrimination task using the DMTS method [28]. In preliminary tests, a higher retention interval did not lead to more pigeons selecting the escape option. They were able to learn how to avoid the tests altogether after extensive practise. Pigeons may have acquired a link between escape responses and a longer retention delay [29], which could explain these findings.

Pigeons have been shown to exhibit adaptive and efficient information-seeking behaviour in the same-different discriminating test [30] by Castro and Wasserman, and this is independent of the DMTS paradigm. At the same time, two sets of elements, which could be the same or different, were shown in two separate arrays. Pigeons were challenged to tell the difference between two sets of items with varying degrees of difficulty. On some trials, pigeons were given an "Information" button and a "Go" button to stimulate them to make responses by pecking the button, or to increase the amount of objects in the arrays to make the discrimination easier. Pigeons, according to the research of Castro and Wasserman, are more likely to use the "information" button to complete the discrimination job if it is more challenging. This pattern of action demonstrated that pigeons could make an internal assessment of the challenge of the assignment and go on the hunt for answers when necessary.

Dogs have demonstrated a degree of metacognition, suggesting that they can evaluate whether or not new knowledge is relevant to them. When confronted with ambiguity, Belger and Bräuer wanted to see if dogs may actively seek out more information [31, 32]. The reward was hidden beyond one of the two gates, and the dogs were either able to see it or not. The dogs were then directed to the prize by going around a single barrier. When the dogs were unable to observe the baiting process, they were more likely to perform a double-check before choosing the fence. When the delay between baiting the reward and choosing the fence was longer, dogs did not increase their checking behaviours in the same way as apes did. Their research showed that canines are capable of some information-seeking behaviours, albeit with less versatility than apes.

Smith used an auditory threshold paradigm [33] to test dolphins for metacognitive monitoring. There was success in teaching a bottle-nosed dolphin to distinguish between high- and low-frequency tones. In some trials, there was a little prize and an escape opportunity. The results of the study demonstrated that dolphins were capable of making effective use of the unclear answer during trials with low discriminability.

Nonhuman primates, particularly great apes and rhesus monkeys, are widely agreed upon to engage in metacognitive control and monitoring behaviours [34].

However, other animals, including rats and pigeons, showed less convergent evidence [35]. Low-level conditioning mechanisms were proposed as a possible explanation for these performances by some researchers who were critical of these methods [36]. Animals using simple reinforcement models learned to associate rewards with environmental cues. The reinforcement model has been used to try to explain animal behaviour, however numerous investigations have shown that this is not sufficient. Even without a direct payoff, animals have been observed to engage in adaptive metacognitive behaviour.

4. Metacognitive strategies in education

Metacognition is an essential part of any educational discussion. The ability to reflect on one's own learning process and make adjustments to one's strategy is an example of metacognition. The metacognition cycle clearly aids students in enhancing their learning by having them: First, evaluate the task. Second, consider both your advantages and disadvantages. Third, map out your strategy. Fourth, put plans into action. Fifth, reason.

Metacognition is a term largely used in the field of education to describe an individual's awareness of his or her own cognitive processes. That is, the knowledge we have about our knowledge. Knowing how you learn best, the various learning strategies at your disposal, the tasks at hand, and the best way to finish them are all examples of metacognitive knowledge [37]. Metacognitive techniques aid in the organisation, control, and assessment of our academic endeavours. It boils down to the capacity to draw on prior experience and information to formulate plans for tackling challenges, implement those plans, assess their efficacy, and make necessary adjustments. It consists primarily of keeping an eye on and reining in our own internal mental processes.

However, it is vital to keep in mind that cultivating metacognition does not inevitably produce pupils who are able to govern their own learning. If you want your pupils to build their own metacognitive skills as learners, Sword says you need to have a firm grasp of how such skills are acquired and mirror them in your own practise [37].

To achieve the best possible results, it is imperative that professionals inculcate the concepts more thoroughly into their subject-specific practises and place a premium on encouraging students to become more successful independent learners who can critically evaluate their own methods and adjust their own behaviour accordingly.

The educational benefits of metacognition are substantial. According to a research published by the National Academy of Sciences in 2018, effective learning necessitates the integration of several neural networks. Self-regulation and monitoring of learning are necessary for coordinating these processes. Interventions can enhance people's natural, maturing capacity to monitor and control their own learning as it evolves across the lifespan.

Sword lists the following as some of the possible advantages of metacognition for learning:

- Higher achievement levels *for the students*. Clearly metacognitive practices can also compensate for any cognitive limitations that a student might have.

- *Increased ability to learn independently*. Being able to monitor their own progress helps students take control of their own learning, inside and outside the classroom.

- *Improved resilience*. Identifying their successes and failures, and which strategies work best for them—or which have failed—increases students' perseverance in getting better at their work.

- *It aids disadvantaged students*. According to this report, and researches, metacognition is beneficial for students who are at a disadvantage to their peers.

- *Cost-effectiveness*. This method of teaching does not require specialist equipment nor any other large purchases—it only requires teachers to be trained in the method effectively.

- *Transferable knowledge*. It helps students to transmit their knowledge and understanding across tasks and contexts, including reading comprehension, writing, mathematics, memorising, reasoning, and problem-solving.

- *Effective for all ages of students*. Research has looked at both primary and secondary students—and even those who have not yet started school—and found benefits in all cases.

- *Emotional and social growth*. Gaining awareness of their own mental states allows students to think about how to be happy, respected, and confident in themselves. They are also better able to understand other people's perspectives.

5. Teachers' professional approaches to metacognition

Despite the fact that metacognition primarily involves pupils assuming responsibility for their own learning, a teacher's assistance is still necessary. Instead of having separate "learning to learn" or "thinking skills" sessions, it is advised that teachers teach metacognition with topic content. Students have a hard time making the connection between the generalised advice presented in these sessions and the material being covered in class.

As a teacher, it is your responsibility to design lessons that give students opportunities to use metacognitive skills. Lessons should generally be broken down into four phases: you, planning, doing, and reflecting [37].

In the "You" phase, students are presented with a lesson beginning that prompts them to reflect on what they already know about the material and how they have approached learning it in the past.

In the "Plan" phase, students are assigned a project (as well as a specific objective to achieve along the course of the learning process). Clarity and specificity in the learning objective are essential. The best way for students to ensure they put in the appropriate amount of time and effort is to anticipate obstacles and plan accordingly. Metacognition can also benefit from the ability to predict future performance.

In the "Do" phase, the students actually do the work while keeping tabs on their development. The teacher could pause students in the middle of the process and provide sentence scaffolding to help them think about what they have accomplished so far and what they need to do next (such as "I am doing the task successfully because…", "this strategy is working because…", "I am confused by…", "I might have to change my strategy because…", and "my next steps are…"). In order to demonstrate to students that misunderstandings are normal and expected during the learning process, it is crucial to emphasise any topics that give them confusion. Better metacognition is also a byproduct of learning to admit ignorance.

Finally, in the "Review" phase (often at the end of the course), the teacher should provide students time to review what they have learned—how successful was their method in helping them achieve their learning goal? What worked, and what did not, and why? Is there anything they might have done differently next time, and what other problems this method might be applicable to?

The activities students are given need to be challenging (but not impossible) so that they can practise new metacognitive methods, learning from their own mistakes as educators, and reflect thoughtfully on their own learning. Students are more likely to retain knowledge from an engaging, complex assignment than they would be from a superficial one. Work should be demanding, but not beyond their capacities; otherwise, they risk experiencing cognitive overload and having their reasoning break down under the strain of trying to keep too much knowledge in working memory. You must evaluate your pupils' metacognitive skills so that you can assign appropriate tasks.

According to Sword [37], David Perkins's (1992) four-level approach for characterising metacognitive learners—tacit learners, conscious learners, strategic learners, and reflective learners—is widely used.

Tacit learners refer to learners or students who are unaware of their metacognitive knowledge. They do not think about any particular strategies for learning, and merely accept if they know something or not.

Aware learners refer to those who know about some of the kinds of thinking that they do, such as generating ideas, finding evidence, etc. However, thinking is not necessarily deliberate or planned.

Strategic learners refer to those who organise their thinking by using problem-solving, grouping and classifying, evidence-seeking, decision-making, etc. They know and apply the strategies that help them learn.

Reflective learners refer to those who are not only strategic about their thinking, but also reflect upon their learning while it is happening. They consider the success or failure of any strategies they are using, and revise them as appropriate.

Teachers can better assist their students in their learning if they have an idea of where their pupils now stand. Teachers of tacit students, for instance, need to pay close attention to all facets of metacognition as they lead their students through the learning process. When teaching more advanced students, you might gradually reduce your involvement [37].

Provide the kids with methods to improve their learning. Students need exposure to a variety of learning tactics before they can evaluate their effectiveness. The instructor must provide students with opportunity for self-assessment and reflection on their learning. One strategy for doing so is to demonstrate your own metacognitive strategies by walking them through the steps you would use to complete a certain assignment. The instructor should also act in ways that demonstrate resilience. This is incredibly helpful because it reveals the inner workings of success, the challenges that everyone must overcome to master a new skill. It highlights the need of a growth mindset, the belief that one's cognitive abilities may be honed via repeated efforts rather than being fixed at birth.

6. Conclusion

The purpose of this chapter is to introduce the idea of metacognition to any reader interested in learning more about it. The chapter opens with a broad explanation of the topic at hand. The ability to reflect on and analyse one's own cognitive functioning is known as metacognition. Content knowledge, task knowledge, and strategic knowledge are only a few examples of metacognitive expertise. Concepts and assumptions about social cognition are the focus of social metacognition. Social metacognition and the self-concept, social metacognition and stereotypes, and social metacognition and attitude were all discussed. Chimpanzees, rhesus macaques, rats, pigeons, dogs, and dolphins are only few of the nonhuman primates studied in the field of animal metacognition at this time. Researchers agree that apes and rhesus monkeys engage in metacognitive control and monitoring behaviour [28], based on a survey of the literature on the topic. It suggests that animals may have the same capacity to reflect on, monitor, or exert control of their mental states as humans do (i.e., conscious metacognition). Students' capacity to reflect on and modify their own learning tactics—known as "metacognitive strategies in education"—is described. Students can enhance their learning with the help of the metacognitive cycle, which consists of five steps: (i) gaining access to the task, (ii) assessing strengths and weaknesses, (iii) developing a strategy, (iv) putting the approach into practise, and (v) reflecting on the process. The focus of this chapter's subtitle, "Teachers' Professional Approaches to Metacognition," is on metacognition as a process that empowers students to direct their own education, with the caveat that teachers are responsible for fostering in their students the skills and strategies necessary to do so. It suggests that, instead of having dedicated learning to learn or thinking skills sessions, teachers should teach metacognition alongside topic content. Students have a hard time making the connection between these sessions and the subject matter being covered, hence they are useless. As a teacher, you should design your session so that pupils have ample opportunity to use metacognitive skills. The teacher should generally divide the lesson into four stages: the you stage, the planning stage, the doing stage, and the reviewing stage. Sword [37] elaborated by noting that David Perkin's description of the four levels of learners—tacit learners, conscious learners, strategic learners, and reflective learners—serves as a popular foundation for justifying the degrees of metacognitive learners. After determining where their pupils stand, educators can tailor their instructions to meet their pupils' needs. It has long been known that metacognition as a teaching concept is crucial for students to understand and use effectively.

Author details

Manasseh Ternenge Adi
Information and Protocol Unit, Office of the Vice-Chancellor, Federal University Wukari, Taraba, Nigeria

*Address all correspondence to: manassehadi@gmail.com

IntechOpen

© 2023 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

References

[1] Raghunah, C. Metacognition Demystified [Internet]. 2023. Available from: www.google.com [Accessed: June 20, 2023]

[2] Cambridge Assessment, International Education Getting Started with Metacognition [Internet]. 2023. Available from: https://cambridege-community.org.uk/professional-development/gswmeta/index.html

[3] Coulacoglous C, Saklofske DH. Metacognition, empathy, and cognitive biases in schizophrenia and OCD. Psychometrics and Psychological Assessment. 2017

[4] Hampton RR. Metacognition and metamemory in non-human animals. In: Choe JC, editor. Encyclopedia of Animal Behavior. Elsevier Academic Press; 2019. pp. 383-389

[5] Ochilova VR. Metacognition and its history. Frontline Social Sciences and History Journal. 2021;**1**(3):18-44. DOI: 10.37547/social.fsshj-10-03-04

[6] Wikipedia – The free Encyclopedia. Metacognition. 2023. Available from: www.google.com [Accessed: June 20, 2023]

[7] Flavell JH. Metacognition and cognitive monitoring. A new area of cognitive-development inquiry. American Psychologist. 1979;**34**(10):906-911. DOI: 10.1037/0003-066X.34.10.906

[8] Dunlosky J. In: Bjork RA, editor. Handbook of Metamemory and Memory. New York: Psychology Press; 2008

[9] Becton, L. Using Metacognitive Strategies in Education: The Complete Guide Retrieved [Internet]. 2023. Available from: www.google.com [Accessed: May 20, 2023]

[10] Jost JT, Kruglanski AW, Nelson TO. Social metacognition: An expansionist review. Personality and Social Psychology Review. 1998;**2**(2):137-154. DOI: 10.1207/s15327957pspr0202_6. ISSN 1088-8683

[11] Tullis JG, Fraundorf SH. Predicting others' memory performance: The accuracy and bases of social metacognition. Journal of Memory and Language. 2017;**95**:124-137. DOI: 10.1016/j.jml.2017.03.003. ISSN: 0749-596X

[12] Thompson L, Cohen TR. Metacognition in teams and organizations. In: Social Metacognition. US: Taylor & Francis; 2012. pp. 283-302. DOI: 10.4324/9780203865989. ISBN: 9780203865989

[13] Dweck CS, Chiu C, Hong Y. Implicit theories and their role in judgments and reactions: A word from two perspectives. Psychological Inquiry. 1995;**6**(4):267-285. DOI: 10.1207/s15327965pli0604_1. hdl:10722/44536. ISSN: 1047-840X

[14] Levy B, Langer E. Aging free from negative stereotypes: Successful memory in China and among the American deaf. Journal of Personality and Social Psychology. 1994;**66**(6):989-997. DOI: 10.1037/0022-3514.66.6.989. ISSN: 0022-3514. PMID 8046582

[15] Steele JR, Ambady N. "Math is hard!" The effect of gender priming on women's attitudes. Journal of Experimental Social Psychology. 2006;**42**(4):428-436. DOI: 10.1016/j.jesp.2005.06.003. ISSN: 0022-1031

[16] Briñol P, Briñol P, Demarree K, editors. Social Metacognition. New York: Psychology Press; 2012. pp. 21-42. DOI: 10.4324/9780203865989. ISBN: 9780203865989

[17] Briñol P, Briñol P, Demarree K, editors. Social Metacognition. New York: Psychology Press; 2012. pp. 43-62. DOI: 10.4324/9780203865989. ISBN: 9780203865989

[18] Briñol P, Briñol P, Demarree K, editors. Social Metacognition. New York: Psychology Press; 2012. pp. 243-262. DOI: 10.4324/9780203865989. ISBN: 9780203865989

[19] Yzerbyt VY, Schadron G, Rocher S. Social judgeability: The impact of meta-informational cues on the use of stereotypes. Journal of Personality and Social Psychology. 1994;**66**(1):48-55. DOI: 10.1037/0022-3514.66.1.48. ISSN: 0022-3514

[20] Plaks JE, Stroessner SJ, Dweck CS, Sherman JW. Person theories and attention allocation: Preferences for stereotypic versus counterstereotypic information. Journal of Personality and Social Psychology. 2001;**80**(6):876-893. DOI: 10.1037/0022-3514.80.6.876. ISSN: 1939-1315

[21] Yzerbyt V, Corneille O, Estrada C. The interplay of subjective essentialism and entitativity in the formation of stereotypes. Personality and Social Psychology Review. 2001;**5**(2):141-155. DOI: 10.1207/s15327957pspr0502_5. ISSN: 1088-8683.S2CID 17740957

[22] Georgia State University. Chimpanzees may know when they are right and move to prove it. Science Daily. 2015. Available from: www.sciencedaily.com/releases/2015/06/150608212743htm [Accessed: August 17, 2023]

[23] Beran MJ, Smith JD, Perdue BM. Language-trained chimpanzees (pan troglodytes) name what they have seen but look first at what they have not seen. Psychological Science. 2013;**5**:660-666. DOI: 10.1177/0956797612458936

[24] Rosati AG, Santus LR. Spontaneous metacognition in Rhesus monkeys. Psychological Science. 2016;**27**(9):1181-1191. DOI: 10.1177/0956797616653735. Available from: https://www.ncbi.nih.gov/pmc/articles/PMC5292828/ [Accessed: August 17, 2023]

[25] Foote AL, Crystal JD. Metacognition in the rat. Current Biology. 2007;**17**(6):551-555. DOI: 10.1016/j.cub.2007.01.061. ISSN: 0960-9822

[26] Templer VL, Lee KA, Preston AJ. Rats know when they remember: Transfer of metacognitive responding across odor-based delayed match-to-sample tests. Animal Cognition. 2017;**20**(5):891-906. DOI: 10.1007/s10071-017-1109-3. ISSN: 1435-9448

[27] Iwasakie S, Watana Be S, Fujite K. Pigeons (*Columba livia*) know when they will need hints: Prospective metacognition for reference memory? Animal Cognition. 2018;**21**(2):207-217. DOI: 10.1007/s10071-017-1153-z

[28] Adams A, Santi A. Pigeons exhibit higher accuracy for chosen memory tests than for forced memory tests in duration matching-to-sample. Learning & Behavior. 2011;**39**(1):1-11. DOI: 10.1007/s13420-010-0001-7

[29] Iwasaki S, Kuroshima H, Fujita K. Pigeons show metamemory by requesting reduced working memory loads. Animal Behavior and Cognition. 2019;**6**(4):247-253. DOI: 10.26451/abc.06.04.04.2019. ISSN: 2372-5052

[30] Castro L, Wasserman EA. Information-seeking behavior: Exploring metacognitive control in pigeons. Animal Cognition. 2013;**16**(2):241, 10.1007/s10071-012-0569-8-254. ISSN: 1435-9448

[31] Belger J, Bräuer J. Metacognition in dogs: Do dogs know they could

be wrong? Learning & Behavior. 2018;**46**(4):398-413. DOI: 10.3758/s13420-018-0367-5. ISSN: 1543-4494

[32] Call J. Do apes know that they could be wrong? Animal Cognition. 2010;**13**(5):689-700. DOI: 10.1007/s10071-010-0317-x

[33] Smith JD. Inaugurating the study of animal metacognition. International Journal of Comparative Psychology. 2010;**23**(30):401-413

[34] Smith JD, Couchman JJ, Beran MJ. Animal metacognition: A tale of two comparative psychologies. Journal of Comparative Psychology. 2014;**128**(2):115-131. DOI: 10.1037/a0033105. ISSN: 1939-2087

[35] Schraw G. Promoting general metacognitive awareness. Instructional Science. 1998;**26**:113-125. DOI: 10.1023/A:1003044231033

[36] Wright, F. APERA Conference. 2008. Available from: http://www.apera08.nie.edu.sg/proceedings/4.24.pdf [Accessed: June 22, 2023]

[37] Sword, R. Metacognition in the Classroom: Benefits and Strategies. 2023. Available from: www.google.com [Accessed: June 25, 2023]

Chapter 4

Perspective Chapter: Metacognitive Learning Strategy

Parlan Parlan

Abstract

Metacognition is an important aspect of learning because metacognition affects a person's learning process. Metacognition is also a strong predictor of academic success and problem solving. To improve students' metacognition skills, appropriate learning strategies are needed. Metacognitive learning strategy is one strategy that has the potential to improve students' metacognitive abilities. This study aims to produce metacognitive learning strategy. The research design used is Research and Development, which refers to the 4D development model from Thiagarajan, namely *Define, Design, Develop*, and *Disseminate*. The *define, design, and develop stages produce valid*, practical, and effective metacognitive learning strategy. Validation of learning strategy and tools was carried out by three experts in the field of chemistry education. The development of metacognitive learning strategy was carried out through limited trials and implementation was carried out on the undergraduate students of Chemistry Education Study Program in Malang Indonesia, in the Organic Chemistry I course. The resulting metacognitive learning strategy is called PDCA Metacognitive Learning Strategy (*Preparing, Doing, Checking, and Assessing & Following-Up*).

Keywords: metacognition, metacognitive learning strategy, understanding, meaningful learning, PDCA

1. Introduction

The lecturing format based on textbooks still dominates learning today, although many active student-based learning models are known [1]. Learning in this way causes students to learn by rote learning, inhibiting the development of critical thinking and meaningful learning [2]. Some of the reasons for using the lecture learning method are to cover all the material that must be taught and still be able to control the class [1]. Textbook-based learning often fails, due to low student attention, simplifying examples, and too much material being presented at one time [3], as well as resulting in superficial understanding [2].

The results showed that students' understanding of the relationship between molecular structure and its properties was still low. For example, there are still many students who cannot apply their knowledge of hydrogen bonding in interpreting physical properties and molecular spectra data despite understanding the concept of hydrogen bonding. Some students experience misconceptions in explaining the concept of boiling point associated with hydrogen bonding [4]. There are still many students who have difficulty connecting the concepts learned with other related concepts. Understanding of the relationship between concepts in chemistry/science is still very minimal. Students have difficulty explaining the properties of compounds based on their molecular structure. For example, students assume that if a liquid boils, then there is a break of covalent bonds in the molecules of the compound. There are still many students who consider that if a substance melts (melts) there is a break in covalent bonds (and not bonds between molecules [5].

Only a small (1.35%) of students were able to understand the relationship of molecular structure to compound properties with scientific *mental models (Scientifically* Correct, SC), 98.65% alternative mental models (5.53% mental models of type NR *(No Response*), 42.57% type SM (*Specific Misconceptions*), and 50.54% of PC type (*Partially Correct*). In general, students cannot yet understand the relationship of molecular structure to the properties of compounds, which includes representations of the three levels of chemistry and their interconnections [6]. The author's experience in learning the material and the properties of compounds shows that only about 25% of students can do problems that relate two or more variables. This data is a challenge for chemistry/science teachers.

Future chemistry/science teachers are teachers who master the three pillars of knowledge, namely content knowledge, pedagogical knowledge, and pedagogical content knowledge [7, 8]. In addition to these three pillars, in the era of technology, teachers must master technological knowledge [9]. Content knowledge states knowledge of the material to be taught. Pedagogic knowledge expresses general knowledge of how students learn or in a special sense expresses ability about methods/ways of teaching material to students. Pedagogic content knowledge is special knowledge to teach certain topics to certain students under certain conditions (*PCK = pedagogical content knowledge*).

Content knowledge (CK) is an important aspect in learning because, without adequate content knowledge, teachers will not be able to teach well. Content knowledge is the teacher's knowledge of the material to be studied or taught to students. Content knowledge includes knowledge of concepts, theories, ideas, scientific organizational frameworks, evidence and how to prove, and approaches to developing that knowledge. Content aspects in science include knowledge of scientific facts and theories, the scientific method, and evidence-based reasoning [9]. A teacher can teach his/her students well if he masters the learning content to be taught. Teachers who understand learning content well can explain concepts well and use best learning practices that support concept construction and development of abstract concepts by their students [10].

Understanding of learning content occurs when the learning experience experienced is meaningful learning. In learning, it means that a knowledge/concept is understood as a unity with knowledge/concepts that have been understood before. Previous knowledge is more specifically mastered knowledge needed to understand the new knowledge being learned called *prior knowledge* [11]. The link between initial knowledge and new knowledge learned will form a broader knowledge build with consistent meaning. Early knowledge acts as *an advance organizer* [12]. Meaningful learning occurs when students are involved in learning that is directed at goals that have been understood/mutually agreed, students are actively involved in learning, and there is multidirectional interaction (student with student, student with teacher, student with media and learning resources) so that there is a construction of concepts in students and authentic assessment (measuring complex and contextual abilities).

Learning carried out by teachers/lecturers is directed to help students build knowledge and thinking skills so that they can find relationships between the concepts learned and use the understanding of these concepts to explain relevant phenomena. One example is finding relationships between molecular structure and macroscopic properties in meaningful learning [13]. The reality shows that the learning carried out by teachers/lecturers in the classroom is still dominated by conventional learning/approaches [1, 2]. Empirical evidence shows that conventional learning/approaches cannot assist students in developing an understanding of the relationship between structure and compound properties. Student learning experiences cannot help develop an adequate conceptual framework.

Evidence shows that students' understanding of the relationship between molecular structure and its properties is still low, for example, there are still many students who cannot apply their knowledge of hydrogen bonds in interpreting physical properties and molecular spectra data, even though they understand the concept of hydrogen bonding. Some students experience misconceptions in explaining the concept of boiling point associated with hydrogen bonds. To overcome these problems, it is necessary to apply appropriate learning strategies [4].

One of the efforts that can be made to overcome these problems is to choose/apply the right learning strategy. Choosing the right learning strategy is an important aspect that is carried out so that students can master the concepts learned in depth and their application in the appropriate context. The strategies chosen in learning must be able to improve critical thinking skills, equip students with problem-solving skills and strategies in a broader context, and provide a model of knowledge about how a person learns. These aspects are included in the higher-order thinking component, which consists of (1) problem-solving skills, (2) creative thinking, (3) critical thinking, and (4) decision-making [14, 15].

Starting in the late twentieth century, science learning shifted from learning that required students to memorize facts to learning as a way of figuring out and thinking [16]. Metacognitive learning strategies are one alternative strategy that is suitable and meets the demands of these needs. The use of metacognitive learning strategies allows learners to develop their metacognitive knowledge and skills. Both components of metacognition are important aspects of science learning. In this learning, students are expected to be able to describe objects and events, ask questions, construct scientific explanations, test explanations with appropriate scientific knowledge, and communicate their ideas. In this way, students actively build understanding of science by combining scientific knowledge with reasoning (scientific explanation) and thinking skills.

The ability of students to construct scientific explanations is one of the benchmarks for students' understanding of the concepts learned and the relationship between concepts, as well as their application in appropriate contexts. Understanding of the material studied affects students' ability to use effectively the evidence in scientific explanations made. In constructing scientific explanations, students must be able to obtain, select, and use data as evidence to support claims. Generally, students have difficulty in such complex tasks. Even someone who has had considerable educational experience and is an expert also has difficulty in distinguishing evidence from theory and using evidence to support claims [17]. In addition, students also still have difficulties in choosing the right and appropriate evidence [18].

At the beginning of the twenty-first century, there has also been a paradigm shift in learning in schools, where a new approach is used that considers aspects of literacy as important to deal with the complexity of contemporary life. The development of information and knowledge systems has an impact on shifting the paradigm from just knowing information to being able to remember and process information to be able to find and use it effectively. The learning process is not only applied to the relationship of stimulus and response (S-R) and the provision of reinforcement but also related to logical and rational relationships that involve the process of acquisition or change from within (*insight*), outlook (*outlook*), expectations or patterns of thinking [19].

The development of cognitive science recognizes the importance of thinking and problem-solving in learning. Learning is closely related to thinking and reasoning. If a person understands certain knowledge, then he is able to use that knowledge to solve new relevant problems. In line with this thinking, current learning practices emphasize learning with understanding [20]. Understanding a topic means being able to think and act creatively and competently with what is known about the topic [21]. An important implication of this view is that mental processes related to thinking are not limited to some level of learning. Instead, thinking skills determine learning success even at the basic level of reading, math, and all other subjects in school. If knowledge acquisition is defined as learning by understanding, then learning cannot occur without thinking [22]. Therefore, students' understanding can be improved by practicing thinking and reasoning skills in learning.

According to Wong et al. [23], thinking cannot occur spontaneously but must be generated by problems and questions or by giving some conflict (cognitive conflict). Dewey's concept of thinking fits with the results of research on metacognitive learning strategies and the importance of teaching students to think about their thought processes [24]. According to Marzano et al. [25], the dimension of thinking is expressed by the dimension of learning. In Marzano's learning dimension, metacognition is the highest dimension of learning. Educators have used the learning dimension as a reference in developing learning strategies, lesson planning and assessment, making systematic reforms, and determining what students must master to solve each problem and make decisions in various situations [26].

Wilson and Bai [27] conducted research on the relationship between teachers' metacognitive knowledge and pedagogic understanding of metacognition. The results showed that teachers' metacognitive knowledge had an impact on their understanding of metacognition. Teachers who have a better understanding of metacognition teach their students to be metacognitive, a complex understanding of metacognition and metacognition thinking strategies. Effective learning not only improves the quality of learning but also helps students to develop the metacognitive skills necessary to master higher levels and to reconstruct conceptual knowledge and procedural strategies if needed [28]. Undergraduates' students reading comprehension in the metacognitive group was significantly higher than the students in the conventional reading group [29].

Based on the results of theoretical studies and research results, it is known that metacognition is an important aspect of learning. The use of metacognitive strategies facilitates students mastering/improving mastery of the components of metacognition, namely metacognitive knowledge and skills. Mastery of metacognition knowledge through meaningful learning in metacognitive strategies increases students' reasoning abilities because the three components of cognition knowledge are what (declarative), why (conditional), and how (procedural) trigger the development of students' thinking skills. If the student is faced with a certain phenomenon, then he will activate the components of his metacognitive knowledge. If the three components of metacognitive knowledge can develop well, then students can construct scientific explanations well.

Christ (1988) developed a metacognitive learning strategy, consisting of four steps, namely *preview, learn, review, and study*. Ref. [13] adapted Christ's model to develop a metacognitive learning strategy called the learning cycle, which consists of five steps, namely *preview, attend, review, study, and assessment*. This model provides students with strategies that can be applied to improve their learning skills and monitor their learning strategies. The five steps are: (1) *Preview*: preview before class—read a short chapter, underline/follow important words, review the summary, find the purpose of the chapter, and compile questions that the teacher will ask to students. (2) *Attend*: activities in class, answering and asking questions, and making important defects. (3) *Review*: immediately after in class—make defects, fill in gaps, and write each question. (4) *Study*: Ask questions such as why, how, and how if, ..., and (5) *Assess*: assess learning — periodically check readiness: (a) Am I using the learning method effectively? and (b) Do I understand enough material to teach other friends?

The results of research conducted [13] on the application of metacognitive strategies in basic chemistry obtained several findings, including (1) students are more motivated in participating in basic chemistry learning (especially students majoring in health), (2) after being introduced to Bloom's taxonomy, students understand the importance and how to develop higher-order thinking skills, (3) students know ways of learning other than memorization, and (4) after students using these strategies and feeling a better understanding and success, his ability/performance continues to improve, and is motivated to continue using the way of learning.

The model developed by Cook et al. has not expressly conditioned students to associate with the prior knowledge needed to understand new material. In addition, at the final stage of learning, there is no assessment of student understanding after strengthening learning and also no follow-up activities on learning outcomes associated with subsequent learning activities. The authors developed a metacognitive learning strategy adapted from the model of Cook et al.

The metacognitive learning strategy developed consists of four steps, namely *preparing* (preparation), *doing (study),* checking *(monitoring),* and assessing and following-up *(assessment and follow-up)* abbreviated as PDCA. The steps are developed as in **Figure 1**.

Information:

——→: Step flow.

- - - →: Occurs in process.

PDCA metacognitive learning strategy is developed based on metacognition theory [29], meaningful learning theory [12], constructionism theory [30], active learning theory [31], and transfer of learning theory [32, 33] learning theory, and self-regulation learning theory (*self-regulated learning*) [34].

The environment that supports PDCA metacognitive learning strategy is a learning environment that allows students to understand their learning objectives, prerequisite knowledge, and cognition knowledge and determine how to learn to construct the concepts they learn through their activities in class together with other friends, and evaluate their learning. Therefore, the role of teachers/lecturers is to facilitate students to identify and formulate their learning goals, recognize the knowledge that has been mastered that is needed to learn new material (prerequisite knowledge), choose a way of learning that suits the learning style and characteristics of the material studied, monitor their learning progress, and evaluate the learning outcomes that have been formulated. Teachers/lecturers need to provide a learning environment that supports student learning activities, namely helping students access information sources (teaching materials), providing appropriate teaching materials,

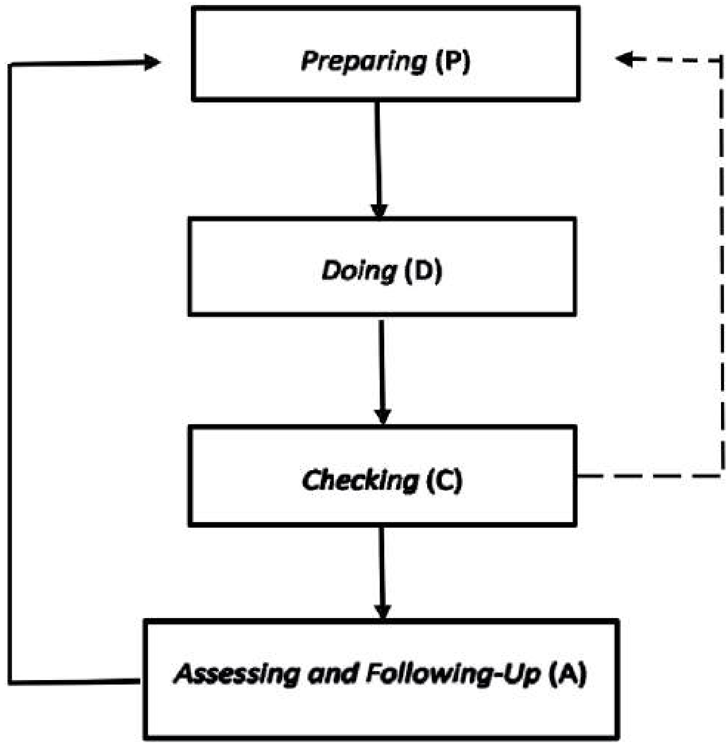

Figure 1.
Stages of PDCA metacognitive learning strategy.

and organizing learning activities in class so that interaction between students and with learning resources can run well so that a cooperative learning atmosphere can occur. Teachers/lecturers must encourage learners to be actively involved in learning through discussions, presentations, and questions and answers so that concept construction can take place properly.

2. Characteristics of PDCA metacognitive learning strategy

PDCA metacognitive learning strategy is developed by combining metacognition theory with the concept of *quality assurance* based on relevant learning theories as described in the theoretical rational section. According to [35], a model/strategy can be used/applied to achieve goals if it meets four special characteristics, namely: (1) the design is prepared with logical theoretical rationales, (2) there is a rationale about the learning objectives to be achieved, (3) teacher and students activities are illustrated in learning so that the strategy can be implemented effectively, and (4) the learning environment needed so that the learning objectives can be achieved.

2.1 Rational

According to cognitive learning theory (Peaget), the learning process occurs in four stages: assimilation, accommodation, organization, and association (new balance). At the assimilation stage, students receive new information that is being studied, which leads to an imbalance of existing cognitive structures (schematics). In the accommodation phase, students match the new information with existing cognitive structures. At the organizational stage, there is an adjustment of new cognitive structures due to the interaction between schematics and new information received, while in the final stage, new cognitive structures are formed as a result of learning.

The accommodation process can occur if the new information received by students is not something new at all, but there is information related to information that has been mastered/learned before, which is called initial knowledge or prior *knowledge*. Prior knowledge is all the knowledge that students have when entering a learning environment that is potentially relevant to acquiring new knowledge [11]. Prior knowledge can also be expressed as all the knowledge that students have, both knowledge about content (content), strategies, and personal knowledge when the person concerned will learn new material.

Prior knowledge is an important factor influencing learning [12]. Prior knowledge is an important variable because it is the foundation for learning achievement in optimal learning. Optimal learning occurs when the material learned is compatible with the prior knowledge. In other words, students can learn well if the prior knowledge/prerequisites have been mastered. Differences in prior knowledge are an important source of individual differences in the classroom. Students who have a prior knowledge of procedural and declarative knowledge (part of metacognitive knowledge) are stronger in a topic, then the student is able to learn new information better in that topic [36].

The results showed a correlation between the quantity and quality of prior knowledge with the acquisition of knowledge and high-level problem-solving abilities. Prior knowledge can explain 81% of the variance in final test scores [37]. If the student's prior knowledge is not suitable and does not match, it will be able to hinder the learning process.

Prior knowledge affects learning achievement in three ways [38]. First, prior knowledge has a direct effect by facilitating the learning process thus leading to better learning outcomes. Second, prior knowledge affects indirectly by optimizing the clarity of teaching material. Third, prior knowledge indirectly affects learning outcomes by optimizing study and learning time.

Prior knowledge is also a very important variable in the view of educational psychology. The knowledge a person has is largely determined by what has been learned and remembered [39]. Understanding is the best manifestation as a result of the interaction between the content learned and prior knowledge. Prior knowledge directly facilitates the learning process and leads to better learning outcomes. Prior knowledge indirectly optimizes the clarity of teaching materials and the use of study time. Prior knowledge and access to relevant cognitive structures enhance learning acquisition. Prior knowledge is a better predictor of learning outcomes compared to intelligence [40, 41].

If students associate appropriate knowledge, they already have with the material being studied, their understanding will increase. Good learners always try to associate what is being learned with what is already known. If the teacher can facilitate these activities before, during, and after the lesson then the teacher has taught critical understanding strategies. Good learners use these abilities unconsciously (happen automatically). The use of such strategies explicitly results in deep understanding and results in independent learners. If students learn by relating their experiences to the material being studied, they have a foundation and help, from which they can place new facts, ideas, and concepts that are being learned.

If the student activates and associates prior knowledge with the material studied, then the student performs activities using an organizer graph, such as concept map or flow chart to map his thoughts. Often students associate with journals, where students record thoughts, feelings, insights, and questions about the material being studied. Students can discuss and write the connections they make in small or large groups.

Prior knowledge encourages meaningful learning. According to Ausubel and Piaget [12], meaningful learning occurs when what students learn is not something new at all. This means that within the cognitive structure of the student, there has been an understanding of the concepts related to what is learned (prior knowledge). In order for students to obtain meaningful learning, students must know the purpose of learning a material and know what prior knowledge is needed/mastered beforehand. A very important role of the teacher is to create a learning situation to make students aware of the relationship so that the learning experienced by students becomes meaningful learning.

Prior knowledge is an important component for happening of meaningful learning. Meaningful learning occurs if three main components are fulfilled, namely: (1) students must have prior knowledge to master new knowledge, (2) new knowledge must be meaningfully relevant to the knowledge they already have, and (3) students "must be aware" and deliberately connect new knowledge with knowledge that has been previously possessed [42, 43]. Learning is meaningfully opposite to rote learning, where new concepts learned are not related to each other, but only memorized so that there is no transfer process.

Learning in the classroom not only presents the material being studied but also prepares suitable physical conditions during the learning process so that the transfer process occurs, namely applying the knowledge that has been obtained into new relevant situations. Failure of the transfer process will lead to failure of thinking [44]. Metacognition is a cognitive approach to facilitate transfer. Transfer learning includes cognition, teaching, and reasoning, which is a creative activity with unlimited potential to influence the way learning is perceived.

The results of research in the field of metacognition recognize a new approach to transfer, namely a strategy where students ask questions of themselves known as self-reflection about the learning process. Lemons et al. [45] developed a design called a learning community that aims, among others, to improve learning outcomes and their application. Students are involved in studying modules in groups and various group discussions designed to increase students' active involvement and participation in the learning process.

According to the constructivist view, knowledge construction and learning occur when students engage in activities that produce products or works. Students will be more interested in engaging in learning if what is learned (the product produced) is personally relevant and meaningful in their daily lives [46].

One important aspect in educational psychology is that teachers must facilitate students to construct their own knowledge [31] so that the most suitable learning is active learning. Metacognitive strategy is one of the applications of active learning that facilitates students to reflect on their learning process to achieve learning goals [47].

One of the principles of student-centered learning psychology says that successful learners are active, goal-directed, self-regulated, and responsible for their learning [48]. These activities are depicted in metacognitive strategies. According to Vygotsky, knowledge is constructed when students engage socially in discussion, experimentation, and experience [48], interacting with media that culturally help shape their understanding [44].

In the learning process, teachers must present a learning environment that allows students to construct their own knowledge [49]. The learning environment largely determines whether students can be mentally actively engaged or not. A good learning environment encourages transfer between content domains and also between learning situations and daily life [50]. The teacher's activity in learning largely determines whether students can learn well and determines the quality of learning. Teachers are not only required to have pedagogical knowledge of teaching methods and content knowledge about the topics taught but also must master pedagogical content knowledge (*PCK = pedagogical content knowledge*), that is. awareness of how students build knowledge in a particular content domain [51].

The strategy of delivering and reviewing material little by little, which is carried out periodically allows material to be transferred to long-term memory and reduces the burden of piling up before the exam [13]. At this stage, students check/monitor/review whether the planned learning strategy has taken place as expected. Whether the chosen strategy is effective enough to be used to solve the task. This activity is a self-reflection on learning activities associated with plans that have been prepared at an early stage (*preparing*). Monitoring activities during the learning process, testing, revising, and evaluating the effectiveness of the strategies used is one of the efforts to direct learning [52]. Students relate and associate concepts that exist to subordinate elements in their cognitive structure. At this stage, there is an organization of new information that is adjusted to the information already owned in the cognitive structure so that new understanding is formed.

Monitoring comprehension and evaluating progress toward task completion are metacognitive activities [53]. Monitoring includes assessment of learning, understanding, and strategies used [54]. A good learner is a reflective learner, who is able to think deeply and critically about his own learning [55].

Assessment of learning outcomes has a role, among others, to help students find out learning outcomes. Based on the assessment of learning outcomes, teachers and students can obtain information about learning weaknesses and strengths. By knowing their weaknesses and strengths, teachers and students have a clear direction on what needs to be improved and can reflect on what they are doing in learning. In addition, for students, it is possible to transfer their learning methods to overcome their weaknesses. Assessment of learning outcomes by teachers has a function to monitor learning progress, monitor learning outcomes, and detect the need for continuous improvement of student learning outcomes.

Assessment is one part of the metacognitive setting [56]. Assessing outcomes according to efficiency and effectiveness criteria is one way of directing learning [57]. Successful learners are learners who focus on learning objectives. Monitoring goal achievement is part of the *self-regulated learning* model [34].

In the context of *standard-based education,* competency-based curriculum*, and* mastery learning *approach* assessment of learning processes and outcomes are parameters for the minimum level of competency achievement. For this reason, various approaches, strategies, methods, techniques, and learning models need to be developed to facilitate students to easily learn and achieve optimal learning success.

Follow-up activities (*following-up*) are carried out to strengthen students' understanding of the material that has been learned. This activity can be in the form of making summaries, concept maps, or other assignments that match the characteristics of the material. Included in this stage is to use the understanding that has been gained to plan activities in the next learning so that the learning packages carried out by students are learning cycles (four stages of learning).

2.2 Social system

The social system built in PDCA metacognitive learning is a social system that allows multidirectional communication (teacher-student, student-student, student-media, student-learning resource) that the teacher seeks so that students are actively involved in learning to find and interpret as many facts as possible so that there can be construction of understanding by students. In order for the social system to be formed, learning is designed from the beginning (*by design).* For example, relevant teaching materials are prepared, appropriate media are used, and in group learning a cooperative group is formed. Teachers facilitate the learning atmosphere in groups and in the classroom so that mutual honing and nurturing learning occurs, and there is a healthy climate of competition between groups, so that students' reasoning skills can develop.

The social system built into learning is based on cooperative learning, meaning that each student engages and cooperates in learning to achieve a common goal. Each student learns from each other and depends on each other to master the concepts learned. Teachers/lecturers play a role in encouraging the creation of these conditions. The involvement of teachers/lecturers in learning is as a facilitator so that active learning occurs.

2.3 Response principle

The response given at each step of learning is to assist students in constructing and expressing their conceptions. If there are questions asked by students, the teacher/lecturer does not answer the question directly but students are guided by guiding questions to explore understanding and help students construct concepts. Teachers/lecturers also need to encourage students to question their understanding to themselves (*self-questions*) in an effort to monitor and evaluate their learning.

2.4 Support system

Every component of learning that supports metacognitive learning must be pursued and facilitated by teachers/lecturers. The system/conditions created by teachers/lecturers should encourage students to be ready to learn, set learning goals, choose appropriate learning methods, set study times, be actively involved in learning, and monitor and evaluate learning. Teachers/lecturers need to have an understanding related to the processes and strategies that support meaningful learning. For this reason, it is necessary to master the theory of meaningful learning [12], constructivism theory, active student learning models *(active* learning), and self-regulated learning theory (*self-regulated learning*).

2.5 Goals

The development of PDCA metacognitive learning strategy aims to provide meaningful learning experiences for students in order to construct their understanding in learning new material so that their learning outcomes are better.

2.6 Activities of teachers/lecturers and students in learning

PDCA metacognitive learning strategy was developed based on a constructivist approach, which is a student-centered learning strategy. This learning strategy consists of 4 (four) stages, namely *preparing (P),* doing *(D),* checking *(C), and* *assessing & following-up* (A) abbreviated as *PDCA*. Learning steps are arranged based on metacognitive theory and steps in the *quality assurance* process so that the flow of learning activities experienced by students is a planned, organized, and monitored learning experience to provide opportunities for students to control their learning and construct their understanding deeply.

The learning steps that have been prepared are used as a reference for compiling learning tools. Based on the results of the development that has been carried out, the stages of the strategy as shown in **Figure 1** are obtained. An explanation of each step in PDCA metacognitive learning strategy is described as follows.

2.6.1 Preparing

This stage aims to prepare students to participate in classroom learning. Before learning in class, teachers/lecturers provide teaching materials/hand-outs to students, and students are asked to preview the material to be learned by reading the material while marking important parts, underlining, summarizing, reading, and interpreting pictures/tables/graphs that are useful for students when participating in classroom learning. Through previews, students can recognize patterns and increase interest and courage to ask questions.

According to the model [58], at this stage, students check their learning environment to understand the profile of the assignment given. The profile intrinsically blends perceptions of purpose and attitudes about the task [59] and other motivational information, such as decisions about self-efficacy. The result of this stage is an idiosyncratic description of the task according to the student (learner). After framing the task, the learner sets goals and a work plan to complete the task. Next, students choose strategies and ways to complete the task. The *preparation* stage aims to mentally prepare students to receive the new material learned. At this stage, it is also agreed what activities will be carried out in learning.

2.6.2 Doing (study)

At this stage, students are involved in learning activities that have been designed and used in the previous stage. Teachers/lecturers facilitate students to be actively involved in learning through discussions, questions and answers, completing assignments, presentations, and or making concept maps/*mind-maps*. Through these activities, students construct their understanding with the guidance of teachers/lecturers. According to learning, the introduction of concepts is easier for students to understand if elaborated and developed from general concepts (global) to smaller/simpler concepts.

In order for directed learning teachers/lecturers provide discussion sheets or provide problems for students to discuss/solve in groups. According to Vygotsky's theory, students learn through interaction with others or peers who are more capable [31]. Through group learning, it is hoped that mutual learning can occur between friends in groups or between groups. Teachers/lecturers monitor student learning activities, and direct learning and help students if they experience difficulties.

2.6.3 Checking (monitoring)

In this step, students are facilitated to check/review their learning. Reviews are conducted immediately after learning or even during learning to help students identify overlapping materials between those obtained in class and those read in books, correct any misconceptions discussed in class, and determine whether appropriate assistance and planning are needed. In this step, students also check whether the chosen method or way of learning is appropriate. This step can overlap with the previous step, meaning it can be done together with the previous step.

2.6.4 Assessing and following-up

At this stage, an assessment of performance/learning outcomes of learning tasks is carried out. In addition, the arrangement of emotional responses related to learning outcomes and experiences is also carried out. Teachers/lecturers need to anticipate cognitive conflicts by arranging the relationship of concepts through a conceptual hierarchy.

Assessment helps students find out their learning outcomes (*outcomes*), which are expressed in the form of learning objectives that have been formulated at the beginning of learning. The results of the assessment can be used by teachers/lecturers and students to obtain information about the strengths and weaknesses of learning that has been done so that a clear direction is known about what must be improved and can reflect on what is done in learning.

The end of this step is the follow-up carried out by teachers/lecturers with students, for example, whether additional tasks are needed, whether remedial learning is needed, or can be continued for the next material. If the final conclusion is chosen, the learning plan starts from the first step as before so that the four steps repeat as a cycle.

The four steps in PDCA metacognitive learning strategy facilitate students to organize their learning well starting from planning/*preparing, doing*, *monitoring,* and *evaluating*. If the four stages can be done well, student learning becomes a complete learning activity by activating all the components of metacognition it has. These three components of metacognition skills allow students to facilitate learning and their abilities [28]. Empirical studies show that students who learn *metacognitively* show better results than those who do not. The more students are aware of the effectiveness of their learning strategies, the higher their learning outcomes [60]. Individuals who have a high level of metacognitive knowledge and metacognitive skills are able to recognize parts of learning as soon as possible and change their tools or strategies to achieve goals [61].

2.7 The learning environment necessary to achieve goals

The important thing that teachers/lecturers must do in implementing PDCA metacognitive learning strategies is to create conditions or learning environments that allow the four steps in learning to be carried out properly. Before learning activities (pre-learning) teachers/lecturers need to convey about the role of students in metacognitive learning. In this activity, students are oriented to determine learning objectives, review learning materials, identify the necessary prior knowledge, choose a suitable way of learning, identify important concepts, and make a list of questions.

During classroom learning activities, students must be actively involved in learning. Concept construction by students occurs through active learning activities (discussions, questions and answers, lab activities, presentations) that are well-planned, so as to create meaningful learning. The role of teachers/lecturers is to facilitate learning activities so that active learning activities can take place in a directed manner. Learning tasks given by teachers/lecturers must stimulate students to be active in activities. The role of teachers/lecturers is to encourage and direct students to play an active role in learning and strive to achieve the goals that have been set. Facilitating learning activities, such as this requires a structured learning environment so that students can construct their understanding based on the prior knowledge they have and with the meaningful learning experience experienced.

An important aspect that must be considered by teachers/lecturers is to facilitate students to evaluate their learning. Through this activity, students evaluate whether the learning goals that have been set have been achieved, whether the learning method chosen is in accordance with the characteristics of the material and learning style, and make decisions about what will be done in the next learning activity.

2.8 Theoretical and empirical argumentation stages of PDCA metacognitive learning strategy

Theoretical and empirical argumentation stages of PDCA metacognitive learning strategies.

is presented in **Table 1**.

No	Tahapan Pembelajaran	Argumentasi teoritik dan empirik
1.	Preparing (P)	a. Prior knowledge is an important factor influencing learning [12]. Meaningful learning occurs if the material learned is related to what is already. Known/understood (prior knowledge). b. Prior knowledge can account for 81% of the variation in final test scores [37]. c. Successful learners are active, goal-directed, and accountable for their learning [62]. d. Connect new information with prior knowledge and choose thinking strategies include basic metacognitive strategies [63]. e. Learning that focuses on thinking skills provides opportunities for students to engage in task planning, be creative, and reflective [64].
2.	Doing (D)	a. Learning includes presenting the material being studied and preparing suitable physical conditions during the learning process so that the transfer and thinking process occurs [44]. b. One important aspect in educational psychology is that teachers must facilitate students to construct their own knowledge [30] so that the most suitable learning is active learning. c. Metacognitive strategy is one of the applications of active learning that facilitates students to reflect on their learning process to achieve learning objectives [65]. d. One of the principles of student-centered learning psychology says that successful learners are active, goal-directed, self-regulated, and responsible for their learning [57]. e. According to Vygotsky, knowledge is constructed when students engage socially in discussion, experimentation, and experience [66], interacting with media that culturally help shape their understanding [44]. f. Teachers can provide optimal learning opportunities by setting up a structured learning environment so that students can form an organized and balanced knowledge structure [50].

No	Tahapan Pembelajaran	Argumentasi teoritik dan empirik
3.	Checking (C)	a. Monitoring activities during the learning process, testing, revising, and evaluating the effectiveness of the strategies used is one of the efforts to direct learning [67]. b. Monitoring comprehension and evaluating progress toward task completion are metacognitive activities [53]. c. Monitoring includes assessment of learning, understanding, and strategies used [54]. d. A good learner is a reflective learner, who is able to think deeply and critically about his/her own learning [55].
4.	Assessing & Following-up (A)	a. Evaluation is one part of the metacognitive setting [68]. b. Evaluating outcomes according to efficiency and effectiveness criteria is one way of directing learning [67]. c. Monitoring goal achievement is part of the *self-regulated learning* model [34].

Table 1.
Theoretical and empirical argumentation stages of PDCA metacognitive learning strategy.

3. Conclusion

Based on the results obtained, the following conclusions can be formulated

1. The validated forms of metacognitive learning strategies developed are:

   a. The syntax consists of four stages, namely *preparing (P),* doing *(D),* checking *(C), and* assessing *&* following-up *(A).*

   b. Named PDCA metacognitive learning strategies.

   c. Based on metacognition theory, meaningful learning theory, constructionism theory, active learning theory, *transfer of learning theory,* mastery learning *theory, and* self-regulated learning theory.

   d. Aims to improve metacognitive abilities, build scientific explanations, learning achievement, and higher-order thinking of students.

2. The metacognitive learning strategy developed has qualified as a good learning strategy, with the following indicators.

   a. Have met the requirements of content validity (relevance) and construct validity (consistency) with very valid categories.

   b. Have met the practicality requirements, namely the stages of the SM-PDCA learning strategy can be implemented as a whole by lecturers with very high categories.

3. PDCA metacognitive learning strategies are effective in:

a. Improving students' metacognitive abilities in both metacognitive knowledge and metacognitive skills with N-Gains of 0.31 and 0.35, respectively.

b. Improve students' ability to build scientific explanations in both aspects, namely technical aspects and conceptual validity with N-Gain of 0.83 and 0.79 respectively. Increased ability to construct scientific explanations occurs proportionally balanced in both aspects of scientific explanation (technical aspects and conceptual validity).

c. Increase student achievement with *d-effect size* and N-Gain by 3.39 and 0.56, respectively.

d. Improve students' higher-order thinking skills with *d-effect size* and N-Gain of 3.23 and 0.61, respectively. PDCA's metacognitive strategies facilitate higher-order thinking improvement in low-group students (below the grade average) than high high-group students (above the grade average).

4. Based on student responses to questionnaires, information was obtained that:

    a. All students think that the tasks given before learning help prepare themselves for learning

    b. Students feel they can learn well through activities to prepare themselves to learn, choose and plan ways of learning, be actively involved in learning, monitor understanding, and evaluate their learning,

    c. Most (93%) students stated that the learning steps experienced made it possible to understand the material well,

    d. All students feel that the lecturer provides an opportunity to monitor their understanding, and

    e. Most (96%) students stated that the quiz given at the end of the lesson helped to find out the understanding of the material that had been learned.

Author details

Parlan Parlan
Faculty of Mathematics and Sciences, Chemistry Department, Universitas Negeri Malang, Indonesia

*Address all correspondence to: parlan.fmipa@um.ac.id

IntechOpen

© 2024 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

References

[1] Paulson DR. Active learning and cooperative learning in the organic chemistry lecture class. Journal of Chemical Education. 1999;**76**(8):1136-1140

[2] Schrock J, Benko S. Using fundamental concepts and essential question to promote critical thinking. Engaged, Connected, Empowered, Teaching and Learning. Available from: https://www.facultyfocus.com/articles/course-design-ideas/using-fundamental-concepts-essential-questions-promote-critical-thinking/

[3] Keyser MW. Active learning and cooperative learning: Understanding the difference and using both styles effectively. Research Strategies. 2000;**17**(1):35-44. DOI: 10.1016/s0734-3310(00)00022-7

[4] Henderleiter J, Smart R, Anderson J, Elian O. How do organic chemistry students understand and apply hydrogen bonding? Journal of Chemical Education. 2001;**78**(8):1-5. DOI: 10.1021/ed078p1126

[5] Smith KC, Nakhleh MB. University students' conceptions of bonding in melting and dissolving phenomena. Chemistry Education Research and Practice. 2011;**12**(4):398-408. DOI: 10.1039/C1RP90048J

[6] Sucitra IGNB, Suja IW, Muderawan IW, Nurlita F. Profil Model Mental Siswa Tentang Korelasi Struktur Molekul Terhadap Sifat Senyawa Organik. Bali; 2016

[7] Sunaryo W. Taksonomi Kognitif. Bandung: Rosda Karya; 2012

[8] Bucat R. Pedagogical content knowledge as a way forward: Applied research in chemistry education. Chemical Education Research and Practice. 2004;**5**(3):215-228. DOI: 10.1039/b4rp90025a

[9] Koehler MJ, Mishra P. What is technological pedagogical content knowledge (TPACK)? Contemporary Issues in Technology and Teacher Education. 2009;**9**(1):60-70. DOI: 10.1016/j.compedu.2010.07.009

[10] National Science Teachers Association. NSTA Preservice Science Standards. 2012. pp. 1-3. Available from: http://www.nsta.org/preservice/docs/2012NSTAPreserviceScienceStandards.pdf

[11] Biemans HJA, Simons PRJ. Contact-2: A computer-assisted instructional strategy for promoting conceptual change. Instructional Science. 1996;**24**(2):157-176. DOI: 10.1007/BF00120487

[12] Ausubel DP, Piaget J. Ausubel' s learning theory. Fak. Pendidik. 1968:1-17

[13] Cook E, Kennedy E, McGuire SY. Effect of teaching metacognitive learning strategies on performance in general chemistry courses. Journal of Chemical Education. 2013;**90**(2):961-967. DOI: 10.1002/jee.20010

[14] Lewis A, Smith D. Defining higher order thinking. Theory Into Practice. 2009;**32**(3):131-137

[15] Liliasari. Membangun masyarakat melek sains berkarakter bangsa melalui pembelajaran. Proceeding Seminar Nasional Pendidikan IPA. 2011. pp. 1-9

[16] Driver R, Newton P, Osborne J. Establishing the Norms of Scientific

Argumentation in Classrooms. Science Education. 2000;**84**(3):287-312. DOI: 10.1002/(SICI)1098-237X (200005)84:3<287::AID-SCE1>3.3.CO;2-1

[17] Mcneill KL, Krajcik J. Supporting students' construction of scientific explanation through generic versus context-specific written scaffolds. In: Paper Presented at the Annual Meeting of the American Educational Research Association San Francisco. Vol. 15, No. 1. 2006

[18] Sandoval WA, Millwood KA. The quality of students' use of evidence in written scientific explanations the quality of students' use of evidence in written scientific explanations. Cognition and Instruction. 2005;**23**(1):23-55. DOI: 10.1207/ s1532690xci2301

[19] Dahar RW. Teoriteori Belajar dan Pembelajaran. Jakarta: Erlangga; 2011

[20] Bransford JD, Brown AL, Cocking RR. How people learn: Brain, mind, experience, and school. Vol. Expanded Edition. Washington, DC: National Academy Press; 2000

[21] Reigeluth CM. Front Cover Image for Instructional-Design Theories and Models. Volume II, A New Paradigm of Instructional Theory Instructional-Design Theories and Models. Vol. II. Mahwah, N.J.: Lawrence Erlbaum Associates; 1999

[22] Zohar A, Dori YJ, Higher order thinking skills and low-achieving students: Are they mutually exclusive? Journal of the Learning Sciences. 2003;**12**(2):145-181. DOI: 10.1207/ S15327809JLS1202

[23] Wong D et al. Learning science: A Deweyan perspective. Journal of Research in Science Teaching. 2001;**38**(3):317-336. DOI: 10.1002/ 1098-2736(200103)38:3<317::AID-TEA1008>3.0.CO;2-9

[24] Kauchak DP, Eggen PD. Learning and Teaching: Research-Based Methods. Allyn and Bacon, Pearson; 1998

[25] Marzano RJ et al., Dimensions of Learning. 1992

[26] McREL. Putnam Educational Standards and Curriculum Standards for Reasoning the Thinking. 1997. Available from: http://putwest.boces.org/StSu/ ReasThink.html

[27] Wilson NS, Bai H. The relationships and impact of teachers' metacognitive knowledge and pedagogical understandings of metacognition. Metacognition Learning. 2010;**5**(3):269-288. DOI: 10.1007/s11409-010-9062-4

[28] Vrdoljak G, Velki T. Metacognition and intelligence as predictors of academic success. Croatian Journal of Education-Hrvatski Casopis za Odgoj i obrazovanje. 2012;**14**(4):799-815

[29] Babashamasi P, Shakib KS, Binti NN. The effect of explicit training of metacognitive Reading strategies on online Reading comprehension. Arab World English Journal. 2022;**8**:246-261. DOI: 10.24093/ awej/call8.17

[30] Flavell JH. Metacognition and cognitive monitoring, a new area of cognitive—Developmental inquiry. The American Psychologist. 1979;**34**(10):906-911

[31] Slavin RE. Educational Psychology: Theory into Practice. Boston, MA: Pearson Education; 2015

[32] Rahman S, Yasin RM, Salamuddin N, Surat S. The use of metacognitive strategies to develop research skills among postgraduate

students. Asian Social Science. 2014;**10**(19):271-275. DOI: 10.5539/ass.v10n19p271

[33] Perkins DN, Salomon G. Transfer of Learning, International. Oxford, England: Pergamon Press; 1992

[34] Metcalfe J. Is study time allocated selectively to a region of proximal learning? Journal of Experimental Psychology. General. 2002;**131**(3):349-363. DOI: 10.1037/0096-3445.131.3.349

[35] Arends RI. Classroom Instruction and Management. New York: The McGraw-Hill Companies, Inc; 1997

[36] Alexander PA. Coming to terms: How researchers in learning and literacy talk about knowledge authors. In: Patricia A. Alexander, Diane L. Schallert, Victoria C, editors. Vol. 61, Issue no. 3. American Educational Research Association; 2016. pp. 315-343. Available from: http://www.jstor.org/sta

[37] Dochy. Chapter 2 Effects of prior knowledge on study results and learning processes: Theoretical approaches and empirical evidence. Journal of Educational Psychology. 1982;**1978**:23-44

[38] Dochy F. The relation between assessment practices and outcomes of studies: The case of research on prior knowledge. In: Dochy F, Segers M, Buehl MM, editors. Vol. 69, Issue no. 2. Source: Review of Educational Research; 1999. pp. 145-186

[39] Thiede KW, Dunlpsky J, Griffin TD, Wiley J. Understanding the delayed-keyword effect on metacomprehension accuracy. Journal of Experimental Psychology: Learning, Memory, and Cognition. 2005;**31**(6):1267-1280. DOI: 10.1037/0278-7393.31.6.1267

[40] Steiner HH. The strategy project: Promoting self-regulated learning through an authentic assignment. The International Journal of Learning in Higher Education. 2016;**28**(2):271-282. Available from: http://www.isetl.org/ijtlhe/

[41] Stern E. Intelligence, Prior Knowledge, and Learning. Second Edi. ed. Vol. 12. Elsevier; 2015

[42] Novak JD. Concep mapping: A useful tool for science education. Research Journal of Science and Technology. 1990;**27**(10):937-949

[43] Bretz SL. Novak's theory of education: Human constructivism and meaningful learning. Journal of Chemical Education. 2001;**78**(8):1107. DOI: 10.1021/ed078p1107.6

[44] Koenig KA, Frey MC, Detterman DK. ACT and general cognitive ability. Intelligence. 2008;**36**(2):153-160. DOI: 10.1016/j.intell.2007.03.005

[45] Lemons CJ, Allor JH, Al Otaiba S, LeJeune LM. 10 research-based tips for enhancing literacy instruction for students with intellectual disability. Teaching Exceptional Children. 2018;**50**(4):220-232. DOI: 10.1177/0040059918758162

[46] Zhou M, Brown D. Educational Learning Theories. 2nd ed. Educ. Open Textb.; 2017. pp. 1-129

[47] Rahman S et al. Student learning style and preferences for the promotion of metacognitive development activities in science class. World Applied Sciences Journal. 2011;**14**:11-16

[48] Hogan, Pressley, Scaffolding Student Learning: Instructional Approaches and Issues. 1997

[49] Kuhn L, Reiser BJ. Students Constructing and Defending Evidence-Based Scientific Explanations. Dallas, TX: Annu. Annual Meeting of National Association for Research in Science Teaching; 2004. pp. 1-35. DOI: 10.1007/s11423-007-9073-2

[50] Schneider M, Stern E. The cognitive perspective on learning: Ten cornerstone findings. In: Organisation for Economic Co-Operation and Development (OECD) (Ed.). 2010

[51] Cox M. Knowledge and teaching: Foundations of the new reform. Harvard Educational Review. 1987;**57**(1):1-22

[52] Darling-hammond DL et al. Session 9 thinking about thinking: Metacognition I. Key questions and learning objectives II. Session overview. The Learning Classroom. 2014:157-172

[53] Zulkiply N. Metacognition and its Relationship with Students' Academic Performance. Serawak Malaysia: Faculty of Cognitif Science and Human Development; 2011

[54] Schraw G, Dennison RS. Assessing metacognitive awareness. Contemporary Educational Psychology. 1994;**19**(4):460-475. DOI: 10.1006/ceps.1994.1033

[55] Borich G. Effective Teaching Methods. 3rd ed. New Jersey: Prentice Hall; 1996

[56] Urena SS, Cooper MM, Stevens RH. International journal of science enhancement of metacognition use and awareness by means of a collaborative intervention. International Journal of Science Education. 2014;**33**(3):323-340. DOI: 10.1080/09500690903452922

[57] Hammond L, Falk B. Supporting Teacher Learning through Performance Assessment. USA: Jossey Bass; 2014

[58] Winne PH. Experimenting to bootstrap self-regulated learning. Journal of Education & Psychology. 1997;**89**(3):397-410. DOI: 10.1037/0022-0663.89.3.397

[59] Pintrich PR, de Groot EV. Motivational and self-regulated learning components of classroom academic performance. Journal of Education & Psychology. 1990;**82**(1):33-40. DOI: 10.1037/0022-0663.82.1.33

[60] Tali LA, Dar IA. Metacognitive strategy usage of primary school teacher trainees in relation to their gender. International Journal of English Language, Literature and Humanities. 2014;**1**(V)

[61] van den Akker J, Bannan B, Kelly AE, Nieveen N, Plomp T. Educational Design Research Educational Design Research2013. pp. 11-50

[62] Bryce D, Whitebread D, Szűcs D. The relationships among executive functions, metacognitive skills and educational achievement in 5 and 7 year-old children. Metacognition Learning. 2015;**10**(2):181-198. DOI: 10.1007/s11409-014-9120-4

[63] Blakey E. ED developing metacognition. ERIC Dig. 1990:1-5. Available from: http://www.nagc.org/index.aspx?id=205

[64] Vickery A, Ansell K, Collier C, Digby R, Foster T, Garside D. Developing Primary Classroom. London: SAGE Publications Inc; 2014

[65] Saemah R, Philips JA. Hubungan antara Kesedaran Metakognisi, Motivasi dan Pencapaian Akademik Pelajar Universiti. Pendidikan. 2006;**31**:21-39

[66] Driver JMSP, Asoko R, Leach H. The nature of scientific knowledge. Educational Researcher. 1994;**23**(7):3. DOI: 10.2307/4449655

[67] Darling-hammond DL, Austin K, Cheung M, Martin D. Thinking about thinking: Metacognition. The Learning Classroom. 2014:157-172

[68] Sandi-Urena S, Cooper MM, Stevens RH. Enhancement of metacognition use and awareness by means of a collaborative intervention. International Journal of Science Education. 2011;**33**(3):323-340. DOI: 10.1080/09500690903452922

Chapter 5

Perspective Chapter: Optimizing Metacognitive Knowledge for Holistic Learner Performance

Rosamma Philip and Jogymol K. Alex

Abstract

This research study aims to assess how metacognitive knowledge effectively contributes to various facets of personality development. The study involved 178 students who gained an understanding of metacognitive knowledge through their coursework. Data collection was conducted using the Metacognitive Knowledge Utilization Scale among the participants. The analysis indicated that the participants frequently apply these metacognitive variables to enhance their personal growth, task performance, and strategy implementation. This study highlights the significance of using metacognitive knowledge for comprehensive learner development and emphasizes the vital role of teachers in imparting metacognitive skills, thereby guiding learners towards personal growth. The findings underscore the potential of metacognitive knowledge in molding individuals into well-rounded personalities, with significant implications for educational practices.

Keywords: metacognitive knowledge, holistic development, person variable, task variable, strategy variable

1. Introduction

In the ever-evolving landscape of education, the quest for holistic learner development goes beyond the traditional boundaries of imparting academic knowledge. It now encompasses a profound understanding of a student's identity, emotions, and psychological well-being, as articulated by Seligman [1]. Simultaneously, it seeks to equip learners with the skills necessary to foster positive and effective interpersonal relationships. Education, in its truest essence, becomes a vehicle not only for academic excellence but also for nurturing lifelong learners, capable of thriving in an ever-changing world. In this pursuit, metacognition emerges as a pivotal concept, allowing students to delve into the intricacies of how they learn, problem-solve, and make decisions. By integrating metacognitive strategies into educational practices, educators empower students to take ownership of their learning journeys [2–4]. This not only enhances their academic performance but also equips them with the adaptability and critical thinking skills required in the contemporary world.

The theoretical underpinnings and empirical insights surrounding metacognitive knowledge offer valuable guidance to educators, seeking to nurture comprehensive learner development [5, 6]. As De Coninck et al. [7] have underscored, holistic learner development spans cognitive, emotional, social, and ethical dimensions [8]. It transcends the mere acquisition of knowledge and skills, aiming to cultivate well-rounded individuals who possess empathy, ethical decision-making abilities, adaptability, and critical thinking skills. At its core, metacognition serves as the cognitive process that enables learners not only to comprehend what they are learning but also how and why they are learning [9].

Indeed, metacognition empowers individuals to monitor, regulate, and control their learning experiences [10]. However, the fruits of these learning experiences extend beyond the cognitive realm, touching upon emotional maturity, the formation of cordial social relationships, moral development, and an enriched esthetic outlook [11]. Learner development is the result of a self-reflective and self-regulatory mechanism, whereas learner engagement spans emotional, cognitive, and behavioral aspects [12]. As learners engage in metacognitive practices, they transform into active participants in their educational journeys. They gain the ability to assess their own understanding, identify their strengths and weaknesses, and adapt their strategies when faced with challenges [13].

This heightened self-awareness not only elevates academic performance but also equips learners with skills essential for personal and interpersonal success. As learners reflect upon their learning strategies and outcomes, they cultivate a profound sense of responsibility for their intellectual growth [14]. They are more likely to recognize the significance of values such as integrity, persistence, and ethical decision-making, both within and beyond the confines of educational contexts. Consequently, it becomes evident that metacognitive knowledge serves as the cornerstone of holistic learner development [15, 16]. To promote students' metacognitive development, teachers should also provide them with opportunities fostering metacognitive experiences, which in turn, will provide input to permanent metacognitive knowledge [13, 17].

Metacognitive knowledge serves as a cornerstone in promoting the cognitive dimension of holistic development. It fosters critical thinking and problem-solving skills. Learners who engage in metacognitive processes are more inclined to approach complex tasks strategically, breaking them down into manageable steps and assessing their progress, a perspective supported by Fogarty [18]. The teacher's awareness and application of metacognitive strategies in executing a task helps the learners to internalize metacognitive knowledge. It relies on the assumption that the teacher knows what strategies are appropriate to be implemented in the classroom and the benefits for their students [19]. Hence, the prospective teachers are to be trained in metacognitive skills [20].

As students become attuned to their learning styles and preferences through metacognition, they develop a profound sense of agency and ownership over their learning journey. This empowerment nurtures their emotional well-being and elevates their self-esteem as they realize their capacity to navigate the challenges inherent in the learning process. Metacognition extends its influence to enhance social interactions by promoting effective communication, empathy, and collaborative problem-solving. Learners who possess insight into their own cognitive processes are better equipped to recognize the diversity of approaches that others may employ, thus, fostering a culture of inclusivity and cooperation [8]. Moreover, metacognition equips students with the ability to be reflective and conscious of their emotions. This self-awareness allows them to exercise self-management, restraining themselves from impulsive actions. Such a knowledge is known as thinking about thinking which helps a person understand and control his or her own cognitive performance [2].

By examining the interconnected dimensions of holistic development and their interplay with metacognitive knowledge, educators can empower learners to evolve into well-rounded individuals capable of navigating the complexities of the modern world, with cognitive, emotional, and social dimensions in harmony. With this understanding as a backdrop, this research paper focuses on determining the extent to which metacognitive knowledge is utilized for holistic performance among learners. The study identifies the use of person variables, task variables, and strategy variables among undergraduate students pursuing Education as a discipline. The findings of the study may assist educators in planning metacognitive training for learners to enhance their personal and social skills in addition to their cognitive skills. These findings may also help explore the optimization of metacognitive learning, the multifaceted dimensions of metacognition, and its role in shaping the future of education, paving the way for more profound and well-rounded learner development.

2. Literature review

Metacognitive learning enhances learners' cognitive development by allowing them to comprehend not only what they are learning but also how they are learning and why. This analytical thinking contributes to their ability to tackle complex issues and scenarios with confidence, ultimately leading to intellectual growth and a capacity to handle a diverse range of cognitive tasks. Metacognition studies are linked with cognitive developmental psychology and social developmental psychology. Hence, the cognitive aspect of metacognition sets the stage for a comprehensive exploration of its impact on other dimensions of holistic development, namely, the emotional and social domains.

2.1 Categorization of knowledge

Metacognition holds the potential to empower individuals to become well-rounded learners capable of excelling in today's multifaceted world. In the realm of education and cognitive development, metacognitive knowledge is a fundamental concept, which is categorized within the revised Bloom's Taxonomy. This categorization, as proposed by Anderson and Krathwohl classifies knowledge into four distinct types, each playing a pivotal role in shaping a learner's cognitive and intellectual landscape [21].

(a) Factual knowledge: this foundational level of knowledge encompasses the basic elements and facts that learners must acquire to become familiar with a particular discipline. It serves as the fundamental building block upon which further learning and understanding are constructed. Factual knowledge provides the essential groundwork that enables students to grasp the core principles and concepts within a subject.
(b) Conceptual knowledge: conceptual knowledge moves beyond the acquisition of isolated facts and delves into the interrelationships among these basic elements. It facilitates the comprehension of how these elements fit into a larger, cohesive

structure, enabling them to function together harmoniously. This type of knowledge is essential for developing a deeper understanding of complex topics and is instrumental in promoting critical thinking and problem-solving skills. (c) Procedural knowledge: procedural knowledge deals with the practical 'how-to' aspects of learning. It involves understanding the methods, techniques, algorithms, and criteria for applying skills and knowledge. This knowledge equips learners with the tools and strategies necessary to actively engage with and manipulate the information they acquire. It is instrumental in problem-solving, experimentation, and the application of subject-specific techniques and (d) metacognitive knowledge: at the highest level of Bloom's Taxonomy, we find metacognitive knowledge that goes beyond the subject matter itself and focuses on the process of cognition. Metacognitive knowledge involves an awareness and understanding of one's own cognitive processes. Learners possessing metacognitive knowledge are not only cognizant of what they are learning but also how they are learning and why. This type of knowledge empowers individuals to monitor, regulate, and control their own learning experiences, promoting self-directed learning and fostering critical thinking, reflection, and self-improvement [21].

In this hierarchy of knowledge, metacognitive knowledge stands as a pinnacle, as it equips individuals with the tools to understand and optimize their own thinking and learning processes. By cultivating metacognitive knowledge, learners become active participants in their educational journeys, gaining the ability to navigate not only the specific subject matter but also the broader landscape of learning and personal development [16, 22].

Metacognition as a thought is about thinking itself which is the interaction between three important aspects as follows: (1) knowledge of the self-thinking process, (2) control or self-regulation, and (3) beliefs and intuition. Knowledge of thinking processes concerns how accurate a person is in expressing their thinking processes, self-awareness or self-regulation, and the accuracy of a person in maintaining and managing what they must do. The self-awareness fostered by metacognition enables individuals to set personal goals, identify areas for improvement, and take charge of their own development. In this context, metacognition becomes a tool for lifelong learning and personal growth, allowing individuals to adapt and flourish in a dynamic world [10, 23].

The metacognitive process includes the ability to ask and answer questions about (1) What do I know about this subject, topic, and subject matter? (2) Do I know what I should know? (3) Do I know where I can get some knowledge information? (4) How long will it take me to learn this? (5) What strategies and tactics can I use to learn this? (6) Do I understand what I hear, read, or see? (7) How do I know if I am studying at the appropriate level? (8) How can I see if I make a mistake? and (9) How should I revise my plan if it does not fit my expectations and satisfaction? [9, 18].

2.2 Categories of metacognitive knowledge

Metacognitive knowledge encompasses three areas of information, namely, an individual, a learning task, and a process of learning. These attributes were then known as person knowledge, task knowledge, and strategic knowledge [22]. The concept of metacognition is a multifaceted construct, encompassing three fundamental components that collectively shape the landscape of metacognitive knowledge. These components provide individuals with the cognitive tools to navigate the complexities of learning and problem-solving in a purposeful and introspective manner.

2.2.1 Self-knowledge: person variable

The first key component, self-knowledge, revolves around an individual's internal understanding and awareness of themselves. Self-knowledge involves recognizing personal strengths, weaknesses, preferences, and learning styles. This self-awareness serves as the foundation upon which effective learning strategies are built. By comprehending their own cognitive processes, emotional triggers, and inclinations, individuals gain the ability to tailor their approach to learning, ultimately leading to enhanced learning outcomes [5, 24].

2.2.2 Task knowledge: task variable

The second essential component, task knowledge, pertains to the understanding of various cognitive tasks that individuals encounter. As Flavell suggests, this encompasses a broad range of activities, from recalling information and reading to writing and engaging in experiments. Task knowledge involves grasping the intricacies, demands, and expectations associated with different cognitive undertakings. With this awareness, individuals can effectively gauge the required skills, resources, and approaches for each task, thereby optimizing their learning [5].

2.2.3 Strategic knowledge: strategy variable

The third cornerstone, strategic knowledge, encompasses the repertoire of effective strategies employed in task execution. This facet involves knowing when and how to apply specific strategies to achieve desired outcomes. Strategic knowledge empowers individuals to select the most suitable methods, techniques, and approaches for different tasks. By leveraging this knowledge, individuals can streamline their learning process, enhance efficiency, and tackle challenges with greater confidence [5, 23, 24].

Metacognition is not confined to the realm of academia; it also permeates professional achievements. In the workplace, individuals who possess metacognitive skills are better equipped to approach complex tasks and challenges with confidence. The ability to break down problems into manageable steps and critically evaluate progress becomes a valuable asset in problem-solving and decision-making [10, 22, 25]. Metacognition encourages a culture of adaptability, innovation, and continuous learning that are highly sought-after qualities in the professional world. In this way, metacognition contributes to career success and fosters a lifelong commitment to professional development [25].

Metacognition's influence extends to the dynamic landscape of social interactions. By promoting effective communication, empathy, and collaborative problem-solving, individuals with metacognitive knowledge are better prepared to engage with others in a meaningful and constructive way. They understand not only their own cognitive processes but also the diversity of approaches that different individuals may employ. This fosters a culture of inclusivity, cooperation, and effective teamwork that are essential in various social contexts, from friendships and family relationships to professional collaborations and community engagement. Metacognition becomes a bridge to building meaningful and harmonious social connections.

Thus, metacognition paints its influence across all facets of human development. It is a multifaceted tool that enriches cognitive development, fosters personal growth, enhances professional achievements, and contributes to the success and harmony of social interactions. Its far-reaching impact underscores the importance of metacognitive knowledge in the holistic development of learners. The utilization of metacognitive knowledge helps prospective teachers to perform well in their personal and professional lives [25].

2.3 Nurturing self-knowledge for holistic development

This introspective exploration, often referred to as self-knowledge, not only illuminates the path to better understanding oneself but also holds the key to unlocking one's full potential across diverse facets of life. Self-knowledge extends beyond surface-level awareness, delving into the intricacies that shape an individual's thoughts, motivations, and behaviors. It involves recognizing both the strengths that propel progress and the vulnerabilities that present opportunities for growth [26]. This profound understanding provides the foundation upon which individuals can build effective strategies for learning, decision-making, and interpersonal interactions. It is a journey of self-discovery that offers the compass needed to navigate the complexities of today's dynamic world. By nurturing self-knowledge, individuals not only enhance their own lives but also contribute to the collective tapestry of personal and societal advancement [27, 28].

Teachers play a crucial role in enhancing students' self-awareness, self-discovery, and overall personal development. They serve as guides, mentors, and facilitators in creating an environment that fosters introspection, self-improvement, and the development of various skills. Here is how teachers can contribute to enhancing students' self-awareness and related aspects.

Engaging in self-analysis paves the way for personal growth and development. By introspectively examining different dimensions of one's personality, individuals can gain valuable insights that contribute to ongoing self-improvement. Understanding how one perceives oneself across various aspects of their character serves as a crucial foundation for continuous self-monitoring [18]. This process enables individuals to track their progress, identify areas for enhancement, and cultivate a deeper awareness of their strengths and areas that require attention.

2.4 Fostering task variables for learner efficacy

Based on Bandura's theory of self-efficacy, students' self-efficacy involves an individual's judgments regarding one's own ability to master a task [15]. Tasks are the learner engagements in performing an activity. Learning efficacy refers to the degree of an individual's confidence in the actual application of skills and knowledge taught to them in either classroom or training sessions.

Efficacious students display a propensity for embracing intricate and demanding tasks. This proclivity is accompanied by adept time management and unwavering commitment to effectively decipher intricate conceptual challenges. Tasks fundamentally catalyze a heightened level of learner engagement, propelling a cognitive regulation process for the efficacious execution of assigned undertakings. Proficiency in this context encompasses task awareness, discerning the pertinence of varying tasks, methodically delving into task exploration, and ultimately showcasing productive mastery across a spectrum of learning scenarios. Such a multifaceted approach not only enhances the learning process but also underpins diverse forms of exemplary performance [8, 11, 23].

2.5 Practicing strategic knowledge for goal achievement

In the context of learning, strategic knowledge indicates the knowledge of the general strategies for learning, thinking, and problem-solving. Many strategies are required to plan, monitor, and regulate cognition which is the base of various performances. Strategies are the paths towards the goals and successful strategies are essential to ensure the achievement of goals [10, 25, 29].

Strategic knowledge plays a crucial role in problem-solving across various contexts, empowering individuals to tackle challenges with effectiveness and efficiency. In problem-solving, strategic knowledge refers to a deep understanding of different approaches, methodologies, and tools that can be employed to analyze and address complex issues. In everyday life, strategic knowledge enhances decision-making [30]. Individuals facing personal dilemmas or practical issues can tap into their strategic knowledge to explore different options, anticipate potential outcomes, and select the most suitable course of action. Furthermore, strategic knowledge fosters critical thinking. It encourages individuals to approach problems with a well-rounded perspective, considering multiple dimensions and possibilities. This holistic approach often leads to more comprehensive and effective solutions [13, 24].

Strategies encompass a range of approaches, techniques, and plans that individuals deploy to achieve their goals efficiently and effectively. At the core of this process lies strategic knowledge, which entails understanding on how to analyze situations, devise plans, allocate resources, and adapt approaches to overcome challenges and reach desired outcomes [30]. Teachers play a pivotal role in motivating learners to acquire and apply strategic knowledge effectively [28]. Their guidance and support can inspire students to develop a deep understanding of strategic approaches and their practical applications. Here is how teachers can contribute to fostering motivation and enthusiasm for strategic knowledge.

3. Research methodology

3.1 Research design

The primary aim of this study is to investigate the utilization of metacognitive knowledge in enhancing learner holistic performance. To achieve this objective, a quantitative research design was chosen, with a particular emphasis on the collection and analysis of numerical data.

The researchers employed the survey method as the primary data collection technique. The study's target population comprised teacher aspirants attending UG courses in Education. These students were selected as respondents based on their relevance to the research focus. As part of their academic curriculum, these individuals have been exposed to theoretical constructs related to metacognition. The selection of this particular group allowed for an examination of whether they effectively apply metacognitive knowledge to enhance their overall performance as learners. The present study included a sample of 178 students. This sample was chosen based on the criteria of having a foundational understanding of metacognitive knowledge through their academic coursework.

3.2 Instrument

To assess the respondents' utilization of metacognitive knowledge for holistic performance, the survey instrument was carefully designed. The survey included questions that explored their awareness of metacognitive strategies, how they apply these strategies in their learning processes, and the impact of metacognition on their overall performance.

The scale comprises a series of items that require participants to self-assess their awareness and use of metacognitive knowledge related to person variable, task variable, and strategy variable. It includes statements related to the application of metacognitive knowledge in real-life scenarios, both within and outside the classroom. The scale is designed to measure the depth of participants' metacognitive understanding and its practical utilization. It has three sections: Section 1 for assessing person variable, Section 2 for assessing task variable, and Section 3 for assessing strategy variable. The responses were patterned on a Likert Scale, ranging from 1 to 5 indicating Never, Rarely, Sometimes, Often, and Always. High scores indicate higher use of metacognitive knowledge, whereas low scores indicate minimum use of metacognitive knowledge. The instrument underwent professional critiquing for validity and reliability. The Cronbach alpha coefficient was found to be 0.95, and test-retest reliability results were found to be 0.91.

3.3 Data analysis and results

The obtained data were analyzed to find out the mean scores. These are presented in **Tables 1**–**3**.

Table 1 shows the use of person variable of metacognitive knowledge for holistic performance. The statement 'I can utilize my strengths in various aspects of my life' scored highest with a mean of 4.64. The statement 'My personal experience influences my interactions' scored the lowest with a mean of 2.98. The mean total score is 3.91, which indicates that the respondents often utilizes the person variable of metacognitive knowledge.

Sl no	Statement	Mean	Interpretation
1	My self concept guides me to make apt decisions	3.85	Often
2	I can utilize my strengths in various aspects of my life	4.64	Always
3	I always consider how others perceive me in social context	3.13	Sometimes
4	I can adjust my behavior in social settings	4.6	Always
5	I try to align my beliefs and values with social norms	3.69	Often
6	My personal experience influences my interactions	2.98	Sometimes
7	I work on improving my weakness to achieve personal growth	4.63	Always
8	My past experience always helps me for better actions.	4.32	Often
9	My self-esteem inspires me to maintain healthy life	3.81	Often
10	My reflection on my self help me for emotionally stable	3.58	Often
	Mean of Total Score	3.91	Often

Table 1.
Utilization of metacognitive knowledge- person variable for holistic performance.

Sl no	Statement	Mean	Interpretation
1	I have a clear and organized system for managing tasks and responsibilities.	3.52	Often
2	I allocate specific time slots for important tasks to ensure they get done	3.37	Sometimes
3	I keep a tidy and organized workspace that promotes productivity.	3.42	Sometimes
4	I use digital and physical tools to manage and track my tasks efficiently.	3.9	Often
5	I regularly create to-do lists or task schedules to stay on top of my work	3.82	Often
6	I am skilled at prioritizing tasks based on their importance and urgency.	4.28	Often
7	I set aside dedicated time for my most critical tasks.	4.56	Always
8	I set clear, measurable, and achievable goals for myself	3.98	Often
9	I am open to change and adaptable when faced with unexpected obstacles.	3.75	Often
10	I regularly achieve the goals I set, and this gives me a sense of accomplishment	2.89	Sometimes
11	I regularly review and adjust my time management strategies for better results.	2.73	Sometimes
12	I use time wisely by multitasking effectively when necessary	3.94	Often
13	I approach challenges with a problem-solving mindset, seeking creative solutions.	3.83	Often
14	I minimize distractions and interruptions during focused work periods	3.35	Sometimes
	Mean of Total Score	3.67	Often

Table 2.
Utilization of metacognitive knowledge-task variable for holistic performance.

Table 2 shows the use of task variables among the respondents. The statement 'I set aside dedicated time for my most critical task' scored highest with a mean of 4.56. The statement 'I regularly review and adjust my time management strategies for better results' got the lowest score with a mean of 2.73. The mean total score is 3.67, which shows that the respondents often make use of the task variable of metacognitive knowledge.

Table 3 shows that the statement 'I consider different approaches before deciding on the best one for a given task' scored the highest with a mean of 4.66. The statement 'I evaluate the effectiveness of the strategies I use and adjust as needed' got the lowest score 2.56. The mean total score is 3.67, which indicates that the respondents often use the strategy variables of metacognitive knowledge.

The tables also reveal that person variables are the most utilized component of metacognitive knowledge having a mean of 3.91. The task variables and strategy variables are equally used with a mean of 3.67. Thus, all these three variables are often used by students for enhancing their holistic performance.

Sl no	Statement	Mean	Interpretation
1	I evaluate the effectiveness of the strategies I use and adjust as needed.	2.56	Sometimes
2	I seek guidance from others when deciding on the best strategy for a specific task.	3.86	Often
3	I have a clear plan for how to approach my long-term goals and objectives.	3.97	Often
4	I use a variety of strategies when faced with complex challenges to find the most efficient solution.	3.64	Often
5	I can effectively choose the right strategies to achieve my goals in different areas of life.	3.23	Sometimes
6	I adapt my strategies based on the nature and requirements of the task at hand.	4.12	Often
7	I reflect on my past experiences to determine which strategies have been most successful for me.	3.67	Often
8	I am confident in my ability to choose the most appropriate problem-solving methods.	3.32	Sometimes
9	I consider different approaches before deciding on the best one for a given task.	4.66	Always
10	I find it easy to match the right strategy to the right situation	4.18	Often
11	I ensure that I make efficient use of my resources and time	3.21	Sometimes
	Mean of the Total Score	3.67	Often

Table 3.
Utilization of metacognitive knowledge-strategy variable for holistic performance.

4. Discussion

The sample for the present study was undergraduate Education students, who have adequate awareness about metacognitive knowledge through their course. The findings show that these respondents always utilize their strengths, adjust well to social situations, set aside time for doing important tasks, and choose the best strategies for performance. The respondents often utilize person-related awareness, task-related knowledge, and strategy knowledge for performing well in various fields. This aligns with the findings of other research [25–27].

The study demonstrates that these respondents consistently utilize their strengths and adapt effectively to social situations. This finding is in line with the model of self-regulated learning, where self-awareness of one's strengths and weaknesses is considered a vital component of metacognition. The ability to adapt to social situations may also be attributed to metacognitive skills, which facilitate the regulation of social interactions [20]. Respondents consistently choose the best strategies for performance. This aligns with research on metacognitive regulation that emphasizes the importance of strategy knowledge in enhancing performance [17, 31]. The respondents' ability to select and apply appropriate strategies suggests a high level of metacognitive competency. These findings have significant implications for educators. It suggests that metacognitive knowledge should be emphasized in the curriculum, as it equips students with valuable skills for self-regulated learning and personal development [32, 33]. Educational institutions should consider incorporating metacognitive training programs to enhance students' awareness and the use of metacognitive knowledge.

5. Conclusion

The present study highlights the importance of the three-component framework of metacognition, consisting of self-knowledge, task knowledge, and strategic knowledge. This underscores the importance of self-awareness, task understanding, and strategy application in the pursuit of effective learning and problem-solving [24]. This holistic approach enhances learners' ability to adapt, optimize, and excel in various cognitive endeavors, contributing to their overall growth and success.

To guide learners effectively in achieving their educational and personal growth goals, precise regulation of these components becomes paramount. Personal variables, task variables, and strategy variables intertwine harmoniously within this framework [31]. This comprehensive structure equips individuals with the necessary tools to embark on purposeful and introspective learning journeys. By harnessing self-knowledge, learners gain the ability to tailor their learning strategies in alignment with their distinct attributes [13]. Simultaneously, task knowledge provides a clear comprehension of the cognitive landscape, whereas strategic knowledge empowers learners to navigate this terrain with skillful precision. Teachers need to guide learners towards mastering the art of task selection, integration, and execution to pave the way for a more successful and fulfilling journey towards learners' goals. Metacognition assists students in developing problem-solving and critical thinking skills. Incorporating metacognitive knowledge into teaching practices can have a profound impact on student learning and holistic development. It helps students become more independent, self-regulated learners who are better prepared for the demands of the modern world. Teachers play a crucial role in facilitating this process and supporting students' metacognitive growth.

Author details

Rosamma Philip[1]* and Jogymol K. Alex[2]

1 Mount Tabor Training College, University of Kerala, India

2 Faculty of Education, Walter Sisulu University, South Africa

*Address all correspondence to: roseappachi@gmail.com

IntechOpen

© 2024 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

References

[1] Seligman MEP. Flourish: A Visionary New Understanding of Happiness and Well-Being. Newyork: Free Press; 2011

[2] Ozçakmak H, Kgroglu M, Korkmaz C, Bolat Y. The effect of metacognitive awareness on academic success. African Educational Research Journal. 2021;**9**(2):434-448

[3] Cihanoglu MO. Metacognitive awareness of teacher candidates. Procedia - Social and Behavioral Sciences. 2012;**46**:4529-4535

[4] Pantiwati Y, Husamah. Self and peer assessments in active learning model to increase metacognitive awareness and cognitive abilities. International Journal of Instruction. 2017;**10**(104):185-202

[5] Flavell JH. In: Nelson TO, editor. Metacognition and Cognitive Monitoring, a New Area of Cognitive Developmental Inquiry. Boston: Allyn and Bacon; 1979. p. 1978

[6] Jayapraba G. Metacognitive instruction and cooperative learning - strategies for promoting insightful learning in science. International Journal on New Trends in Education and their Implications. 2013;**4**(1):165-172

[7] De Coninck D, Matthijs K, Luyten P. Subjective well-being among first-year university students: A two-wave prospective study in Flanders, Belgium. Student Success. 2019;**10**(1):33-45

[8] De Bruin AB, van Gog T. Improving self-monitoring and self-regulation: From cognitive psychology to the classroom. Learning and Instruction. 2012;**22**(2):45-252

[9] Zhang D, Goh CC. Strategy knowledge and perceived strategy use: Singaporean students' awareness of listening and speaking strategies. Language Awareness. 2006;**15**(3): 199-119

[10] Shehzad MW, Bin Hamzah MH, Rawian RM. The relationship between metacognitive strategies and self-efficacy beliefs: A review of the literature. Pakistan Journal of Humanities and Social Sciences. 2018;**6**(2):169-187

[11] Koc I, Kuvac M. Pre-service science teachers' metacognitive awareness. European Journal of Educational Studies. 2016;**2**:43-63

[12] Kompal W. Metacognition and motivation: In context with the academic success of students. International Journal of Multidisciplinary Research and Development. 2015;**2**(12):66-68

[13] Abdellah R. Metacognitive awareness and its relation to academic achievement and teaching performance of pre-service female teachers in Ajman University in UAE. Procedia - Social and Behavioral Sciences. 2015;**174**:560-567

[14] Aglina EF, Rohmatillah R, Syamsiah N. The correlation between students' metacognitive awareness and their anxiety in writing performance. English Education: Jurnal Tadris Bahasa Inggris. 2020;**13**(1):63-74

[15] Bandura A. Self-efficacy. The Corsini Encyclopedia of Psychology. John Wiley & Sons, Inc. 2010:1-3. DOI: 10.1002/9780470479216.corpsy0836/

[16] Veenman MV, Van Hout-Wolters BH, Afflerbach P. Metacognition and

learning: Conceptual and methodological considerations. Metacognition and Learning. 2006;**1**(1):3-14

[17] Carr M. The importance of metacognition for conceptual change and strategy use in mathematics. In: Waters HS, Schneider W, editors. Metacognition, Strategy Use, & Instruction. London: The Guilford Press; 2010. pp. 176-197

[18] Fogarty R. How to Teach for Metacognition. Palatine, IL: IRI/Skylight Publishing; 1994

[19] Hilpert JC, Stempien J, van der Hoeven Kraft KJ, Husman J. Evidence for the latent factor structure of the MSLQ: A new conceptualization of an established questionnaire. SAGE Open. 2013;**3**(4):1-10. DOI: 2158244013510305

[20] Labuhn AS, Zimmerman BJ, Hasselhorn M. Enhancing Students' self-regulation and mathematics performance: The influence of feedback and self-evaluative standards. Metacognition and Learning. 2010;**5**:173-194. DOI: 10.1007/s11409-010-9056-2

[21] Anderson LW, Krathwohl DR. A Taxonomy of Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives. New York: Longman; 2001

[22] Shea P, Bidjerano T. Learning presence: Towards a theory of self-efficacy, self-regulation, and the development of a community of inquiry in online and blended learning environments. Computers in Education. 2010;**55**(4):1721-1731

[23] Kim Y, Stormont M. Early childhood teachers' ratings of metacognitive knowledge and behavioral support strategy use in classrooms. Early Childhood Education Journal. 2020;**48**(2):1-8

[24] Menz P, Xin C. Making Students' metacognitive knowledge visible through reflective writing in a mathematics-for-teachers course. Teaching and Learning the College Essay. 2016;**9**:155-166

[25] Schoenfeld EAH. Learning to think mathematically: Problem solving, metacognition, and sense-making in mathematics learning to think mathematically. Reprint;**196**(2):1-38

[26] Yildiz H, Akdag M. The effect of metacognitive strategies on prospective Teachers' metacognitive awareness and self efficacy belief. Journal of Education and Training Studies. 2017;**5**(12):30-40

[27] Bulut I. The levels of classroom and pre-school teachers' metacognitive awareness. International Journal of Educational Research. 2018:2697-2706

[28] Çakıcı D. Metacognitive awareness and critical thinking abilities of pre-service EFL teachers. Journal of Education and Learning. 2018;**7**:116-129

[29] Li J, Ye H, Tang Y, Zhou Z, Hu X. What are the effects of self-regulation phases and strategies for Chinese students? A meta-analysis of two decades research of the association between self-regulation and academic performance. Frontiers in Psychology. 2018;**9**(Dec):1-13. DOI: 10.3389/fpsyg.2018.02434

[30] Boekaerts M. Emotions, emotion regulation, and self-regulation of learning. In: Zimmerman BJ, Schunk DH, editors. Handbook of Self-Regulation of Learning and Performance. New York, NY: Routledge; 2011. pp. 408-425

[31] Schunk DH. Metacognition, self-regulation, and self-regulated learning: Research recommendations. Educational Psychology Review. 2008;**20**(4):463-467

[32] Pathuddin, Budayasa IK, Lukito A. Metacognitive knowledge of a student in planning the solution of limit problems. In: Mathematics, Informatics, Science and Education International Conference (MISEIC) 2018; 2018 Jul 21; Surabaya, Indonesia. Vol. 1108. Journal of Physics: Conference Series; 2018. p. 012032

[33] Weber J, Warmelink H, Martinisi A, Buijtenweg T, Mayer IS. Learning efficacy among executives and students of an organizational growth game. In: Hamalainen J, Stalenhoef JM, editors. Proceedings of the 49th International Simulation and Gaming Association Conference: Game is the Name and Challenges of Simulation; 2018 Jul 9-13; Salaya, Thailand. pp. 1-8

Chapter 6

Perspective Chapter: Is Metacognition 'Just' Imagination? Exploring the Relationship with Implications for Agency and Pedagogy

Helen Burns

Abstract

This chapter presents research, findings and discussion which emerged from a theoretical exploration of imagination as cognition and metacognition. The researcher took a pragmatic stance in addressing a problem encountered in education practice: that an articulated understanding of 'imagination' is largely absent and its likely relationship with metacognition is little articulated, despite these being essential components of learning. Within an interdisciplinary approach, exploring theories across disciplines provided ideas to use in *re-imagining* imagination. This chapter describes and uses the model of imagination and metacognition which emerged through this process. The model suggests that imagination and metacognition are so inter-related that there is potential to consider them as one and the same, asking 'is metacognition 'just' imagination?'. This question is discussed with the conclusion that it is better to acknowledge the complexity of this relationship than to reduce it to an 'either/or' claim. Discussion also includes consideration of a further, intrinsic relationship with personal and social agency, which led to an application of the model to inform and produce evaluative tools for a small research project: Imagination Agents. In conclusion, the chapter recommends that due to the close relationship between imagination, metacognition and agency, we should consider how to better support it within education systems where it is currently neglected.

Keywords: imagination, metacognition, agency, pedagogy, art education

1. Introduction

This chapter is grounded in theoretical research [1, 2] which attempts to set aside 'magical' perceptions of imagination in education and understand it instead, as a fundamental aspect of cognitive and metacognitive capacity. In turn, it offers a perspective of metacognition from the view-point of imagination. A theoretical exploration of the relationship between imagination, cognition and metacognition is cohered and conceptualised within 'emergent models' of imagination, (drawn largely from [1]). Through this exploration, a question arises of whether a combined focus on imagination and metacognition could be potent in developing personal and social agency. If so, we may hypothesise that educational support for the inherent relationships between imagination, metacognition and individual agency creates capacity for democratic agency. The emergence [3–5] of the models demonstrates a fundamental relationship between cognition, metacognition and imagination, with these latter two capacities overlapping to the degree that we arrive at the question of whether metacognition is actually, just imagination. The chapter concludes with discussion of a recent application of these ideas within a research project with young people *Imagination Agents,* before making recommendations for research and practice.

Few would disagree that imagination is essential for originality and for enabling us to see beyond our current state. It is therefore crucial in addressing a 'posthuman convergence' ([6], p. 3) of structural injustice, environmental crisis and a shift in what it means to be human in light of rapid scientific and technological change. Complex personal, local and global challenges require us to re-imagine ourselves and to use imagination to develop autonomy, empathy and the capacity to solve problems. This suggests the importance of nurturing imagination, however; some argue that this is not recognised by or reflected in current education. At the more critical end of the scale, Giroux [7] states that schools have become 'disimagination machines' which leave us ill-equipped for necessary innovation in a challenging world. Biesta ([8], p. 55) describes how education is steered in the direction of 'the production of a small set of measurable learning outcomes' and neglects students' voice, creativity and unique identities.

Imagination is often regarded as a magical phenomenon, rather than as a cognitive or metacognitive capacity which can be educated. This is recognised from a psychological perspective by Ryle, who notes '...a quite general tendency among theorists and laymen alike to ascribe some sort of other-worldy reality to the imaginary.' ([9], p. 232). Within neoliberal contexts, imagination is frequently seen as an escape from reality, often colonised and epitomised by global, corporate bodies such as Disney, Dreamworks and so on. Over the course of my professional and academic career in education, numerous teachers have told me 'It's all about imagination'. They have expressed concern that many children do not have access to the experiences which nurture it and struggle to apply it when it is required, for instance, in literacy or problem-solving activities.

Like many others, I have a love of and belief in imagination which can seem to imply it has an almost magical power. I have no desire to extinguish ideas of magical imagination (after-all, that would be unimaginative!); however, a lack of definition could restrict the capacity to nurture imagination in our contemporary, educational environment, where accountability can dominate (e.g., [10]). As my research into imagination progressed, I became interested in the proximity and overlaps within its relationship to metacognition and in how, by association with metacognition, (perhaps a more frequently defined and implemented concept in education), it is possible to advocate for practices which nurture imagination and cognition/metacognition. Meta-evidence suggests that children can increase their chances of educational success if they are supported to develop metacognition [11]. A strong relationship between imagination and metacognition implies that developing imagination is likely to be beneficial for metacognition and therefore for learning more generally. If this relationship is strong and is understood, we might better develop metacognition by better developing imagination, thereby improving individual learning, in particular, the capacity for self-regulation. Conversely, we might support imagination by educating for metacognition, since this would automatically require us to exercise our imagination. Either way, by developing metacognitive understanding and strategies for self-regulation, these approaches could generate confidence and lead to increased autonomy (Bonnett in [12], p. 156). In turn, this could lead to increased potential for democratic capacity, as described by Dewey [13] and Greene [14].

Imagination as a concept 'has been relatively neglected in our current age' [15]. Little research has been carried out into the condition of imagination in education, perhaps because little has been done to find a way to conceptualise and assess it. The same cannot be said of metacognition, which continues to be well-researched and supported pedagogically through an array of programmes, strategies and curricula. It has been suggested [16] that metacognition may be considered to be a form of imagination, described in terms of Mead's 'generalised other' in which the individual internalises a 'general systematic pattern of social or group behaviour' and applies these 'towards himself, just as he takes the individual attitudes of others.' ([17], p. 158). Such an act is imaginative in requiring a leap of thought in order to consider how the 'generalised other' might respond in a given situation. For Kant, imagination is a means of connecting and synthesising sense perceptions with existing knowledge, making imagination the 'hidden condition of all knowledge' ([18], p. 167). One might also argue, based on Kant, that imagination is a kind of cognitive transcendence and is akin to metacognition. How far do these theories account for the characteristics of metacognition and how else might imagination influence the metacognitive process? By modelling this relationship we might better understand both imagination and metacognition and improve support for learners across both (or perhaps the same) kinds of thought.

To consider *meta*cognition (e.g.; [19–23]) in relation to imagination, it makes sense to explore it as specialised, self-awareness applied to personal thinking and learning and to acknowledge imagination as a critical factor in species-wide human development which enabled the emergence of consciousness of our own existence (e.g.; [24–26]). Literature which is concerned with the relationship between imagination and metacognition, (except through a focus on creativity, e.g., Runco [27], Kaufman and Beghetto [28]). Authors have discussed that there are multiple definitions of metacognition (e.g., [21]). Discussion in this chapter requires a pragmatic, essential yet comprehensive definition, to provide a foundation for relating it to imagination, hence it adopts Flavell's definition in which "Metacognition" refers to one's knowledge concerning one's own cognitive processes and products or anything related to them.' ([29], p. 232). Flavell produced a framework including metacognitive knowledge, experiences, goals and actions ([19], p. 906).

2. Methods

I undertook a theoretical journey towards emergent models of imagination within cognition and metacognition. This research was undertaken from a pragmatic stance (e.g., [30]). It aimed to address a problem which arose within my education practice as a museum and gallery educator: that an articulated understanding of 'imagination' is largely absent and its relationship to metacognition seems little considered.

An interdisciplinary approach to data collection was adopted in order to ensure that the new models are well-grounded, not limited by subject discipline and therefore; robust. The integration of theoretical data from multiple fields of knowledge was designed to enable a novel contribution to education practice due to its roots lying in perspectives emerging from beyond that practice. A method analogous to 'grounded theory' ([31], p. 491), was used inductively in the selection and analysis of literature, which constituted data within the study. Theory emerged from the identification and cohering of themes from the data, in conjunction with the interpretive capacity of the researcher, as an education practitioner. Exploring theories across disciplines unearthed ideas to use in *re-imagining* imagination. This enabled a conceptual escape from what can be a restrictive, educational perspective which can simply serve 'to facilitate a "ready-made" political or moral (normative) purpose' ([32], p. 2), as opposed to creating a means of supporting the productive transformation of our thinking and learning.

The resulting, cognitive and metacognitive models of imagination (see [1]) constituted the basis for the further research which is described in this chapter. This was an action research case study 'Imagination Agents'.

3. Findings: key themes emerging

Two themes emerged strongly. The first, *transcendence*, is concerned with imagination and self-awareness, in a species-wide and individual sense. The second is *imagination as cognition*, which is concerned with imagination as being fundamental within all or almost all of our thought.

3.1 Transcendence

First, the theme of transcendence is concerned with a species-wide, evolutionary perspective. What emerged within the theme is a proposal that by evolving a sufficiently sophisticated imagination, our capacity to develop and use a transcendental 'vision' developed. A significant evolution and enlargement of human brains (which evolutionary psychologists generally accept as taking place about 1 million years ago (e.g., [25], p. 48)) enabled us to develop theories of mind and to be able to consider our place within, whatever we then conceived as the universe. These transcendental theories led to our further evolutionary development, with 'This perception of one's individual existence in space and time…[becoming] a driving force in the evolution of the human animal.' ([26], p. 8). In developing such an understanding of ourselves and of our situation, we could also develop empathy for other humans by imagining their thoughts, feelings and needs.

This capacity for self-awareness and empathy is surely a basic condition for personal agency and from this, social/democratic capacity. For example, self-awareness of how we learn, personally, might lead us to recognise that the holistic well-being of a social group depends on ensuring that others can also learn and need to be cared for in this respect through an empathetic approach to their learning needs and accompanying efforts to accommodate these. Thus, concepts of education for the social and democratic good might arise. Additionally, we see that from the outset of this argument, there is an implied closeness between imagination and metacognition if we consider metacognition to be a special kind of self-awareness, which, in its application to thinking and learning, is perhaps a particularly powerful kind of self-awareness in relation to species-wide development.

There is an interesting role for arts and culture within this evolutionary (as applied to the species) and developmental (as applied to the individual) theory, which has implications for the development of pedagogies to support imagination and metacognition. Montell argues ([26], p. 17) that the evolutionary adaptation of imagination was driven by awareness and fear of death. This had been provoked by the development of our sophisticated capacity for imagination. It may have been advantageous for us to externalise this fear in the form of artefacts ([25], pp. 49–50), with the proliferation of these leading to the development of culture and cultural practices which involved them. These cultural artefacts acted as cognitive anchors for concepts, set outside of ourselves, where they could be contemplated and shared and built upon. This externalisation of ideas as physical objects freed up '...cognitive 'space'' [24], allowing us to over-ride existing mental categories and to develop our ways of thinking, socio-culturally (Ibid). A cycle emerges: evolved imagination leads to self-awareness, leading to socio-cultural dialogue, which further expands social and individual imagination. Considering this in a current, pedagogical context, we might come to understand the special, cognitive value of arts-based experiences and their potential in supporting social dialogues which can lead to individual and social agency. This idea is infused within the Imagination Agents project, described towards the end of this chapter. While the application of imagination need not only be concerned with supporting agency, it is fundamental to this task, since it is what enables us to consider ourselves reflectively, to consider the perspectives of others and what all of this means for successful co-existence.

Kant's philosophical theory of 'transcendental imagination' (Critique of Pure Reason, 1781) asserts that imagination is an innate human faculty which underpins and structures our thinking. Imagination enables us to group and synthesise new, sensory impressions with pre-integrated mental images. Transcendental imagination performs a basic, classifying function, without which we would be left to respond to experiences which would seem chaotic and meaningless. The idea of imagination as a kind of driving, cognitive force towards the progressive development of our understanding emerges, expanding the Aristotelian idea of imagination as the 'movement' of stored mental images, driven by 'desire' for meaning (De Anima, 3, 10, 433a).

Kant's use of the word 'transcendental' then, means that imagination 'comes first' and drives us to transcend what would otherwise be a mess of dis-ordered experiences. Without imagination, we could not synthesise our perceptions into concepts. If we experienced buildings, we could not conceptualise them as part of the environment or consider that, in greater number, they would constitute a city. We could not apply concepts of urban development or compare buildings to other buildings with different purposes. Each experience of a building would be unconnected with any idea which enabled a broader 'sense-making' about them and their place in the world. Likewise, without transcendental imagination about ourselves as humans, we could not understand the relationships between self, species and the universe. This transcendental deficit would negate possibilities for personal and/or social agency, since we could not understand self or social concepts and by extension, how to support self or society.

So far we have considered imagination in the context of cognition but this has strayed into ideas of self-awareness and theories of mind, which could be considered to be related to metacognition, albeit that these are broader concepts. Within metacognition, imagination enables a more focused transcendence, concentrated upon our thinking and learning.

To summarise what has emerged from this theme of 'transcendence' then, there are two key aspects, one evolutionary and the other, philosophical/psychological. First, imagination enabled our self-awareness at an evolutionary level. We then had to cope with the imaginings that this brought. The need to externalise our thinking prompted our cultural development and from that, our further, social development as a species. Considering transcendence at an individual level, it is the organising factor within our thinking. Through this, we are able to synthesise and organise ideas about our own thinking and learning, which constitute metacognition. We can conclude that, based on these ideas, imagination is fundamental to cognition and metacognition, as well as to individual and social development.

4. Imagination as cognition

In *De Anima*, Aristotle provides foundational ideas of cognitive imagination. For him, imagination mediates our sensory perceptions and our judgement. Without imagination, our sensory perceptions would be unavailable to our thought processes and therefore, we could not think properly or function as conscious individuals.

For Aristotle, imagination is 'movement' (De Anima, 3, 3, 428b), concerned with transporting sensory perceptions into the cognitive realm, where they are stored for further use. This 'image store' support us to deliberate and self-regulate by recalling 'images' (while this implies visuality it includes all kinds of sensory perceptions, smell, touch taste etc.) to enable us to reason and self-regulate. According to Aristotle, we are driven by a 'desire' *(De Anima, 3, 7, 431b)* to understand or make meaning. Within this driven process of cognition, imagination connects sensory perception with our existing thought, enables us to make choices and to think backwards and forwards in time (ibid). applying Aristotle's ideas to metacognition: driven by the desire to learn, we make choices and self-regulate our thinking and learning by manipulating stored mental imagery which relates to this. The mental image can be considered as a 'building block' of the imagination which is critical within our thinking.

Jumping forward in time, Hume and Kant developed understanding of imagination as cognition which seems to have laid foundations for more recent, psychological approaches. Hume's [33] philosophy of imagination as a kind of existential keystone, holding together a coherent understanding of the world by filling in gaps in our understanding is resonant with Piaget's, psychological understanding of the role of imagination for young children. For Piaget, imagination compensates for a deficit in material experiences [34]. Kant's 'transcendental imagination' has resonance with Piaget's theory of schema and the accommodation and assimilation of experiences into these (1952).

Vygotsky concurs with Piaget that our thinking is based on storing, manipulating and applying sensory images, conceptualising this not as 'gap filling' within the act of discovering pre-existent truths (in a positivist sense) but as a creative, constructive activity [34]. This implies an agental role for the learner as a constructor of meaning and therefore as a potential change-maker. This function can be applied to the development of metacognition and our capacity to make sense of and strategise our thinking and learning. Furthermore, the implication is that we can create *new* knowledge, which can provoke thinking about new possibilities in relation to the complex challenges which we face individually and socially.

5. Findings: an emerging model of cognitive imagination

Having described what emerged from the research process as significant themes in relation to the study, I will now go on to summarise the models of imagination and cognition and metacognition which were major findings. These were initially described in detail in [1] and are briefly re-presented here, illuminated by new examples of how they might manifest in experience.

Tye of imagination	Definition	Example
Imaging	Evoking images of what is not present, to support our thinking	A child brings to mind an image of a castle which they have experienced, in person or as a sensory representation
Productive	Combining images	The child considers and connects physical attributes from a variety of castles which they have experienced
Creative	Connecting images towards the production of a relatively original idea (relative to the individual)	The child produces an idea of a castle which they have never experienced first-hand but which could, theoretically, exist materially
Fantastical	Bringing to mind things which have not been/cannot be directly, materially experienced	The child brings to mind the 'Castle Greyskull', from the animation He-Man

Table 1.
Types of imagination: Definitions and examples.

The premise of the model of imagination in cognition is that imagination consists of various manipulations of mental images, which we recall from a kind of 'store' or an 'allusionary base' ([35], p. 18), in order to cohere ideas. This premise can be traced back to Aristotle, who described this concept of storage and recall, driven by 'desire', in 'De Anima'. To consider how the model might manifest in our thinking, I will relate the types of imagination to a concept and apply them in the context of a child learning. With reference to Jerome Bruner's chapter 'Possible Castles' [36], I will use the concept of 'a castle' (**Table 1**).

Note that fantastical imagination is 'fantastical' because the child imagined something materially impossible, yet not original. *Fantastical Imagination* may or may not be creative. For instance, it could be said that bringing to mind a dragon requires fantastical imagination since a dragon is not 'real' in a material sense (as far as we know!). This is not necessarily *Creative Imagination* because dragons will usually not be a relatively original imagining. On the other hand, *Fantastical Imagination* could include *Creative Imagination* if the impossible scenario being imagined is original to the person imagining it. *Fantastical Imagination*, while it may or may not involve *Creative Imagination*, like *Creative Imagination*, will also rely on *Imaging* and *Productive Imagination*.

6. Findings: an emerging model of metacognitive imagination

Having modelled the fundamental role of imagination in cognition, it is safe to assume that imagination also supports metacognition [19]. *Metacognition* requires the application of our cognition, within a focus on our cognition; therefore it involves imagination. Within a metacognitive process, the kinds of imagination identified in the cognitive model would be applied to the issue of our own thinking and learning.

Basically, to model imagination and metacognition we need to recall and objectify the cognitive model in order to gain a 'meta' view. While focussed on our thinking and learning, imagination within our metacognition is likely to perform in basically the same way as it does within our cognition, however, the relationship is more complex in requiring a more demanding role for self-awareness, which, as discussed above (and in [1]), is dependent on imagination. Imagine a child, metacognitively reflecting on how they produced a story about travelling back in time. The categories of imagining are interacting within a self-transcendent lens, as the child reflects on how they incorporated experiences from a visit to their local museum to create their vision of the world of a child living 200 years ago. Using imaginative, self-awareness the child metacognises that drawing on personal, material, experience inspires their creativity. They decide that this is a helpful, future learning strategy, thereby developing their metacognitive skill. They have used their cognitive capacities in the context of their transcendental capacity for self-awareness. Both capacities were supported by imagination, within a metacognitive process.

Table 2 attempts to summarise the role of each kind of imagination within metacognition. To provide some tangible insight into how the metacognitive model might apply to a piece of thinking, we will use the example of a child faced with a challenging exam including the topic of photosynthesis.

If we see self-awareness as the foundation of metacognitive knowledge, we might expect imagination to have an amplified role in metacognition. The deliberate application of our thought to our unique and individual thinking implies novelty and requires *Creative Imagination*. The role of imagination is increased if we cross, conceptually, from cognition to metacognition. *Creative Imagination is the key to unlocking metacognition*. *Imaging* and *Productive Imagination* are of course required but metacognition is grounded in cognitions previously acquired through socio-cultural experience and turned into images relating to thinking and learning. We accomplish this by using *Productive* and *Creative Imagination* at the cognitive level. These capacities are now material for 'meta' reflection. Simultaneously, they are tools for metacognitive manipulation—the same thought processes applied to our concepts of thinking and learning. 'Only when we have embarked on the creative task of developing metacognitive knowledge and skill do we continue to manipulate and combine imaging and products of imaging at this higher level, transcending and 'looking

Type of imagination	Definition of role in metacognition	Example
Imaging	Bringing to mind images about thinking and learning	A child brings to mind an experience of struggling to comprehend the idea of photosynthesis
Productive	Cohering imagery of experience to imagery of concepts related to thinking and learning	The child recalls comprehending the idea of evolution after seeing a visual representation of this online and copying it with pencil and paper
Creative	Applying relevant concepts in order to reason about one's own states—necessarily a relatively novel piece of thinking	The child reflects that seeing information presented visually and making a visual copy helps with their comprehension of big ideas like photosynthesis. For the first time, they find visual representations of photosynthesis online and make their own diagram which summarises these
Fantastical	Bringing to mind ideas about thinking and learning which have not/cannot be materially experienced	The child imagines that everything they could possibly learn about is presented visually in school, which becomes a kind of infinite learning 'gallery'. The idea of this inspires them to produce further images, as a strategy for comprehension, which they display on their bedroom walls

Table 2.
Types of imagination in metacognition: Definitions and examples.

down' on our own learning, having accumulated a sufficiently sophisticated lexicon of symbolic language in order to achieve this' ([1], p. 12). In Vygotskian terms, at this point our thoughts have been crystallised into mental tools which allow us to open up and construct thinking within a metacognitive realm.

The example in **Table 2** is of course, simplified. The categories of imagination will interplay more, however; it provides a starting point for considering what are usually tacit processes. We can now speculatively 'map' imagination and its relationship with metacognition. Metacognitive knowledge and skill can be situated within a larger 'pool' of *Imaging* in relation to thinking and learning. From this pool, can bring to mind what is not present in relation to 'learning'. 'Ready-cohered within this pool of images is a range of cognitive tools which, when directed towards the concept of our own learning, enable us to manipulate and generate new thoughts which enhance metacognitive knowledge and skill' ([1], p. 12). Metacognitive knowledge and skill need and feed each other. Skill requires knowledge as a foundation from which to construct successful strategy. To obtain metacognitive knowledge we need to apply metacognitive skill. Metacognitive knowledge uses *Productive Imagination* to recall existing and integrate new images. *Creative Imagination* is needed in order to synthesise these thoughts by making and applying 'rules' to organise them coherently.

Moving on to consider metacognitive skill, due to its focus on self-regulation and strategy, this is largely supported by *Creative Imagination*, 'since these executive functions require the ability to reason and solve problems which are personal (therefore novel) to the learner' ([1], p. 13). While it is likely to draw directly on *Imaging* and *Productive Imagination*, in allowing connections to be forged and thoughts to flow, it also draws on *Productive Imagination* which has been previously crystallised into metacognitive knowledge as imagery related to thinking and learning. It requires the ability to speculate about and create strategies for application and adaptation in different contexts. This metacognitive capacity for 'adaptive intelligence' ([37], p. 1) is essential for responding effectively to turbulent, socio-cultural environments and for enabling us to better address the significant challenges we face during the current. 'convergence of crises' [38] we face. By increasing our metacognitive skill there is the potential to increase our confidence and perception of ourselves as capable, democratic agents.

In summary of what is described above and more fully in Burns [1] as an emergent model of metacognitive imagination: metacognitive knowledge and skill dynamically interact with each other. They are dependent on and consist largely of imagination. Reaching a metacognitive state requires us to transcend into self-awareness (individually and historically, as a species), using Imaging and the other kinds of imagination described. Imagination enables us to construct knowledge. We can then apply creative imagination to cohere our unique, concept of self. With this in place, we are able to 'step outside' of our thinking, as if it were an artefact. We can then reflect and build on it, metacognitively, with imagination continuing to support those metacognitive processes.

7. Discussion

7.1 Just imagination?

Having explored and modelled imagination and metacognition let us return to the question which partially forms the title of this chapter 'Is metacognition just imagination?'. First, it is important to address the fact that the word 'just' can imply lesser value for imagination. This author hopes that, in having made a case for and modelled imagination in such a way as to demonstrate its fundamental and pervasive presence within our thinking, we do not see it as a lesser faculty. We can also reflect that, while metacognition is necessarily concerned only with our own thinking and learning, imagination is a far broader concept in terms of its potential application to any given aspect of our world/universe. While this applicability is broad, it does not necessarily follow that it penetrates every aspect of our thinking or of our metacognition.

Next then, perhaps we can ask, what is left of metacognition without imagination? What seems to remain within metacognitive processes beyond imagination are any operations which do not require mental images (for instance, isolated verbal coding and perhaps, structures for thinking through, *if* it is possible for these not to depend on imagery). If this is the case, then imagination and metacognition are very, very close and we might argue that the terms are interchangeable.

What if, rather than using the word 'metacognition' in education, we had used 'imagination'? As well as enabling us to work with metacognition, as a specific aspect of imagination, this would allow us to understand and would emphasise the need to nurture imagination more generally or to recognise it clearly as the foundation for metacognition, in addition to its further benefits for learning, beyond imagining concerned with the self. This might elevate imagination in education from being seen as a 'fluffy', magical and non-educable force into a cognitive/metacognitive capacity which it is vital to teach for. Given the accountability agenda which prevails in many of our current, global education systems and the impact this has on what and how children learn (for instance, the emphasis on STEM subjects and on measurable outcomes) we might concur with Giroux, that in neoliberal societies schools act as 'disimagination machines' and insist that we need to generate a healthier attitude to and provision for imaginative learning experiences. Ascribing the same importance to imagination as we do to metacognition might help to remedy this, with many educators understanding that the global and social issues we face can only be solved by imaginative individuals, communities and societies. This could be understood as an act of embracing multiplicity in order to address:

> *'the posthuman convergence…[as] a multi-directional opening that allows for multiple possibilities and calls for experimental forms of mobilization, discussion and at times even resistance' ([38], p. 9).*

To some extent I am 'resisting' and playing devil's advocate here, out of anger and despair at what I see as a lack of imagination in education (both in what learners experience and in how teachers perform or are allowed to perform), as well as for the purpose of emphasising the essential role of imagination for metacognition and more generally, for living a good life. Perhaps it is useful or necessary to retain 'metacognition' as a more specific concept, rather than to lose it to 'imagination'. Ideally, we should have the language, conceptual understanding and indeed, the imagination to embrace both ideas and their relevance to each other, for application within our learning, for the development of personal and social agency and ultimately, for social justice and the good of our planet.

7.2 Applying the findings

Recently, the author applied the models, along with a model of individual 'agency' [39] in research with young people in a Scottish, inner-city secondary school. The project was called Imagination Agents and was funded through a Royal Society of Arts Catalyst

Grant. At the time of writing, data collection has only just been completed, so while it is not yet possible to report with rigour on the findings, it is useful to describe the application of the models (above) here, with some minor speculation as to the results. Led by an artist, Imagination Agents aimed to support young people to develop personal agency through an experiential process designed to nurture metacognition of their imagination and through this, their sense of personal agency. The hypothesis we worked with was that imagination enables the originality for creativity, which enables us to create unique, personal understandings of and strategies for metacognition, with metacognition enabling confidence for taking action, or, in other words, personal agency.

The project took a 'grass-roots' approach, identifying pertinent issues within the local environment of the school and encouraging the young people to respond to these artistically. This artistic challenge acted as a 'vehicle' for them to develop their sense of agency. In having no 'right answers', the subjectivity of art as a discipline allowed the young people to make their own decisions within an imaginative and creative process. The artistic outcomes of this included the production of sculptures, cast in plaster from discarded packaging and situated within the local environment and alternative signage, which the young people took out into their local streets and park.

Data collection tools were embedded within the pedagogic approach. They were 'catalytic' [40] in providing research data whilst simultaneously enabling the young people participating to reflect on and develop a metacognitive perspective of their imagination and agency. These tools (see **Figure 1**) took the form of handbooks, which included axial tools related to the models of imagination (above) and a model of 'ecological agency' [39]. Within the art-based context, these self-evaluation tools were designed to be as visual as possible and to minimise the need for writing, in order to engage young people who had chosen to join the project because of its artistic focus. The handbook also included opportunities to visually represent imagination and agency at the start and at the end of the project by drawing metaphors for each of these. Additionally, there were sketchbook-style, blank pages and further activities

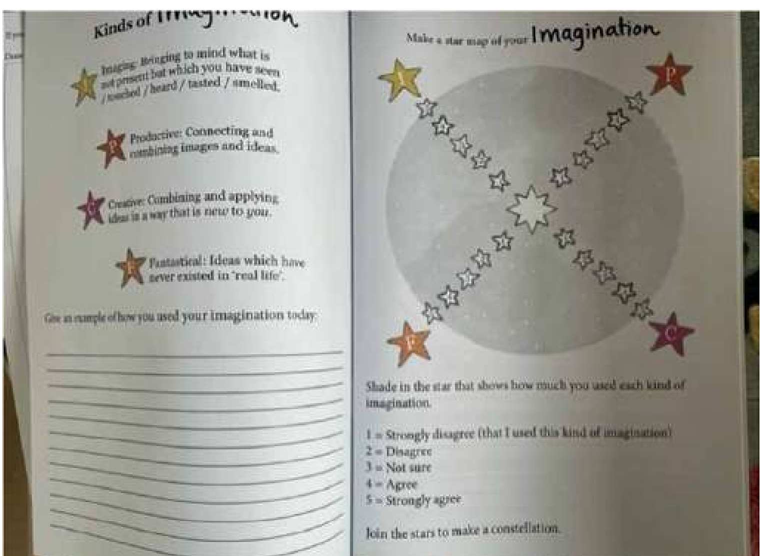

Figure 1.
Tool for self- evaluating imagination.

relating to the project focus on local sustainability, so that the handbooks might work both as data collection tools and in supporting the pedagogy. They were designed in collaboration with the artists who worked on the project to ensure that they served these combined purposes.

While the handbooks worked well, despite our best efforts, they still seemed to be and 'add on' to the main project activity. The young people completed them but really, they would have preferred to stay with their personal, art making and told the researchers so. They also said that they did not want to write at all, even though this was a minimal requirement, within the context of an art project. We did explain that this was necessary since the handbooks would also constitute data which we wanted to interpret correctly, in accordance with participant intentions. In this communication, the young people were of course, exhibiting agency. The axial tools were quick to complete and as such, yielded participation and useful data. Importantly, the young people (aged 12–13) were easily able to comprehend the models of imagination and agency presented to them, which is an encouraging finding in relation to the practicality of the models presented within this paper.

As mentioned above, data has not yet been fully analysed but what can be said is that in yielding hand-made signs on a walk around the local area, the young people certainly exhibited confidence and agency, as they selected appropriate settings in which to photograph them and were happy to be photographed with them. The nature of these signs and the slogans the young people created on them was usually humorous and friendly, playing with ideas of dictatorial instructions in relation to the environment, such as 'LOOK at the nice ducks!' (**Figure 2**). While, superficially, this can be interpreted as light-hearted fun, it can also be seen as an attempt at social influence by democratic means. By reminding people to focus on the positive, the young artist hoped to stimulate appreciation of and empathy for the environment. As discussed above, this capacity for empathy is based on the capacity to imagine the perspective of others, in this case, the ducks and the people who have the opportunity to experience them. From a posthuman perspective (e.g.; [6, 38]), this can be seen as an important philosophical step towards de-centralising our position as human beings

Figure 2.
Image of young person's artwork.

within environments, re-imagining the place of fellow species, their connection with us and the environments we make and share. Such an approach chimes with concepts of 'The Imaginary Institution of Society' [41] in which, 'What we call 'reality' and 'rationality'' (p. 3) are works of imagination and as such, can be changed.

8. Conclusion

The emergent models imply that imagination is fundamental to cognition, metacognition and is at the root of our potential for agency. Imagination must be recognised as a critical means of supporting personal and democratic agency. This implies that imagination, along with metacognition, should be considered as an educational priority which need to be effectively supported by curricula, teachers and pedagogy.

Imagination is not a magical addition to our thought. Rather, it is intrinsic throughout. The necessity for imagination in metacognition is particularly important, given that metacognition supports achievement and attainment. In its close association with metacognition, imagination could share some of the credit for enabling our learning which is usually associated with the former capacity. Through this association it might be possible to raise the status of educational provision for imagination and increase opportunities for simultaneous, imaginative and metacognitive development.

The emergent models are offered firstly; as a basis for dialogue across the field of education. This may lead to their rejection, adaptation or even their replacement, as a means of progressing this area of education. I make no claim that they are comprehensive, complete or in any way 'ultimate'. They simply offer a means of discussing what has often been considered to be largely inaccessible and indescribable, while also constituting a valuable part of our learning. Secondly; the models are offered to practitioners and researchers who are interested in exploring their potential within their areas of interest. The accumulation of findings from such explorations can help to establish how useful the models are and suggest pathways for their transformation.

The models can help us to establish the current state of practitioner understanding of imagination and the in/adequacy of support offered for this. They also offer a framework to support pedagogic design. They could be used to form criteria for the exploration of imagination in and across contexts, in relation to multiple factors and impacts (not to suggest a solely deductive approach; the models might complement inductive methods). A priority is to expand understanding of the imaginative meta/cognitive processes which support capacity for personal and democratic agency.

If we have tools available to us which can even evidence the development of imagination and through this; metacognition and if we are able to engage in dialogue about how best to support these capacities through the presence of a practical language and framework, it may be more likely that we can encourage serious, focussed approaches to imagination in education. If we can accomplish this, not only will we support metacognition and learning; we might help to secure a better future for our planet by equipping learners to confidently address the complex, global and local problems which we face.

9. Recommendations

Since the initial conclusion of the research described above, further ideas and philosophies of imagination have come to the authors attention as being relevant within a consideration of imagination in education, particularly in terms of its co-relation with agency. Costariadis's ([41], p. 146) ideas of the radical imaginary, in particular, have resonance here, in positing imagination as the basis of social-historical concepts. This suggests that those concepts can be re-imagined, within a 'universe of significations' which are constituted by imagination. This reimagining and subsequent action relating to it might be considered to constitute social agency. Relating this to an individual, metacognitive perspective and focussing specifically on learning, by this argument there is continual potential to re-imagine ourselves as learners. We might otherwise refer to this as creative, metacognitive strategy. While Costariadis's theories were largely related to possibilities for societal change, they also seem to offer relevant insights in relation to imagination, metacognition and agency within the individual. The author recommends the pursuit of and will pursue these and other theories within attempts to ensure the continued emergence of understanding in these areas.

If we consider the example of the 'nice ducks' (above)art seems to be a good vehicle for reimagining, applied to any given focus. It may not seem surprising that art supports imaginative capacities; however, based on the arguments presented above, imagination is critical to rational thought, so, if art supports imagination better than some other subjects, it is worrying that it is so neglected in many curricula (see, for example NSEAD 2015), usually in favour of STEM subjects. We can also assume that, due to imagination's close relationship with metacognition, the deficit in art provision might also impact negatively on opportunities to develop metacognition. After all, what is a work of art if not a 'meta' representation of or reflection on a chosen idea or set of ideas. As such, a recommendation arising from this work is to advocate STEAM (Science, Technology, Engineering, Art, Mathematics) rather than STEM.

A further recommendation is simply to continue with the process of finding ways to evaluate and self-evaluate imagination, perhaps in conjunction with the evaluation of metacognition. This could include the quantitative analysis and reporting of qualitative data, with this perhaps more likely to convince those who retain the idea that imagination is 'magical', unteachable, or too abstract to be evidenced. The ability to evidence imagination statistically could play into prevailing concerns with accountability, enabling recognition of its importance and thereby, its existence in education systems. This said, this author would hope that in evidencing its cognitive and metacognitive value, there might also be the possibility to illuminate the limitations of such instrumental regimes within education, which can act to negate important areas of learning (see [42]). Embracing imagination as cognition and metacognition enables creative possibilities beyond meeting pre-imposed learning outcomes and increases our chances of finding new solutions to complex problems in individual as well as social life. It allows individuals to be re-creators, rather than spectators (after [43], p. 56). This could include the reimagining and re-creation of our education.

All in all, the recommendations above cohere to suggest a much more substantial focus on imagination within education. Along with this we need to recognise and understand imagination's close relationship with metacognition, with this relationship offering a route to personal and social agency.

Author details

Helen Burns
School of Humanities, Social Sciences, Law, University of Dundee, Scotland, UK

*Address all correspondence to: hburns001@dundee.ac.uk

IntechOpen

© 2024 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

References

[1] Burns H. Imagining imagination: Towards cognitive and metacognitive models. Pedagogy, Culture & Society. 2022:1-20

[2] Burns H. Imagination: Exploring cognitive and metacognitive perspectives in relation to visual-arts education [PhD thesis]. Newcastle Upon Tyne: Newcastle University; 2018

[3] Osberg D, Biesta GJ. Beyond presence: Epistemological and pedagogical implications of 'strong'emergence. Interchange. 2007;**38**:31-51

[4] Osberg D, Biesta G, Cilliers P. From representation to emergence: Complexity's challenge to the epistemology of schooling. Educational Philosophy and Theory. 2008;**40**(1):213-227

[5] Osberg D, Biesta G. Beyond curriculum: Groundwork for a non-instrumental theory of education. Educational Philosophy and Theory. 2021;**53**(1):57-70

[6] Braidotti R. Posthuman feminism. Polity; 2022

[7] Giroux H. When schools become dead zones of the imagination: A critical pedagogy manifesto. In: The Wiley Handbook of Global Educational Reform. 2018. pp. 503-515

[8] Biesta G. Letting Art Teach. 2nd ed. ArtEZ Press, Arnhem, Netherlands; 2020

[9] Ryle G. The Concept of Mind. London: Penguin Books; 1949

[10] Clarke M, Phelan A. The power of negative thinking in and for teacher education. Power and Education. 2015;**7**(3):257-271

[11] Higgins S, Katsipataki M, Kokotsaki D, Coleman R, Major LE, Coe R. The Sutton Trust-Education Endowment Foundation Teaching and Learning Toolkit. London: Sutton Trust; 2013

[12] Bridges D, editor. Education, Autonomy and Democratic Citizenship: Philosophy in a Changing World. New York: David Bridges Routledge; 1997

[13] Dewey J. The Public and its Problems. New York: Swallow Press; 1927

[14] Greene M. Releasing the Imagination. San Francisco: Jossey-Bass; 2000

[15] Andrews M. Narrative Imagination and Everyday Life. Explorations in Narrative Psyc. 2014

[16] Sadoski M. Imagination, cognition, and persona. Rhetoric Review. 1992;**10**(2):266-278

[17] Mead GH. Mind, Self, and Society. Vol. 111. Chicago: University of Chicago press; 1934

[18] Kearney R. The Wake of Imagination. London: Routledge; 1988

[19] Flavell JH. Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. American Psychologist. 1979;**34**(10):906-911

[20] Flavell JH. Cognitive development: Children's knowledge about the mind. Annual Review of Psychology. 1999;**50**:21-45

[21] Tarricone P. The Taxonomy of Metacognition. Hove, New York: Psychology Press; 2011

[22] Veenman MVJ, Wilhelm P, Beishuizen JJ. The relation between intellectual and metacognitive skills from

a developmental perspective. Learning and Instruction. 2004;**14**:89-109

[23] Wall K, Burns H, Llewellyn A. Mind the gap: An exploratory investigation of a family learning initiative to develop metacognitive awareness. Journal of Early Childhood Research. 2017;**15**(2):115-129

[24] Donald M. Origins of the Modern Mind: Three Stages in the Evolution of Culture and Cognition. Cambridge Massachusetts, London, England: Harvard University Press; 1991

[25] Mithen S. The evolution of imagination: An archaeological perspective. SubStance. 2001;**94**(95):28-54

[26] Montell C. On evolution of god-seeking mind. Evolution and Cognition. 2002;**8**(1):1-19

[27] Runco MA. Meta-creativity: Being creative about creativity. Creativity Research Journal. 2015;**27**(3):295-298

[28] Kaufman J, Beghetto R. In praise of Clark Kent: Creative metacognition and the importance of teaching kids when (not) to be creative. Roeper Review. 2013;**35**(3):155-165

[29] Flavell JH. Metacognitive aspects of problem solving. The nature of intelligence; 1976

[30] Biesta G, Burbules N. Pragmatism and Educational Research. Lanham, Boulder, New York, Toronto, Oxford: Rowman and Littlefield; 2003

[31] Cohen L, Manion L, Morrison K. Research Methods in Education. 6th ed. London: Routledge; 2008

[32] Osberg D, Biesta G. Beyond the educational machine: Prolegomena for an aesthetic theory of education. In: Paper Presented at the European Conference for Education Research (ECER); 2018; Bolzano;

[33] Hume D. A Treatise of Human Nature. London: Penguin Classics; 1739. 1985

[34] Zittoun T, Cerchia F. Imagination as expansion of experience. Integrative Psychological and Behavioural Science Journal. 2013;**47**:305-324

[35] Broudy H. The Role of Imagery in Learning. Los Angeles: The Getty Education Institute for the Arts; 1987

[36] Bruner J. Actual Minds, Possible Worlds. Cambridge Massachusetts, London, England: Harvard University Press; 1986

[37] Sternberg RJ. A theory of adaptive intelligence and its relation to general intelligence. Journal of Intelligence. 2019;**7**(4):23

[38] Braidotti R. Posthuman Knowledge. Cambridge: Polity Press; 2019

[39] Priestly M, Biesta G, Robinson S. Teacher Agency: An Ecological Approach. Bllomsbury; 2016

[40] Baumfield V, Hall E, Wall K. Action Research in Education. Singapore, Washington DC: Sage; 2013

[41] Costariadis C. The Imaginary Institution of Society. Cambridge, Malden: Polity Press; 1987

[42] Biesta G. Good education in an age of measurement: On the need to reconnect with the question of purpose in education. Educational Assessment, Evaluation and Accountability. 2009;**21**:33-46

[43] Freire P. Pedagogy of the Oppressed. London: Penguin; 1970

Section 2

Cognition and Human Psychology

Chapter 7

Personalization in Education

Orit Avidov-Ungar and Sara Zamir

Abstract

In today's increasingly competitive world, the concept of "one-size-fits-all" has become anachronistic and unproductive. Today's reality requires educational organizations to rethink the services they give to meet students' individual needs, as well as the ways available to enable them to reach their full potential. The current review aims to examine the most recent studies on the subject including the doubts, tensions, and ambiguities they raise.

Keywords: personalization in education, technology, educational assessment, students' achievement, role of teachers

1. Introduction

In today's increasingly competitive world, the concept of "one-size-fits-all" has become anachronistic and unproductive. Today's reality requires organizations to rethink the services they provide to the consumers of their services in order to meet their individual needs. At the same time, these consumers have expectations that organizations will be instrumental in helping them to realize goals that reflect their personal values in line with their understanding and preferences.

Yet, there are certain areas in which the principles of personalization are either not applied at all or only partially applied despite their enormous potential in promoting the field in question.

In recent years, the perception among education experts has been that personalized education is the way to enable students to reach their full potential and that it is an approach that represents an optimal investment of the system's resources. Personalization can even help narrow gaps between students in important and challenging disciplines. If, in the past, there were no tools to do so, today, technology may be a crucial factor in the implementation of personalization in education.

Along with its analysis of personalization in education policy as a modern but controversial reorganization, this chapter also reviews some of the latest studies on the subject including the doubts, tensions, and ambiguities they arouse.

2. Personalization

2.1 Definitions and designations

Personalization should be clearly distinguished from customization. Both customization and personalization are based on the assumption that a uniform offering is not sufficient to meet everyone's needs. As defined by Webster's Dictionary, to personalize means "to make something individual; specifically: to mark as the property of a particular person" [1]. This definition implies that the goal is to first become aware of the needs and then effectively meet them [2].

The major result of personalization in education is the maximization of motivation, resourcefulness, and creativity of students and teachers alike, teaching and learning through measures, such as implementing individualized educational programs, designing individualized learning goals and methods, and finally, meeting individual special needs [3]. Personalization of learning is intended to create a situation that helps the learners realize their potential and reach expertise in various fields by choosing appropriate learning strategies from a wide range of possible pedagogical strategies [4]. Students are empowered and hence expected to take responsibility and ownership of their learning in accordance with their interests and personal goals and finally, to understand its unique value for them. For the personalization process to succeed, students should regularly receive feedback, in real-time, to promote their learning and develop independent learning skills [5].

The Myers-Briggs Type Indicator (MBTI), developed by Katharine Briggs and Isabel Myers, has helped people to understand themselves and their behaviors. It is based on typological theory (2014), which posits four essential psychological functions through which we see the world: sensation, intuition, feeling, and thinking. All of us rely on one function more than others. The MBTI identifies our preferences which are driven by our interests, values, needs, and motivations. It describes personality preferences rather than measuring skills or abilities and suggests that there are no "good or bad" preferences, rather, that all the personal preferences are equally important [6]. This has been well documented and researched in hundreds of scientific studies over the past 40 years [6–8]. The Myers-Briggs Type Indicator reports a person's preferences on four scales as follows:

1. Extraversion or introversion -where a person prefers to focus attention

2. Sensing or intuition - how a person prefers to absorb information

3. Thinking or feeling - how a person deals with the external world

4. Judging or perceiving - how a person understands external messages

The concept of personalization derives from two significant origins sources: the theory of multiple intelligences developed by Howard Gardner [9, 10] and the theory of meaningful learning [11].

2.1.1 Gardner's theory as an underpinning of personalization

Gardner's theory of multiple intelligences revolutionized the definition of intelligence. For decades, intelligence was seen as a uniform entity: general fitness (g) that can be measured using the IQ scale, the location along which people are rated as more or less intelligent.

According to Gardner, humans have multiple, largely autonomous intelligences, which are not simple to measure quantitatively. The theory is based on a simple insight: people are not generally intelligent in all areas of endeavor rather, people are intelligent in certain fields. A person can be very intelligent in certain areas, and not in others. In other words, each person has an "intelligence profile."

The message of the theory of multiple intelligences to educators is that students differ from one another. Each student is intelligent in their own way and therefore, everyone deserves an education tailored to their skills and tendencies.

The theory of multiple intelligences has great educational promise of which only a small part has been realized so far. Many educators around the world, influenced by this theory, have developed ways to diagnose the profile of student intelligences, organize educational content, and evaluate and design spaces and materials in ways that suit the different intelligences [12].

2.1.2 The theory of meaningful learning as another underpinning of personalization

Correspondingly, meaningful learning is a personal knowledge-building process during which the learner raises questions, locates sources of information, processes information, and creates personally relevant new knowledge. According to Ausubel [11], the most important factor influencing learning is what the learner already knows. Meaningful learning seeks to enable the student to fully realize personal potential and develop excellence. Meaningful learning provides an experience of growth and development, while deepening the topics that interest learners and are suitable for their needs.

Within the meaningful learning process, the pedagogical and psychological experiences of learning complement, influence, and empower each other. To ensure meaningful learning and achieve its goals, teachers are required to re-examine many components, including learning objectives, learner characterization, learning processes, teaching and assessment methods, the nature of the educational organization, and training of staff entering the profession. The curriculum of meaningful personalized learning should be linked to real life whenever possible, helping students to connect their education to the future. Each school at any level identifies a set of essential studies – in literature and language, writing, mathematics, social studies, science, and the arts – in which students must demonstrate achievement in order to graduate [13].

Meaningful learning, which leads to longer retention than memorization, occurs when students relate new concepts to pre-existing familiar ones. Changes then occur in our cognitive structure, concepts are modified, and new links are created. It is a useful tool because it enables real learning, generates greater retention, and facilitates transfer to other real-world situations [14, 15].

2.2 Personalization and technology

Personalized learning employing computers and mobile devices such as phones and tablets is one of the latest trends making a global impact, promising to deliver new methods that enhance and promote learning. Nevertheless, there are some concerns around access, security, affordability, teacher expertise, and learner proficiency in using digital tools. The devices and practices connected with their use have been appealing to education stakeholders for a variety of reasons, yet personalization has been the dominant motive in e-learning research and practice, even if it has not always been identified this way. The technology helps to ensure that students are not held back or left behind by larger groups.

2.2.1 Personalization and cognition

Personalization in education refers to tailoring educational capabilities and instructional strategies to meet the individual's cognitive level. Hence, it involves adapting instructional strategies, content, and pace to optimize learning outcomes for each learner. The connection between personalization in education and cognition is multi-faceted and refers to the mental processes and abilities involved in acquiring, processing, storing, and using information.

Personalized learning approaches consider students' anticipatory schemata, namely, their interests, goals, and prior knowledge, which can significantly enhance their motivation [16]. When learners are actively interested in and motivated to learn, their cognitive processes become more efficient and effective. This heightened engagement facilitates attention, memory encoding, and information processing.

Everyone usually has his/her own learning style. Studies show that individuals will learn the different methods and have their own preferences and ways to receive and process information [17]. Personalization recognizes that learners have different learning styles and preferences. Some students may excel in visual learning, while others may prefer auditory or kinesthetic learning. By aligning instructional methods with cognitive individual learning styles, personalized education can optimize cognitive processing and improve information preservation and understanding.

Cognitive load theory [18] suggests that learners have limited cognitive resources available for processing new information. Cognitive load may be viewed as the level of "mental energy" required to process a given amount of information. As the amount of information to be processed increases, so the associated cognitive load. Cognitive load theory suggests that effective instructional material promotes learning by directing cognitive resources toward activities that are relevant to learning rather than to processes that are adjunct to learning. Personalization can help to manage the cognitive load by presenting information in a way that matches each student's current knowledge level. By building upon existing cognitive schemas and scaffolding new information, personalized education reduces cognitive overload and promotes deeper learning.

Moreover; personalization also empowers students to take ownership of their learning process [19]. When learners have choices and control over their educational experiences, they develop self-controlled learning skills. Self-regulated learners actively monitor their own thinking, set goals, plan strategies, and reflect on their cognitive growth. Those processes enhance cognition by promoting self-awareness, strategic thinking, and adaptive learning.

Personalized education often incorporates mastery-based learning, which allows students to progress at their own pace and advance upon mastering specific skills or concepts. Mastery learning is an instructional philosophy based on the belief that all students can learn if given an appropriate amount of time as well as appropriate opportunities [20]. Mastery-based learning aligns with cognitive theories of expertise development, emphasizing deliberate practice, and gradual knowledge construction. By enabling learners to focus on individual areas of improvement, personalized education fosters deeper understanding and expertise development.

2.2.2 Personalization and mobile devices

Because mobile devices are generally owned by their users, are highly customizable, and carried by their person throughout the day, they lend themselves to personalization in a way that shared and secured technologies do not. While PCs have offered similar affordances for years, the technology came with serious limitations: learners could not easily carry computers to and from education centers, and many learners could not afford them, so the technology – even when available in computer labs – was not truly personal. Mobile technologies, by virtue of being highly portable and have become a necessity of life, and most students have one, have enormously expanded the potential and practicability of personalized learning. Learning that is both mobile and personalized holds many attractions [21], for instance, applications on mobile phones and tablets enable the selection of more difficult or easier texts for reading assignments depending on the learner's skills and background knowledge. The conclusion in the policy guidelines is that over time, the adoption of personal mobile technology in learning "will supersede one-size-fits-all models of education" [22].

To date, developments have focused on technology rather than on learner-centric issues. Indeed, each person has a preferred learning style and ignoring this can lead to unstable or ineffective online learning solutions. In fact, it is commonly believed that most people prefer ways of interacting with, absorbing and processing stimuli or information, or simply using a visual medium [8].

2.3 Personalization and educational assessment

Personalization in educational assessment aims to provide parallel pedagogical considerations with respect to student characteristics. A teacher who individualizes instruction identifies the learners' needs through assessments based on their challenges or disabilities. The teacher analyzes the findings and then formulates recommendations emerging from the assessment. Recommendations are made with or without other professionals' input in adapting materials and instruction for the different learners with cognitive or neurological diversity [23].

The relationship between internal assessment, which is a prerequisite for personalized evaluation, and external assessment has long been a topic of discussion with regard to the issue of quality assurance in education [24]. External assessment in the form of school inspections appears to have always enjoyed a somewhat distinguished existence due to their ascribed attributes of objectivity, reliability, and comparability [25]. While there is consensus regarding the need for them, their execution has always been heavily criticized [26]. In response to this criticism and in line with recent trends of decentralization and increasing school autonomy, the discussion of personalization assessment methods has become broader. Moreover, some have even suggested [27] adding sections to the Psychometric University Entrance Test, considered one of the most standardized tests, that would reveal a range of aptitudes as well as expose multiple intelligences such as emotional intelligence and creativity.

2.3.1 The value of online assessment to educational assessment

Online assessment, when done via computer or mobile phone, becomes an important component of personalized education. It is currently used as part of the learning process, not only in e-learning but also in blended learning.

Online assessment is utilized both for self-assessment and for exams and tends to replace or complement traditional methods of assessment of the student's performance [28]. Providing formative and summative feedback is especially crucial in online assessment as students need to be informed about the results of their performance in real-time. Personalized feedback aims, on the one hand, to prevent destructive feedback and on the other, to provide a student with the feedback that is most suitable and useful for their personality. The development of personalized feedback requires having the answers to the questions of: what can be personalized in the feedback and, to which type of user or performance characteristics should feedback be personalized? [29].

2.4 Personalization and student achievement

Personalization is associated with accomplishments that are significant, worthwhile, and meaningful for learners in the realm of both academic achievement and emotional growth [30].

2.4.1 Personalization and recall

Studies on personalization and academic achievement show that during personalized learning, students exhibit better achievements over time [31, 32]. Miller and Kulhavy [33] hypothesized that personalization improves memory by increasing the associative strength of the personalized material and students' existing schemata. They found that integrating personalized representations during encoding led to significantly greater recall. The meaningfulness of a task may increase when its context is personalized, thereby enabling pupils to mentally place themselves in the situation. Personalization may not only build stronger associations related to the task, but in doing so it may ease the cognitive demands of the problem-solving process [34].

2.4.2 Math and reading improvement through personalization

The achievement was examined in 62 US public charter and district schools pursuing a variety of personalized learning practices, and details of implementation were examined for 32 of those schools. The results were described in a report entitled "Continued Progress - Promising Evidence on Personalized Learning" [35]. Researchers obtained achievement data for personalized learning students and a matched comparison group of students attending other schools serving similar populations. It was found that students' achievement growth in mathematics and reading over 2 years exceeded that of the comparison group, overall, and compared to a majority of schools. A large proportion of students with lower starting achievements, experienced greater growth rates than their peers, particularly in mathematics. Growth continued to accrue in schools over 3 years of implementation.

A study conducted by Bloom and Unterman [33] provides solid evidence that going small – when the schools are startups, nonselective, and entered by choice – has substantial effects on academic achievement. The researchers found that enrolling in a small school of one's choice rather than in a comprehensive high school, significantly improves graduation rates for a large population of low-income, disadvantaged students of color. Personalization also improves students' attitudes toward the subject matter. The teachers' attitudes toward personalization, which evolves in positive student-teacher relationships, also help students struggling in specific subject areas. For instance, Midgley, Feldlaufer, and Eccles [36] discovered that, after controlling for students' initial mathematics performance and interest, students in classrooms with high levels of personalization showed more excitement for mathematics, and their willingness to engage with the material remained high when compared to students with low levels of personalization. Moreover, students who move from low- to high-support classrooms improve their self-efficacy and enjoyment with respect to mathematics [37].

Studies regarding personalization and emotional growth validate the psychological theory of self-determination. The important concept of self-determination refers to each person's ability to make choices about and control their own life. This ability plays an important role in psychological strength and well-being. Self-determination allows people to feel that they have power over their choices and lives. It also impacts motivation – people are motivated to take action when they feel that what they do will affect the outcome. The concept of self-determination has been applied to a wide variety of areas including education, work, parenting, exercise, and health. Research suggests that having high self-determination can foster success in many different domains of life [38, 39].

Moreover, an overwhelming majority of students accept responsibility and ownership over their learning when it is personalized [40].

It has been found that the students exhibit effort and work harder to solve complex and challenging problems, give up less often in the face of difficulties, and learn more profoundly, both in comparison to students in a control group who studied in a traditional education setting, and to their own prior functioning in a former traditional education framework [41].

2.4.3 Personalization and the role of teachers

The process of the personalization of learning has significantly changed the role of teachers. The teacher is no longer the main source of knowledge but rather a moderator and learning navigator [42]. Teachers' attitudes toward this kind of change and their readiness to become active partners is considered a factor critical to success [43]. Similarly, resistance to change is considered one of the main reasons for the failure of change processes in organizations in general and in education systems, in particular [44]. In the case of innovative technology implementation in schools, which is most often a crucial element in personalization, teachers' resistance is reported by some studies to be the most dominant contributing factor to the project's failure [45].

2.4.4 Teachers as the main axis of personalization

School improvement and school turnaround efforts rest largely on the shoulders of the teachers since these are the individuals who can most immediately bring about change in their students and hence, affect both the climate and culture of their school. There are five types of power in teachers' educational environment. The first is the legal power granted to teachers due to their appointment and permission to make decisions affecting their students. The second is the power of expertise since only teachers who are experts in their field are permitted to teach and provide students with professional knowledge. The third is the power of charisma; that is to say, their authority stems from their personality and their investment in their job. The fourth is the power of reward, based on teachers' ability to reward good behavior, excellence, and appreciation. The fifth is the punitive authority, i.e., teachers' authority to punish students according to school rules [46]. The teacher's role in personalized learning sometimes needs the "courage to forget" those convenient and conventional origins of power and turn to the power of "relational persuasion" [47]. In personalized learning, the teacher organizes an infinite mass of potential content into an orderly and discernible curriculum, explicitly teaches new concepts and skills unique to the audience, enlarges the student's scope of individual interests, and fosters logical thinking through questioning and particular dialogs [48].

2.4.5 The multifaced role of teachers

Bishop et al. [49] examined the roles of teachers in personalized learning environments regarding statewide legislation of personalized learning plans, flexible educational pathways, and proficiency-based assessment. The study used data from interviews with a purposefully selected group of 20 elementary and middle school teachers. Findings revealed that teachers' perceptions of their role included four components: (*a*) empowerment, (*b*) scouting, (*c*) supporting, and (*d*) assessing. Even though all those components lead to the personalization of learning, there is potential for intra-role conflict and role tension between and among these sub-role components.

One way to overcome this conflict of sub-roles may be following the ethos of Dweck [49], who argues that connecting the performance of learning tasks to personal aspirations rather than to past performance or group stereotypes frees the teacher to engage in personalized learning. This appreciation for what Dweck calls "incremental intelligence," the notion that the ability to achieve is not fixed but is incrementally improved, contributes not only to a student's motivation to learn but also to a teacher's more effective response to the student's learning needs.

3. Conclusion

In response to individual needs, personalization in education facilitates not only students to learn better by using different strategies but also provides teacher's instructional needs in designing varied teaching platforms. Overall, personalization in education and cognition are closely intertwined. By adapting educational experiences to align with individual learners' needs, preferences, and cognitive processes, personalized education optimizes engagement, motivation, learning styles, cognitive load management, self-regulated learning, mastery-based learning, and feedback – all of which significantly influence cognitive development and academic achievement. Moreover, personalized learning using computers and mobile devices is one of the latest trends making a global impact, promising to deliver new methods that enhance and promote learning. Nevertheless, using the technologies without considering pedagogical theories and models often may lead to malfunction.

This review offers both the opportunities and necessities of personalized education as well as the essential criticism of its function for future research papers about this important topic.

Author details

Orit Avidov-Ungar* and Sara Zamir
Faculty of Education and Leadership, Achva Academic College, Israel

*Address all correspondence to: oritav65@gmail.com

IntechOpen

© 2024 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

References

[1] Merriam-Webster's Collegiate Dictionary. 11th ed. Springfield: Merriam-Webster; 2003. Available from: https://www.merriam-webster.com/dictionary/personalize

[2] Freund R. Welche Auswirkungen hat Mass Customization auf das Management der beruflichen Weiterbildung. Freiburg, Germany: Vortrag an der Pädagogischen Hochschule; 2001

[3] Cheng YC. Local knowledge and human development in globalization of education. In: Keynote Speech Presented at The International Conference on Globalization and Challenges for Education organized by National Institute of Educational Policy and Administration (NIEPA); New Delhi, India. 2003. pp. 19-21. Available from: http://efaidnbmnnnibpcajpcglclefindmkaj/https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=97ccca5aef88100ae6c4193ed105beeda60b74eb

[4] Abbott J, Basham J, Nordmark S, Schneiderman M, Umpstead B, Walter K, et al. Technology-Enabled Personalized Learning Summit: Findings and Recommendations to Accelerate Implementation. Raleigh, NC: Hosted by the Friday Institute for Educational Innovation at NC State University; 2014

[5] Office of Ed Tech. What is Personalized Learning? Medium. 2017. Available from: https://medium.com/personalizing-the-learning-experience-insights/what-is-personalized-learning-bc874799b6f [Accessed: December 5, 2021]

[6] Myers IB. Introduction to Type. Sunnyvale: Consulting Psychologists Press; 1993

[7] Myers IB, McCauley M, Quenk N, Hammer A. MBTI Manual: A Guide to Development and Use of the Use of the Myers-Briggs Type Indicator. Sunnyvale: Consulting Psychologists Press; 1998

[8] El Bachari E, El Adnani M. E-learning personalization based on dynamic learners' preference. AIRCC's International Journal of Computer Science and Information Technology. 2011;**3**:200-216

[9] Gardner H. Reflections on multiple intelligences: Myths and messages. El Paso, TX, USA: Phi Delta Kappan; 1995;**77**:200-2007

[10] Gardner H, Moran S. The science of multiple intelligences theory: A response to Lynn Waterhouse. Educational Psychologist. 2006;**41**:227-232

[11] Ausubel DP. The Acquisition and Retention of Knowledge. Amsterdam: Kluwer; 2000

[12] Pykett J. Personalization and de-schooling: Uncommon trajectories in contemporary education policy. Critical Social Policy. 2009;**29**:374-397

[13] Keefe JW. What is personalization? Phi Delta Kappan. 2007;**89**:217-223

[14] Ausubel DP, Novak JD, Hanesian H. Educational Psychology: A Cognitive View. 2nd ed. New York: Holt, Rinehart and Winston; 1978

[15] Vallori AB. Meaningful learning in practice. Journal of Education and Human Development. 2014;**3**:199-209

[16] Awofala AO. Effect of personalisation of instruction on students' motivation

to learn mathematics word problems in Nigeria. Turkish Journal of Computer and Mathematics Education (TURCOMAT). 2016;**7**(3):486-509

[17] Dorça FA, Araújo RD, De Carvalho VC, Resende DT, Cattelan RG. An automatic and dynamic approach for personalized recommendation of learning objects considering students learning styles: An experimental analysis. Informatics in education. 2016;**15**(1):45-62

[18] Cooper G. Cognitive load theory as an aid for instructional design. Australasian Journal of Educational Technology. 1990;**6**(2):108-113. DOI: 10.14742/ajet.2322

[19] Cunningham P, Matusovich HM, Hunter DA, McCord RE. Teaching metacognition: Helping engineering students take ownership of their own learning. In: 2015 IEEE Frontiers in Education Conference (FIE). El Paso, TX, USA: IEEE; 2015. pp. 1-5

[20] Ozden M. Improving science and technology education achievement using mastery learning model. World Applied Sciences Journal. 2008;**5**(1):62-67

[21] Jung CG. Analytical psychology. In: An Introduction to Theories of Personality. New York & London: Taylor & Francis Group; 2014. pp. 53-81

[22] West M, Vosloo S. UNESCO Policy Guidelines for Mobile Learning. Paris: United Nations Educational, Scientific and Cultural Organization; 2013. Available from: https://unesdoc.unesco.org/ark:/48223/pf0000219641 [Accessed: December 26, 2021]

[23] Bray B, McClaskey K. Personalization vs. Differentiations vs. Individualization, Report, (PDI). Amherst, NH, USA: V3 Personalize Learning, LLC; 2017. Available from: www.personalizelearning.com [Accessed: January 10, 2022]

[24] Vanhoof J, Van Petegem P. Matching internal and external evaluation in an era of accountability and school development: Lessons from a Flemish perspective. Studies in Educational Evaluation. 2007;**33**:101-119

[25] Zamir S, Flavian H. The psychometric entrance test: Lecturers' perceptions and standpoints concerning the nature of higher education admission exams in Israel. The Journal of Pedagogy, Pluralism and Practice. 2015;**7**:9-24. Available from: https://digitalcommons.lesley.edu/cgi/viewcontent.cgi?article=1090&context=jppp [Accessed: January 6, 2022]

[26] Norton GW. Improvement or control? A U.S. view of English inspection. In: Cullingford G, editor. An Inspector Calls: OFSTED and its Effect on School Standards. London: Kogan Page; 1999. pp. 70-96

[27] Nevo D. School evaluation: Internal or external? Studies in Educational Evaluation. 2001;**27**:95-106

[28] Nevo D. Dialogue evaluation: Combining internal and external evaluation. In: Nevo D, editor. School-Based Evaluation: An International Perspective. Oxford: Elsevier Science; 2002. pp. 3-16

[29] Vasilyeva E, De Bra P, Pechenizkiy M. Immediate elaborated feedback personalization in online assessment. In: Dillenbourg P, Specht M, editors. Times of Convergence. Technologies across Learning Contexts. EC-TEL 2008. Lecture Notes in Computer Science. Vol. 5192. Berlin, Heidelberg: Springer; 2008. pp. 449-460. DOI: 10.1007/978-3-540-87605-2_50

[30] Vasilyeva E, Puuronen S, Pechenizkiy M, Räsänen P. Feedback adaptation in web-based learning systems. Special issue of Int. Journal of Continuing Engineering Education and Life-Long Learning. 2007;**17**:337-357

[31] Tseng JC, Chu HC, Hwang GJ, Tsai CC. Development of an adaptive learning system with two sources of personalization information. Computers & Education. 2008;**51**:776-786

[32] McClure L, Yonezawa S, Jones M. Can school structures improve teacher-student relationships? The relationship between advisory programs, personalization and students' academic achievement. Education Policy Analysis Archives. 2010;**18**:n17

[33] Miller DC, Kulhavy RW. Personalizing sentences and text. Contemporary Educational Psychology. 1991;**16**:287-292

[34] Lopez CL, Sullivan HJ. Effect of personalization of instructional context on the achievement and attitudes of Hispanic students. Educational Technology Research and Development. 1992;**40**:5-14

[35] Pane JF, Steiner ED, Baird MD, Hamilton LS. Continued Progress: Promising Evidence on Personalized Learning. Santa Monica, CA: RAND Corporation; 2015. Available from: http://www.rand.org/pubs/research_reports/RR1365.html [Accessed: December 06, 2021]

[36] Bloom H, Unterman R. Sustained Positive Effects on Graduation Rates Produced by New York City's Small Public High Schools of Choice. New York: MDRC Publications;

[37] Midgley C, Feldlaufer H, Eccles J. Student/teacher relations and attitudes toward mathematics before and after the transition to junior high school. Child Development. 1989;**60**:981-992. DOI: 10.1111/J.1467-8624.1989.TB03529.X

[38] Shemesh O. Personalization of Learning. Hebrew: Trump Foundation; 2020

[39] Jenkins JM, Keefe JW. Two schools: Two approaches to personalized learning. Phi Delta Kappan. 2002;**83**:449-456

[40] Gates Foundation. Continued progress: Promising evidence on personalized learning – Report. 2016. Available from: https://usprogram.gatesfoundation.org/news-and-insights/usp-resource-center/resources/continued-progress-promising-evidence-on-personalized-learning--report [Accessed: December 13, 2021]

[41] Coffman T. Getting to the heart of technology integration: Virginia's instructional technology resource teacher program. Learning and Learning with Technology. 2009;**36**:20-23

[42] Day C, Gu Q. Variations in the conditions for teachers' professional learning and development: Sustaining commitment and effectiveness over a career. Oxford Review of Education. 2007;**33**:423-443

[43] Fullan M, Hargreaves A. What's Worth Fighting for in Your School? New York: Teachers College Press; 1996

[44] Zimmerman J. Why some teachers resist change and what principals can do about it. NASSP Bulletin. 2006;**90**:238-249

[45] Avidov-Ungar O, Eshet-Alkalai Y. [Chais] Teachers in a world of change: Teachers' knowledge and attitudes towards the implementation of innovative technologies in schools. Interdisciplinary Journal of E-Learning and Learning Objects. 2011;**7**:291-303

[46] Avinun Y. What kind of authority should be restored? Hed Hachinuch. 2007;**09**:60-61 (Hebrew)

[47] Redding S. Through the Student's Eyes: A Perspective on Personalized Learning and Practice Guide for Teachers. Center on Innovations in Learning. Philadelphia: Temple University; 2013

[48] Bishop PA, Downes JM, Netcoh S, Farber K, DeMink-Carthew J, Brown T, et al. Teacher roles in personalized learning environments. The Elementary School Journal. 2020;**121**:311-336

[49] Dweck C. Self-Theories: Their Role in Motivation, Personality, and Development. London: Psychology Press; 2000

Chapter 8

Perspective Chapter: The MetaFlex Framework – Harnessing Metacognition to Foster Psychological Flexibility and Growth

Sunder Kala Negi

Abstract

The aim of this chapter is to explore the MetaFlex Framework, which is a novel approach that combines metacognition and psychological flexibility to foster personal growth and enhance psychological well-being. The MetaFlex Framework focuses on the integration of metacognitive strategies and techniques to enhance self-awareness, cognitive flexibility, and adaptive thinking. The chapter used in-depth examination method of the theoretical foundations, practical applications, and potential outcomes associated with implementing the MetaFlex Framework. It highlights the importance of psychological flexibility in navigating life's challenges and emphasizes the role of metacognition in promoting adaptive behavior and values-driven action. The chapter discusses the empirical research and theoretical perspectives that underpin the MetaFlex Framework, providing valuable insights into the synergistic relationship between metacognition and psychological flexibility. Furthermore, the chapter provides practical guidance for individuals, educators, and professionals seeking to incorporate metacognitive practices into their daily lives to facilitate personal growth, resilience, and psychological well-being. By exploring the MetaFlex Framework, readers will gain a deeper understanding of how metacognition with psychological flexibility can serve as a powerful tool in cultivating resilience and fostering personal growth.

Keywords: metacognition, psychological flexibility, MetaFlex, psychological well-being, resilience, personal growth

1. Introduction

In today's rapidly changing and complex world, individuals are faced with various challenges and uncertainties that can impact their well-being and personal growth. The ability to navigate these challenges and adapt to changing circumstances is crucial for thriving in both personal and professional domains. The MetaFlex Framework offers a comprehensive approach to harnessing the power of metacognition to foster psychological flexibility and promote growth.

The MetaFlex Framework combines the principles of metacognition and psychological flexibility to provide individuals with a powerful set of tools and strategies for enhancing self-awareness, regulating emotions, and making intentional choices aligned with their values and goals. By integrating metacognitive processes with psychological flexibility techniques, individuals can develop a greater sense of agency, adaptability, and resilience, empowering individuals to thrive in the face of difficulties and take advantage of chances for personal growth.

Metacognition and psychological flexibility can improve cognitive, emotional, and well-being. Metacognition—self-awareness and cognitive regulation—complements psychological flexibility, which entails adapting to thoughts and emotions in accordance with values. Recent studies show that metacognition improves psychological flexibility [1–4]. Metacognition raises awareness of cognitive processes and beliefs, allowing more flexible responses to ideas and emotions and psychological flexibility. This integration may improve cognitive and emotional well-being and personal progress. Combining these constructs in research and interventions may help achieve these goals.

Metacognition, the cornerstone of the MetaFlex Framework, refers to one's awareness and comprehension of their own cognitive processes. It involves monitoring and reflecting on one's thoughts, beliefs, feelings, and behaviors, as well as the ability to regulate and manage them effectively. By developing metacognitive awareness, individuals gain an understanding of their own cognitive capabilities and weaknesses, identify unhelpful thinking patterns, and make conscious choices to support their well-being and personal growth. Psychological flexibility, another key component of the MetaFlex Framework, is the ability to fully engage with the current moment and make behavior choices that are consistent with the person's beliefs and objectives. It requires individuals to remain open, adaptable, and resilient in the face of challenges, setbacks, and uncertainty. Psychological flexibility enables individuals to respond to life's difficulties with greater acceptance, mindful awareness, and a willingness to take purposeful action.

MetFlex Framework by integrating metacognition and psychological flexibility offers a special and powerful approach to personal growth and well-being. It recognizes the interplay between metacognitive processes and psychological flexibility, as individuals develop a deep understanding of their cognitive and emotional states and learn to regulate them effectively to make informed choices and take meaningful action. In this comprehensive framework, individuals will explore various aspects of metacognition, including metacognitive understanding and metacognitive control, to enhance self-awareness and self-reflection. They will also learn how to apply metacognitive strategies to regulate and manage emotions effectively, promoting emotional well-being and resilience. Furthermore, the MetaFlex Framework provides individuals with practical tools and techniques to cultivate psychological flexibility in challenging situations. It emphasizes the value of adopting a growth mindset, learning from setbacks, and seeking opportunities for growth, allowing individuals to adapt, thrive, and flourish in the face of adversity.

The MetaFlex Framework extends its application beyond personal growth and well-being to interpersonal relationships, learning strategies, workplace challenges, and continuous professional development. It emphasizes the role of metacognition and psychological flexibility in improving communication, conflict resolution, learning outcomes, and adaptability to workplace changes. By leveraging the power of metacognition and psychological flexibility, using the MetaFlex Framework, people can develop a stronger sense of self-awareness, adaptability, and resilience. It trains them with the tools and strategies needed to navigate the complexities of life, make intentional choices, and embrace opportunities for personal growth and fulfillment.

In the following chapters, we will delve into the various components of the MetaFlex Framework and explore practical techniques and exercises to enhance metacognitive awareness, develop psychological flexibility, and foster personal growth. Through a comprehensive understanding and application of the MetaFlex Framework, individuals can embark on a transformative journey toward greater psychological flexibility, well-being, and a more fulfilling life.

1.1 Understanding metacognition and psychological flexibility and its relevance to human cognition

Higher-order cognitive processes known as "metacognition" involve reflecting on and controlling one's own cognitive processes. It includes being aware of and comprehending one's own ideas, knowledge, and cognitive processes as well as the capacity to keep an eye on, manage, and control those processes. Metacognition is the knowledge of one's own cognitive processes, outcomes, or anything connected to them [5]. John Flavell, a prominent psychologist, is widely regarded as the pioneer in the study of metacognition. His definition of metacognition places an emphasis on the knowledge component, which includes awareness, understanding, and the capacity for reflection on and control over one's cognitive processes. "Metacognition" is the ability to consciously control one's own cognitive processes as well as knowledge of one's own cognitive processes [6]. Ann L. Brown, another influential researcher in metacognition, echoes Flavell's definition but adds the element of conscious regulation. Brown claims that metacognition entails both awareness of one's own cognitive processes and the capacity to actively control, monitor, and modify those processes. Today's major projects emphasize metacognition and metacognitive skills [7–9]. Educational institutions, stakeholders, the education governing body, and scholars employ various terminologies, such as "twenty first-century skills," "higher-order thinking skills," "deeper learning outcomes," and "critical thinking and communication skills" in order to delineate and elucidate these particular proficiencies [10–12].

"Metacognition refers to the procedures by which learners organize, monitor, and evaluate their comprehension and performance" [13]. Dunlosky and Goodman's definition highlights the practical aspects of metacognition in learning contexts. It emphasizes the dynamic engagement of learners in planning their learning strategies, supervising their comprehension and progress, and evaluating their own understanding and performance. These definitions collectively emphasize the consciousness, control, and regulation of one's cognitive processes, including knowledge about one's own thinking, monitoring, and adapting strategies, and reflecting on one's understanding and performance. Metacognition enables individuals to be conscious of their own thought processes, including thoughts, beliefs, and knowledge. It involves recognizing what one knows, understands, and remembers, as well as identifying gaps in knowledge or areas that require further understanding.

Monitoring: Metacognition involves the ability to monitor one's own thinking processes, such as paying attention to how information is being processed, evaluating comprehension, and assessing the accuracy and effectiveness of problem-solving strategies. It allows individuals to assess their own understanding and performance in various cognitive tasks.

Control and regulation: Metacognition enables individuals to control and regulate their cognitive processes. This includes the ability to plan and set goals, select appropriate strategies, allocate attention and resources effectively, and adapt strategies when faced with challenges or changing circumstances. Metacognitive regulation involves monitoring one's progress toward a goal, evaluating the effectiveness of strategies being used, and making adjustments as necessary.

Reflection and evaluation: Metacognition encourages individuals to reflect on their own thinking, learning, and problem-solving experiences. It involves evaluating the success or failure of cognitive strategies, identifying areas for improvement, and making adjustments to enhance future performance. Reflection and evaluation facilitate deep learning and promote the transfer of knowledge and skills to new situations.

Learning and problem-solving: Metacognition is closely tied to learning and problem-solving. By being conscious of their own cognitive activities, individuals can engage in effective learning strategies, such as setting learning goals, organizing information, actively monitoring comprehension, and seeking clarification, when needed. Metacognition also aids in problem-solving by enabling individuals to select appropriate strategies, evaluate their effectiveness, and adapt them as necessary.

Metacognition is an essential cognitive ability that allows individuals to be aware of, monitor, control, and regulate their own cognitive processes. It plays a vital role in self-awareness, learning, problem-solving, and overall cognitive functioning. By developing metacognitive abilities, individuals can become more efficient learners, critical thinkers, and self-directed learners.

1.1.1 Exploring metacognitive processes: metacognitive knowledge and metacognitive regulation

Metacognition involves two key processes: metacognitive knowledge and metacognitive regulation. Let us explore each of these processes in more detail (**Figure 1**).

Metacognitive knowledge: The comprehension and awareness of one's own cognitive processes, as well as the understanding of how to govern and manage those processes, are all examples of metacognitive knowledge. It has three further subcomponents that can be separated:

Declarative knowledge: Declarative knowledge is one's own learning style, including knowledge of one's learning preferences, learning preferences, and personal goals. Understanding one's own cognitive capabilities and limitations is necessary for declaring knowledge.

Procedural knowledge: Knowledge regarding various cognitive techniques and approaches that can be used to speed up problem-solving, learning, and task

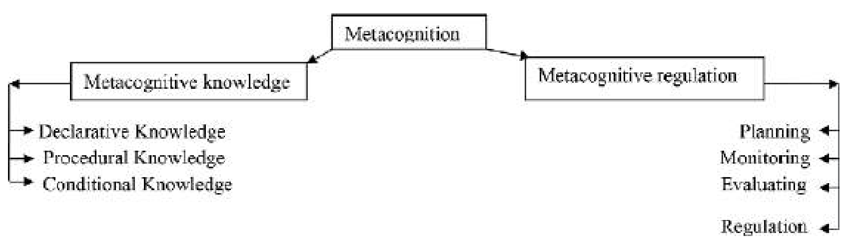

Figure 1.
Components of metacognition: Declarative and procedural knowledge, conditional knowledge, and metacognitive regulation processes [5].

completion is referred to as procedural knowledge. It comprises understanding efficient study methods, memory techniques, problem-solving approaches, and other cognitive abilities.

Conditional knowledge: It is knowing when and why to employ cognitive techniques. It comprises information about the requirements of the task, environmental variables, and contextual signals that affect the choice and use of suitable cognitive methods. People may analyze their cognitive capacities, choose effective learning and problem-solving techniques, and assess their own development and comprehension with the help of metacognitive knowledge.

Metacognitive regulation: The active management and control of one's cognitive processes is referred to as metacognitive regulation. To maximize learning, problem-solving, and performance, it entails monitoring, regulating, and adjusting cognitive methods. Several subcomponents of metacognitive control can be further broken down:

Planning: Setting objectives, organizing tasks, and creating methods to achieve them are all part of planning. Creating a plan of attack and assigning resources are part of it.

Monitoring: Continuous monitoring and evaluation of one's own cognitive processes while doing a task. It entails verifying comprehension, monitoring development, and identifying mistakes or misconceptions. Recognizing when extra tactics or changes are required is another aspect of monitoring.

Evaluating: Evaluating entails analyzing one's performance and results, comparing them to predetermined standards or benchmarks, and making decisions on the efficacy of one's tactics. People can evaluate their methods for learning or solving problems and make necessary changes for future growth.

Regulation: Regulation is the active management and modification of cognitive tactics based on observation and assessment. It entails choosing and putting into practice sensible techniques, keeping an eye on their efficacy, and adapting or replacing strategies as necessary. Metacognitive control helps people to learn more strategically, adaptably, and independently. They gain the ability to strengthen their cognitive functions, spot challenges and overcome them, and adjust their learning and performance.

While metacognitive regulation is actively monitoring, managing, and modifying these processes to attain desired goals, metacognitive knowledge gives people a grasp of their own cognitive processes and the techniques at their disposal. Both actions are vital to self-regulated learning and cognitive flexibility and are fundamental parts of metacognition.

1.2 Understanding the role of metacognition in self-awareness and self-reflection

Metacognition strongly encourages self-awareness and self-reflection. An examination of how metacognition affects these features is provided below:

Self-awareness: By encouraging a greater grasp of one's own cognitive functions, ideas, and emotions, metacognition improves self-awareness. People become aware of their own thought patterns, learning preferences, strengths, shortcomings, and biases through metacognitive processes. People can learn more about their cognitive capabilities, limits, and opportunities for development, thanks to this awareness [14, 15]. People can study their cognitive processes objectively by using metacognitive techniques, such as keeping track of their own thoughts and feelings. People who are conscious of their ideas can recognize harmful or unfavorable thought patterns, such as cognitive biases or distortions, and question them to encourage more accurate and balanced thinking. Further metacognition also assists people in identifying and controlling their emotions. People can better grasp how their emotions affect their ability to think clearly and make wise decisions by becoming more conscious of their emotional moods. Self-awareness of emotions empowers people to control their emotional outbursts and make more deliberate and well-informed decisions. Self-awareness of emotions empowers people to control their emotional outbursts and make more deliberate and informed decisions.

Self-reflection and regulation: Metacognition also aids in the process of self-reflection, which entails analyzing one's own ideas, deeds, and experiences. People can reflect on their own cognitive performance, learning methods, and problem-solving techniques, thanks to metacognitive processes. People can evaluate the efficacy of their cognitive processes and tactics through metacognitive reflection. They can pinpoint their strengths and potential improvement areas. People who reflect on their learning experiences can learn what worked and what did not, allowing them to improve their methods and improve learning results in the future. By helping people to think about different viewpoints and question their own preconceptions, metacognition also promotes reflective thinking. It encourages critical evaluation of one's own opinions and cognitive biases as well as open-mindedness. People can get a more complex knowledge of themselves and the world around them *via* this introspective process. Metacognition is a multidimensional concept consisting of different elements [16]. Additionally, metacognitive self-reflection encourages a development attitude since people realize that their skills and intellect may be improved *via* hard work and education. People may find lessons learned and create plans for ongoing progress by thinking back on previous experiences, failures, and accomplishments. In self-planned learning, problem-solving, decision-making, and general cognitive functioning, metacognition is essential. Because it enables individuals to develop awareness of their own thinking processes and control their cognitive activity, metacognition is crucial to human cognition. We may shed light on important features of metacognition and their application to human cognitive functioning by having a complete grasp of these processes and their crucial role in fostering self-awareness and self-reflection (**Figure 2**).

Metacognition plays a vital role in their cognitive processes, aiding the monitoring and management of thoughts and emotions, encouraging critical self-examination, and supporting a growth-oriented mentality; metacognition also plays a crucial role in self-awareness and self-reflection. People can improve their understanding of themselves, make better decisions, and actively participate in self-directed learning and personal growth by developing metacognitive skills [19, 20].

1.3 Psychological flexibility: embracing change and adaptability

Psychological flexibility refers to the capacity of a person to adapt, change, and successfully handle the difficulties that life provides. It entails the ability to actively participate in the experiences of the moment while making decisions and doing actions that are consistent with one's values and objectives. "Psychological flexibility is the ability to contact the present moment more fully as a conscious human being, and to change or persist in behavior when doing so serves valued ends" [21]. It entails the capacity of an individual to adapt, change, and successfully address the problems and ever-changing demands of life. It entails the ability to actively participate in the experiences of the moment while making decisions and doing actions that are consistent with one's values and objectives.

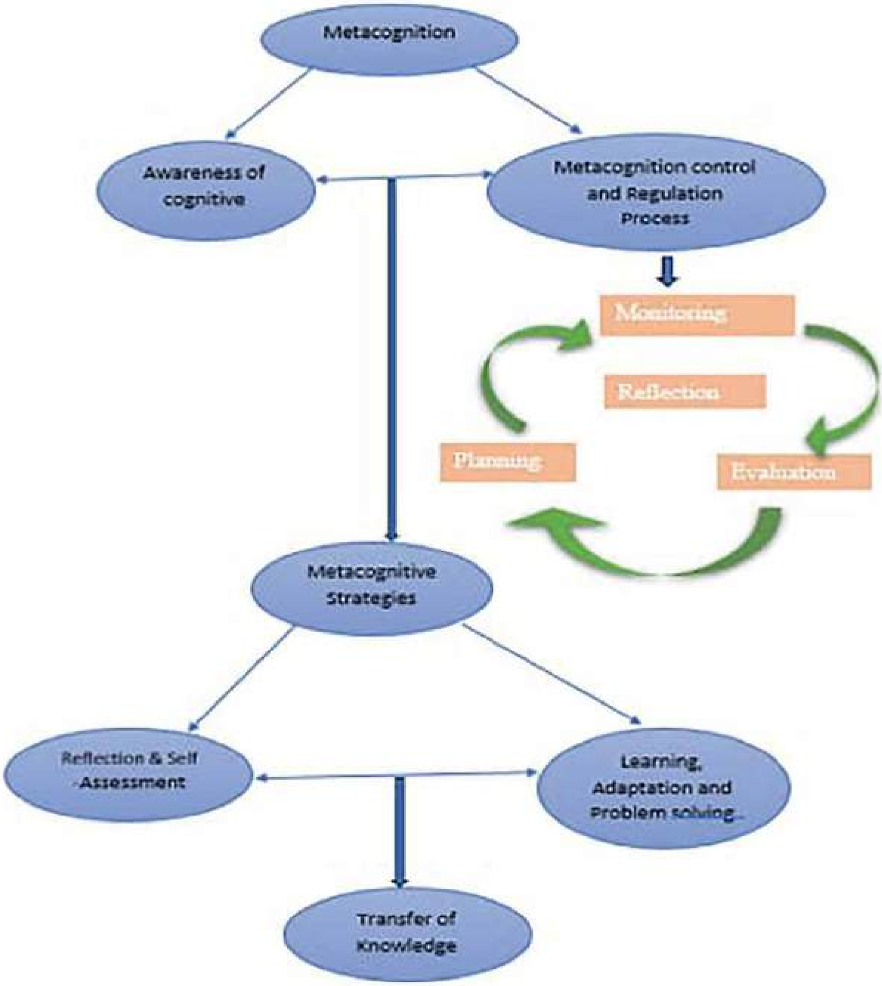

Figure 2.
The multifaceted elements of metacognition ([17, 18], p. 171).

One of the founders of Acceptance and Commitment Therapy (ACT), Steven C. Hayes, defines psychological flexibility as the ability to be fully present and engaged in the present moment, while simultaneously being able to flexibly modify or persist in one's behavior in alignment with personal values and goals. It emphasizes the value of adaptation, values-driven activity, and awareness. In the words of Kelly G. Wilson and Kirk D. Strosahl, "Psychological flexibility is the ability to make contact with the present moment and change or persist in behavior that serves valued ends" [22]. Psychological flexibility is the capacity to make decisions that are in line with one's values and effectively engage with the present moment, according to Wilson and Strosahl, who were also influential in the development of ACT. It highlights the value of behavior change.

Psychological flexibility is the capacity to maintain awareness of the present moment in the face of unpleasant thoughts, feelings, or physical sensations while making decisions about one's behavior that are motivated by values rather than immediate impulses. Psychological flexibility, as defined by Frank W. Bond and colleagues, is the ability to stay in the present moment, despite the presence of difficult thoughts, emotions, or physical sensations [23]. It places emphasis on the capacity to choose actions that are consistent with one's ideals rather than being merely motivated by irrational emotions or avoidance. Overall, psychological flexibility entails being aware of being present in the moment, as well as having the capacity to modify, alter, or maintain behavior in support of valued goals.

Acceptance and Commitment Therapy (ACT) is a form of psychotherapy that focuses on promoting psychological flexibility and helping individuals live a meaningful and values-driven life. Steven C. Hayes, Kelly G. Wilson, and Kirk D. Strosahl created it in the 1980s. The cognitive-behavioral therapy (CBT), behavior therapy, and mindfulness techniques are all incorporated into the context-dependent behavioral science framework that underpins ACT. The fundamental ideas and methods of ACT are intended to promote acceptance, mindfulness, and commitment to acts that are motivated by values in order to aid people in developing psychological flexibility. The main tenets and elements of Acceptance and Commitment Therapy are as follows:

- Acceptance: ACT emphasizes accepting and embracing difficult thoughts, emotions, and bodily sensations rather than attempting to suppress or avoid them. It involves acknowledging and making room for these experiences without judgment or attachment.

- Cognitive defusion: ACT utilizes techniques to help individuals distance themselves from unhelpful thoughts and beliefs. By learning to observe thoughts rather than becoming entangled in them, individuals can reduce the impact of negative or unproductive thinking patterns.

- Mindfulness: Mindfulness practices are an integral part of ACT. By cultivating present-moment awareness and nonjudgmental observation, individuals can develop a more accepting and open attitude toward their experiences.

- Values clarification: ACT encourages individuals to identify and clarify their personal values—what is truly important and meaningful to them. By aligning behavior with values, individuals can make choices that lead to a more fulfilling and purpose-driven life.

- Committed action: In ACT, individuals are encouraged to take action consistent with their identified values. This involves setting goals and engaging in behaviors that align with those values, even in the face of discomfort or challenging thoughts and emotions.

One of ACT's main objectives is psychological adaptability. It speaks to the capacity to efficiently adjust to shifting situations and obstacles in life. Individuals can become more resilient, receptive, and adaptable in the face of challenges by cultivating psychological flexibility. A variety of psychological issues, such as anxiety disorders, depression, substance misuse, chronic pain, and stress-related illnesses, have been successfully treated with ACT. It can be combined with other therapeutic modalities and is frequently given in individual or group treatment settings. With the help of ACT, people may manage the problems of life, increase their psychological pliability, and improve their general well-being. It has gained popularity for its emphasis on acceptance, mindfulness, and values-driven action as key components of psychological well-being and personal growth. Psychological flexibility is a fundamental concept within Acceptance and Commitment Therapy (ACT). It serves as a guiding principle and a desired outcome of ACT interventions. Psychological flexibility refers to an individual's ability to adapt and respond effectively to the ongoing challenges and stressors of life while staying committed to their values and taking action that aligns with those values.

ACT recognizes that human suffering often arises from attempts to avoid or control difficult thoughts, emotions, and sensations. Psychological rigidity, which manifests as experience avoidance, rigid thought patterns, and being ruled by one's ideas and feelings, can exacerbate emotional suffering and make it more difficult to lead a fulfilling life. ACT, on the other hand, strives to foster psychological flexibility in order to enhance well-being and lessen suffering. It entails the creation of six fundamental processes: By allowing painful thoughts, feelings, and physical sensations to be present without fighting or rejecting them, ACT encourages people to make place for them. Learning to view thoughts and beliefs as merely cognitive experiences as opposed to unchanging facts is a necessary step in this process. It assists people in separating themselves from negative ideas and minimizing their influence on behavior.

ACT places a strong emphasis on developing mindfulness and raising present-moment awareness, which enables people to fully engage in their experiences. Realizing that people's beliefs, feelings, and experiences do not define them is a step in this process. It encourages a sense of self that is distinct from these fleeting qualities, encouraging a more adaptable and sympathetic viewpoint. By focusing on these fundamental processes, ACTs seek to improve psychological adaptability. People can better negotiate life's problems, lessen suffering, and live a more authentic and values-driven life by encouraging acceptance, defusion, mindfulness, self-as-context, values definition, and committed action. According to research, psychological flexibility is linked to favorable outcomes for mental health, such as decreased psychological distress, enhanced well-being, and boosted resilience. A valuable method for resolving a variety of psychological issues and fostering personal growth and flourishing, ACT offers useful tools and treatments to cultivate psychological flexibility.

1.3.1 Benefits of psychological flexibility for well-being and personal growth

Psychological flexibility, as cultivated through practices such as Acceptance and Commitment Therapy (ACT), offers numerous benefits for well-being and personal growth. Here are some key advantages:

- Reduced psychological distress: Psychological flexibility helps individuals effectively cope with difficult thoughts, emotions, and life challenges, leading to reduced psychological distress. By accepting and allowing for uncomfortable experiences without getting entangled in them, individuals can experience a greater sense of inner calm and resilience.

- Improved emotional regulation: Psychological flexibility enhances emotional regulation by promoting acceptance and mindful observation of emotions. Rather than trying to suppress or avoid emotions, individuals learn to acknowledge and tolerate them, which can lead to greater emotional balance and a decreased tendency to be overwhelmed by negative emotions.

- Increased resilience: The ability to adapt and respond flexibly to life's challenges is a key aspect of psychological flexibility. It enables individuals to bounce back from setbacks, navigate stressful situations, and cope with adversity more effectively. Psychological flexibility fosters resilience by helping individuals stay connected to their values and take meaningful action even in the face of difficulties.

- Enhanced problem-solving and decision-making: Psychological flexibility promotes clearer thinking and flexible problem-solving. By cultivating cognitive defusion, individuals can disentangle themselves from unhelpful thought patterns and engage in creative problem-solving. This ability to approach problems with a more open and adaptive mindset can lead to more effective decision-making and problem-solving skills.

- Increased well-being and life satisfaction: Psychological flexibility is associated with greater well-being and life satisfaction. By aligning one's behavior with personal values and engaging in actions that are meaningful and fulfilling, individuals experience a greater sense of purpose and satisfaction in life.

- Improved interpersonal relationships: Psychological flexibility supports healthier and more satisfying relationships. By being present and accepting in interpersonal interactions, individuals can communicate more effectively, empathize with others, and respond flexibly to relationship challenges. This leads to improved communication, increased understanding, and enhanced relationship quality.

- Personal growth and authenticity: Psychological flexibility fosters personal growth by encouraging individuals to live in alignment with their true values and aspirations. It supports self-discovery and self-acceptance, allowing individuals to develop a more authentic and meaningful life path.

- Greater engagement in life: Psychological flexibility encourages individuals to engage fully in their experiences and pursue activities that are personally meaningful. By clarifying their values and taking committed action aligned with those values, individuals can prioritize what truly matters to them and actively participate in activities that bring fulfillment and purpose. This engagement in meaningful pursuits promotes a sense of satisfaction and a deeper sense of well-being.

- Increased self-awareness and self-reflection: Psychological flexibility involves a heightened awareness of one's thoughts, emotions, and experiences. Through practices like mindfulness and self-reflection, individuals develop a clearer understanding of themselves and their inner experiences. This self-awareness allows individuals to make more intentional choices, align their behavior with their values, and make constructive changes in their lives.

Overall, psychological flexibility offers a range of benefits for well-being and personal growth. It empowers individuals to navigate life's challenges with greater resilience, make choices aligned with their values, enhance emotional well-being, and cultivate meaningful relationships. By embracing psychological flexibility, individuals can foster a sense of fulfillment, growth, and overall psychological well-being.

DOI: http://dx.doi.org/10.5772/intechopen.113920

2. The MetaFlex framework: integrating metacognition and psychological flexibility

The integration of metacognition and psychological flexibility provides a promising framework for understanding and enhancing individuals' cognitive and emotional processes, as well as their overall well-being. Metacognition, which involves the awareness and regulation of one's own cognitive processes, can complement psychological flexibility, which focuses on adaptively responding to thoughts, emotions, and experiences in line with personal values. Recent studies support the notion that combining these two constructs can yield synergistic benefits.

Research by Sugiura and Sugiura [1, 4] found that individuals with higher levels of metacognitive awareness demonstrated greater psychological flexibility. Metacognitive awareness facilitated the ability to recognize and regulate unhelpful thinking patterns, enabling individuals to flexibly respond to challenging situations and align their behavior with their values. Similarly, a study by de Bruin et al. [3] highlighted the positive relationship between metacognitive skills and psychological flexibility, emphasizing that metacognition can enhance individuals' ability to adaptively respond to their thoughts and emotions. Moreover, a study by Gloster et al. [24, 25] examined the role of metacognitive beliefs in the context of psychological flexibility. The findings indicated that individuals with more flexible metacognitive beliefs, characterized by a balanced view of their thoughts and emotions, exhibited higher levels of psychological flexibility. These results suggest that metacognitive beliefs can influence individuals' ability to engage in valued actions, despite the presence of challenging thoughts or emotions.

Additionally, studies have shown that interventions targeting metacognitive processes and psychological flexibility can lead to positive outcomes. For instance, a randomized controlled trial by Gillanders et al. [26] evaluated the effectiveness of a metacognitive therapy intervention that incorporated elements of psychological flexibility. The intervention resulted in improved psychological flexibility and reductions in symptoms of anxiety and depression.

Recent studies provide empirical support for the integration of metacognition and psychological flexibility. Metacognition enhances individuals' awareness of their cognitive processes and beliefs, allowing for more flexible responses to thoughts and emotions. This integration has been associated with improved psychological flexibility and positive outcomes. Further research and interventions combining these constructs hold promise for enhancing cognitive and emotional well-being and promoting personal growth.

2.1 Exploring the synergistic relationship between metacognition and psychological flexibility

Metacognition and psychological flexibility are two distinct constructs that play complementary roles in enhancing cognitive and emotional processes. Metacognition involves the awareness and regulation of one's own cognitive processes, including thinking, memory, and problem-solving. On the other hand, psychological flexibility refers to the ability to adaptively respond to thoughts, emotions, and experiences in a way that aligns with personal values and goals. While these constructs operate at different levels of cognitive processing, recent research suggests that they have a synergistic relationship that can enhance overall well-being and personal growth.

The integration of metacognition and psychological flexibility allows individuals to develop a deeper understanding of their cognitive and emotional experiences, as well as the ability to respond to them in a flexible and adaptive manner. By cultivating metacognitive awareness, individuals become more attuned to their thoughts, emotions, and beliefs, allowing them to recognize unhelpful thinking patterns and biases. This heightened self-awareness enables individuals to disengage from automatic and rigid cognitive processes, promoting psychological flexibility.

Studies have demonstrated a positive relationship between metacognition and psychological flexibility. For instance, research by Levin et al. [27] found that metacognitive awareness was associated with greater psychological flexibility in individuals with anxiety disorders. The study revealed that those who exhibited higher levels of metacognitive awareness were better able to engage in valued actions, despite experiencing anxious thoughts and emotions. This suggests that metacognition can enhance individuals' ability to respond flexibly to challenging internal experiences (**Table 1**).

Moreover, metacognition can facilitate the application of psychological flexibility strategies. For example, the process of cognitive defusion, which involves creating distance from unhelpful thoughts and beliefs, can be strengthened through metacognitive awareness. By recognizing thoughts as mental events rather than accurate representations of reality, individuals can defuse from them more effectively and choose responses that align with their values. The integration of metacognition and psychological flexibility has practical implications for interventions and therapies. Combining metacognitive strategies with Acceptance and Commitment Therapy (ACT) or cognitive-behavioral therapy (CBT) interventions can provide individuals with a comprehensive toolkit for enhancing cognitive and emotional well-being. Interventions that target metacognitive processes, such as metacognitive therapy, can be integrated with techniques that promote psychological flexibility, such as values clarification and mindfulness. This integrated approach allows individuals to develop metacognitive skills that support flexible responses to their thoughts and emotions, ultimately leading to improved mental health outcomes.

Facets	Metacognition	Psychological flexibility	Intersection (MetaFlex)
Key traits	Awareness of thoughts	Adaptive responses	Enhanced decision-making
	Self-reflection	Open-mindedness	Flexible problem-solving
	Monitoring cognitive processes	Values-driven actions	Mindful self-awareness
Concept focus	Understanding one's own	Responding effectively to	Combined elements leading to
	thinking and cognitive	emotional and cognitive	heightened cognitive and
	processes	challenges	emotional flexibility
Beneficial traits	Informed decision-making	Adaptable problem-solving	Improved problem-solving
	Mindful self-reflection	Values-driven choices	Enhanced emotional intelligence
	Better cognitive control	Openness to experience	Resilient responses
		Mindfulness	

Table 1.
Relationship between metacognition and psychological flexibility as MetaFlex framework [27].

The relationship between metacognition and psychological flexibility is synergistic, as they mutually enhance and support each other. Metacognitive awareness provides individuals with the ability to recognize and regulate their cognitive processes, while psychological flexibility allows for adaptive responses to thoughts and emotions in alignment with personal values. Future research and interventions can further explore and leverage this synergistic relationship to promote well-being, personal growth, and effective coping strategies in various contexts.

2.2 Role of metacognition in enhancing psychological flexibility and promoting growth

Metacognition plays a crucial role in enhancing psychological flexibility and promoting personal growth. When integrated with psychological flexibility, metacognition can facilitate adaptive responses to internal experiences, promote resilience, and foster personal growth. Metacognition enables individuals to become aware of their thoughts and beliefs, including their accuracy, biases, and impact on emotions and behaviors. This awareness allows individuals to recognize unhelpful or negative thinking patterns and cognitive distortions. By identifying and challenging these patterns, individuals can cultivate psychological flexibility and develop more adaptive ways of thinking. Metacognition supports cognitive defusion, a process central to psychological flexibility. Cognitive diffusion involves creating distance from and changing the relationship with one's thoughts, allowing individuals to observe them as mental events rather than absolute truths. Metacognitive awareness helps individuals recognize the transient nature of thoughts and reduces their impact on emotions and behaviors, enabling more flexible and adaptive responses.

Metacognition encourages self-reflection, introspection, and the ability to take different perspectives. Through metacognitive processes, individuals can reflect on their thoughts, emotions, and experiences, gaining insights into their own cognitive and emotional processes. This self-reflection promotes self-understanding, empathy, and a broader perspective, all of which contribute to psychological flexibility and personal growth. Metacognition involves monitoring and regulating emotions, which are integral components of psychological flexibility. By being aware of their emotional states, individuals can identify when emotions are driving their thoughts and behaviors. This awareness allows individuals to choose responses aligned with their values rather than being driven by reactive emotions. Metacognitive strategies, such as emotion regulation techniques and mindfulness, can enhance emotional self-regulation and support psychological flexibility.

Metacognition facilitates learning from experiences and adjusting cognitive and behavioral strategies accordingly. Through metacognitive processes, individuals can reflect on past experiences, evaluate their effectiveness, and make moral and mature adjustments for future situations [28]. Popandopulo et al. [29, 30] highlight the iterative process of self-reflection and learning enhances adaptive responses, fosters personal growth, and promotes the development of more effective coping strategies. Research supports the link between metacognition and psychological flexibility. Studies have found that metacognitive interventions, such as metacognitive therapy or mindfulness-based approaches, enhance psychological flexibility and reduce psychological distress [31, 32]. The integration of metacognitive strategies within Acceptance and Commitment Therapy (ACT) has also shown promising results in promoting psychological flexibility [27].

Research supports the importance of metacognition and psychological flexibility in promoting growth and well-being. For example, a study by Sauer et al. (2019) found that metacognitive awareness was positively associated with psychological well-being and adaptive coping strategies. Individuals with higher levels of metacognitive awareness demonstrated greater emotional regulation and resilience in the face of stressors.

Similarly, research by Kashdan et al. [33] highlighted the benefits of psychological flexibility for well-being. The study showed that psychological flexibility was associated with higher levels of life satisfaction, positive emotions, and overall psychological well-being. It also found that psychological flexibility played a protective role against the negative impact of stress on mental health.

Interventions that target metacognition and psychological flexibility have also shown promise in promoting growth and well-being. For instance, metacognitive therapy and Acceptance and Commitment Therapy (ACT) interventions incorporate strategies to enhance metacognition and psychological flexibility, respectively. These interventions have been effective in reducing symptoms of anxiety, depression, and other mental health disorders while promoting personal growth and adaptive functioning.

Metacognition plays a crucial role in enhancing psychological flexibility and promoting personal growth. By cultivating metacognitive awareness, individuals can develop a deeper understanding of their cognitive and emotional processes, challenge unhelpful thoughts and beliefs, regulate emotions, and engage in adaptive responses. The integration of metacognition with interventions and therapies can support individuals in developing greater psychological flexibility, resilience, and personal growth. Metacognition and psychological flexibility are essential for promoting growth and well-being. Metacognition enables individuals to develop self-awareness, challenge unhelpful thinking patterns, and improve cognitive functioning. Psychological flexibility empowers individuals to accept their internal experiences, make choices aligned with their values, and respond adaptively to life's challenges. By cultivating these constructs, individuals can enhance their resilience, cope effectively with stressors, and pursue meaningful and fulfilling lives.

2.3 Core components of the MetaFlex framework

2.3.1 Developing metacognitive awareness: recognizing and monitoring thoughts, emotions, and behaviors

- Developing metacognitive awareness is a valuable skill that can enhance cognitive functioning, self-reflection, and adaptive thinking. Some strategies and practices to help individuals cultivate metacognitive awareness:

- Mindfulness meditation: Engage in regular mindfulness meditation practices to cultivate present-moment awareness and nonjudgmental observation of thoughts and experiences. Mindfulness helps individuals become more attuned to their cognitive processes and increases their ability to notice thoughts as they arise.

- Reflective journaling: Set aside time for reflective journaling, where you can write about your thoughts, emotions, and experiences. This practice encourages self-reflection and helps you gain insights into your cognitive patterns, biases, and underlying beliefs.

- Thought monitoring: Pay attention to your thoughts throughout the day and actively observe their content and patterns. Notice any recurring themes, negative self-talk, or cognitive distortions. Regularly check in with your thoughts and become aware of their impact on your emotions and behavior.

- Metacognitive questions: Ask yourself metacognitive questions to deepen your awareness and understanding of your cognitive processes. Examples of such questions include:

  "What am I thinking right now?"

  "What evidence supports or contradicts my thoughts?"

  "Are my thoughts based on facts or assumptions?"

  "What are the possible alternative explanations or perspectives?"

- Seek feedback: Engage in conversations with trusted individuals who can provide constructive feedback and different perspectives on your thoughts, behaviors, and decision-making processes. External feedback can help you gain insights into blind spots and biases that may be influencing your thinking.

- Cognitive flexibility exercises: Engage in activities that challenge your cognitive flexibility and encourage you to think outside of habitual patterns. Solve puzzles, engage in brainstorming sessions, or participate in activities that require you to consider multiple perspectives and alternative solutions.

- Metacognitive training programs: Consider participating in metacognitive training programs or workshops that specifically focus on developing metacognitive skills. These programs often provide structured guidance and exercises to enhance self-awareness, critical thinking, and effective learning strategies.

- Reflect on past experiences: Reflect on past experiences and evaluate how your thoughts and beliefs influenced your behavior and outcomes. Consider the lessons learned and identify opportunities for improvement in your cognitive processes.

Developing metacognitive awareness is an ongoing practice that requires patience and persistence. By incorporating these strategies into your daily life, you can gradually increase your metacognitive awareness and gain a deeper understanding of your cognitive processes, leading to improved self-reflection, adaptive thinking, and enhanced cognitive functioning.

2.3.2 Cultivating psychological flexibility: applying the six core processes in daily life

Cultivating psychological flexibility involves applying the six core processes in our daily lives. These core processes, namely acceptance, cognitive defusion, present-moment awareness, self-as-context, values clarification, and committed action, provide a framework for developing flexibility in our thoughts, emotions, and behaviors. First, acceptance involves embracing our thoughts and emotions without judgment or resistance. Instead of trying to push them away or avoid them, we acknowledge and allow them to be present. By accepting our internal experiences, we create space for them and prevent them from dominating our actions and decisions. Second, cognitive defusion focuses on recognizing that our thoughts are not necessarily facts or truths. We learn to step back and observe our thoughts rather than becoming entangled or fused with them. This defusion allows us to see thoughts as passing events and reduces their power to dictate our behavior or hinder our well-being. Third, present-moment awareness involves bringing our attention to the here and now. By practicing mindfulness, we cultivate an ability to fully engage with the present moment, rather than being caught up in regrets about the past or worries about the future. This awareness allows us to respond more intentionally and skillfully to the demands of the present moment [15].

Fourth, self-as-context refers to recognizing ourselves as the observer or witness of our experiences, rather than being solely identified with our thoughts, emotions, or roles. This perspective helps us develop a sense of psychological flexibility and allows us to view our experiences from a broader and more objective standpoint. Fifth, values clarification involves exploring and identifying what truly matters to us in life. By clarifying our core values, we gain a clear sense of what we want to stand for and what gives our lives meaning and purpose. Aligning our actions with our values guides our decision-making and helps us navigate challenging situations in a way that is in harmony with our deepest aspirations. Lastly, committed action entails taking purposeful steps toward our values. It involves setting goals and consistently engaging in actions that move us closer to the life we want to live, even when faced with discomfort or obstacles. Committed action requires perseverance, resilience, and a willingness to step out of our comfort zones [14]. By consciously applying these six core processes in our daily lives, we cultivate psychological flexibility. We learn to accept our experiences, defuse from unhelpful thoughts, be present in the moment, view ourselves as observers, clarify our values, and take committed action. With practice, these processes become integrated into our way of being, allowing us to navigate challenges, adapt to change, and foster well-being and personal growth.

2.3.3 Fostering a growth mindset: embracing challenges, learning from setbacks, and seeking opportunities for growth

Fostering a growth mindset is a transformative approach to personal development that involves embracing challenges, learning from setbacks, and seeking opportunities for growth. When individuals cultivate a growth mindset, they believe that their abilities and intelligence can be developed through dedication, effort, and learning (**Figure 3**).

MetaFlex mindset empowers them to approach life's challenges with resilience, view setbacks as opportunities for learning, and actively seek out new experiences that foster growth and development. Embracing challenges is a fundamental aspect of a growth mindset. Rather than shying away from difficult tasks, individuals with a growth mindset see challenges as opportunities for growth and learning. They understand that by stepping outside of their comfort zones and tackling challenges head-on, they can develop new skills, gain valuable experiences, and expand their knowledge and abilities.

Learning from setbacks is another key component of fostering a growth mindset. Instead of viewing failures or setbacks as indicators of their worth or potential, individuals with a growth mindset see them as valuable learning opportunities. They approach setbacks with curiosity and a willingness to reflect on what went wrong, what they can learn from the experience, and how they can improve in the future.

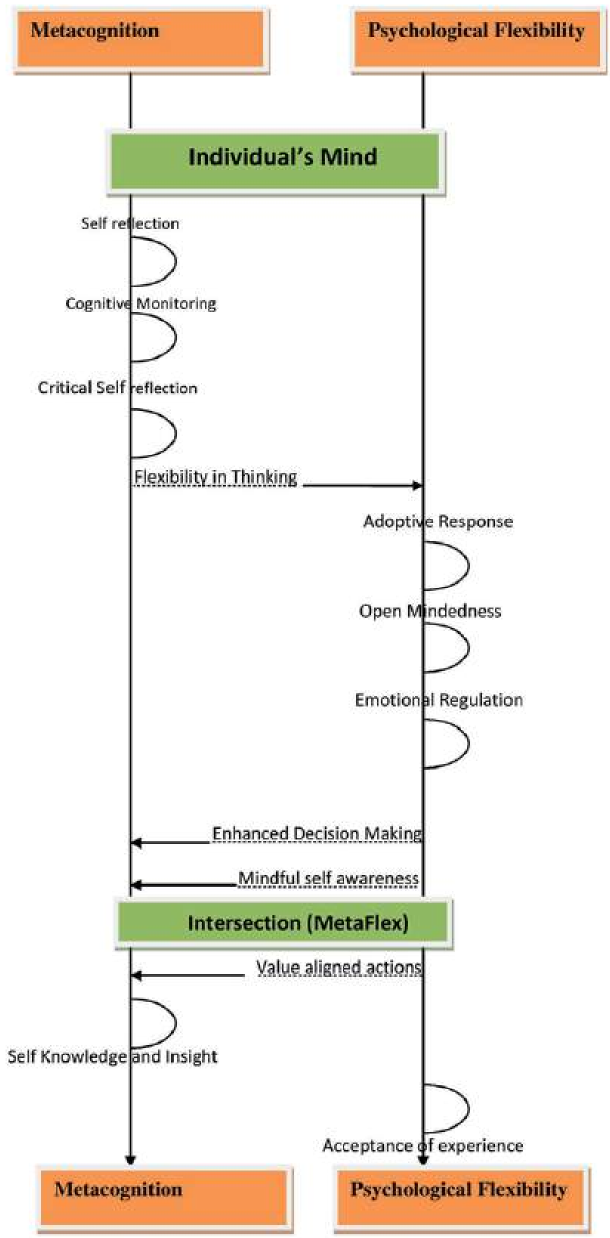

Figure 3.
Diagram for different strategies that can be used to develop cognitive mastery with the MetaFlex framework.

This mindset shift allows them to bounce back from setbacks stronger and more determined than before. Seeking opportunities for growth is an essential practice for fostering a growth mindset. Individuals with a growth mindset actively seek out new challenges and experiences that push them beyond their current capabilities. They understand that growth occurs when they step outside of their comfort zones and embrace new opportunities for learning and development. Whether it's pursuing new skills, taking on unfamiliar projects, or seeking feedback from others, they are committed to continuous improvement and personal growth.

Recent studies have supported the benefits of fostering a growth mindset. For example, a study by Dweck et al. [34] found that students who were taught about the concept of a growth mindset showed increased motivation, effort, and resilience in the face of challenges compared to those who were not exposed to the concept. Another study by Blackwell et al. [35] demonstrated that individuals with a growth mindset outperformed those with a fixed mindset on academic tasks and were more likely to persist in the face of obstacles. Fostering a growth mindset is a powerful approach to personal development. Embracing challenges, learning from setbacks, and actively seeking opportunities for growth can lead to increased resilience, motivation, and a lifelong commitment to learning and self-improvement. By cultivating a growth mindset, individuals open themselves up to new possibilities, continuously expand their abilities, and achieve personal and professional growth.

2.4 Implementing the MetaFlex framework for personal growth

2.4.1 Enhancing self-awareness through metacognitive monitoring techniques

Enhancing self-awareness through metacognitive monitoring techniques is a powerful strategy for personal growth and self-improvement. Metacognitive monitoring involves observing and evaluating our own cognitive processes, including thoughts, beliefs, emotions, and behaviors. By actively engaging in metacognitive monitoring, we cultivate a heightened sense of self-awareness and gain valuable insights into our own thinking patterns and their impact on our well-being and actions.

One technique for metacognitive monitoring is thought monitoring, which involves paying close attention to our thoughts throughout the day. By consistently observing our thoughts, we can identify recurring themes, patterns of negative self-talk, or cognitive distortions that may be influencing our emotions and behaviors. Thought monitoring allows us to become more aware of our cognitive biases and automatic thinking processes, enabling us to challenge and reframe unhelpful thoughts.

Another technique is keeping a reflective journal. Regularly recording our thoughts, emotions, and experiences in a journal provides an opportunity for self-reflection and deeper self-understanding. Writing allows us to process our thoughts and gain clarity about the underlying beliefs and assumptions that shape our perspectives and actions. Through journaling, we can identify patterns, triggers, and areas of personal growth, fostering self-awareness and self-discovery. Metacognitive questioning is another effective technique for enhancing self-awareness. By asking ourselves metacognitive questions, such as "What am I thinking right now?" or "What evidence supports or contradicts my thoughts?" We prompt ourselves to examine our thoughts more critically and objectively. These questions invite us to evaluate the validity and usefulness of our thoughts, encouraging a deeper level of self-awareness and cognitive flexibility.

In recent studies, metacognitive monitoring techniques have been shown to have numerous benefits. For example, a study by Ortner et al. [36] found that individuals who engaged in metacognitive monitoring showed increased self-awareness, self-regulation, and well-being. Another study by Morin [37] demonstrated that metacognitive monitoring techniques, such as thought monitoring and journaling, were effective in reducing rumination and improving emotional well-being. By practicing metacognitive monitoring techniques, we develop a greater understanding of ourselves, our cognitive processes, and their influence on our emotions and behaviors. This enhanced self-awareness allows us to make conscious choices, challenge unhelpful thoughts, and respond more intentionally to life's challenges. It empowers us to cultivate psychological flexibility, make positive changes, and foster personal growth and well-being.

2.4.2 Utilizing metacognitive strategies to regulate and manage emotions

Utilizing metacognitive strategies to regulate and manage emotions is a powerful tool for promoting emotional well-being and enhancing emotional intelligence. Metacognition involves the awareness and monitoring of our own cognitive processes, and when applied to emotions, it allows us to observe and regulate our emotional experiences in a more intentional and adaptive manner. The metacognitive strategy for emotion regulation is cognitive reappraisal. This technique involves consciously reframing or reinterpreting the meaning of a situation or event in order to change our emotional response. By engaging in cognitive reappraisal, we can challenge and modify the thoughts and beliefs that contribute to intense or distressing emotions. For example, we can reframe a challenging situation as an opportunity for growth or view a setback as a temporary setback rather than a reflection of our worth. This cognitive restructuring allows us to regulate our emotional reactions and choose more adaptive responses. Another metacognitive strategy for emotion regulation is attentional deployment. It involves directing our attention away from distressing or negative stimuli and toward more positive or neutral aspects of our environment. By consciously shifting our focus, we can reduce the intensity of negative emotions and cultivate a more balanced perspective. For instance, if we find ourselves ruminating on a past mistake, we can redirect our attention to the present moment or engage in an enjoyable activity to create a positive emotional shift.

Metacognitive monitoring of emotions also involves being aware of our emotional states and the bodily sensations that accompany them. By developing a greater somatic awareness, we can identify and label our emotions more accurately. This self-awareness allows us to respond to our emotions with greater mindfulness and self-compassion, rather than getting swept away by them. Through practices such as meditation or body scans, we can cultivate a nonjudgmental and accepting stance toward our emotions, which promotes emotional regulation and resilience.

Recent studies have demonstrated the effectiveness of metacognitive strategies in emotion regulation. For instance, a study by Kivity et al. [38] found that individuals who engaged in cognitive reappraisal exhibited lower levels of negative emotions and increased well-being compared to those who did not utilize this strategy. Another study by Ortner et al. [39] showed that attentional deployment techniques, such as mindfulness-based interventions, were effective in reducing emotional reactivity and promoting emotional regulation.

Utilizing metacognitive strategies for emotion regulation enables individuals to have greater control over their emotional experiences and responses. By applying techniques such as cognitive reappraisal, attentional deployment, and somatic awareness, individuals can cultivate emotional intelligence, navigate challenging situations with greater resilience, and foster overall well-being. Integrating metacognitive approaches into daily life empowers individuals to regulate their emotions in a more intentional and adaptive manner, leading to enhanced emotional well-being and psychological growth.

2.4.3 Integrating psychological flexibility techniques in challenging situations

Integrating psychological flexibility techniques in challenging situations is a powerful approach to navigate adversity, enhance resilience, and promote well-being. Psychological flexibility refers to the ability to adaptively respond to the ever-changing demands of life by being present, accepting difficult emotions, and taking committed action aligned with one's values. When facing challenging situations, incorporating psychological flexibility techniques can support individuals in effectively managing stress and promoting positive outcomes.

One of the core techniques of psychological flexibility is mindfulness. By cultivating present-moment awareness and nonjudgmental acceptance of one's thoughts, emotions, and sensations, mindfulness allows individuals to engage with the present situation more fully and respond consciously. This practice enables individuals to step out of automatic reactive patterns and make more intentional choices aligned with their values, even in the midst of difficulty. Acceptance is another essential psychological flexibility technique. It involves acknowledging and embracing the full range of emotions, including discomfort and pain, without attempting to avoid or suppress them. Acceptance allows individuals to create space for these emotions to exist while recognizing that they do not define their entire experience. By accepting difficult emotions, individuals can respond to challenges with greater clarity and effectiveness, rather than being overwhelmed or controlled by their emotional reactions. Value clarification and committed action are additional techniques that can be integrated in challenging situations. Value clarification involves identifying one's core values—what truly matters most in life—and using them as a compass to guide decision-making and action. By aligning actions with values, individuals can make choices that are congruent with their authentic selves, even when faced with adversity. Committed action refers to taking intentional steps toward valued goals, even in the presence of discomfort or obstacles. It involves breaking down goals into manageable tasks and persisting in the pursuit of those goals, despite challenges that may arise.

Recent studies have highlighted the benefits of incorporating psychological flexibility techniques in challenging situations. For instance, a study by Gloster et al. [24, 25] demonstrated that individuals who received Acceptance and Commitment Therapy (ACT), an approach that emphasizes psychological flexibility, showed reduced psychological distress and increased well-being compared to those who did not receive the intervention. Another study by Kashdan and Rottenberg [40] found that psychological flexibility was associated with better emotional well-being and adaptive responses to stressors.

Integrating psychological flexibility techniques in challenging situations empowers individuals to navigate adversity with resilience and well-being. By incorporating mindfulness, acceptance, value clarification, and committed action, individuals can cultivate a more adaptive and empowered response to challenging circumstances. These techniques enable individuals to remain present, accept difficult emotions, and take intentional action aligned with their values, leading to increased well-being, personal growth, and positive outcomes.

2.5 MetaFlex in relationships and interpersonal dynamics

2.5.1 Applying metacognition to improve communication and conflict resolution

Applying metacognition to improve communication and conflict resolution can greatly enhance the quality of our interactions and relationships. Metacognition, the awareness and monitoring of our own cognitive processes, allows us to step back and reflect on how we communicate, perceive others, and handle conflicts. By integrating metacognitive strategies into our communication practices, we can become more effective communicators and resolve conflicts in a constructive and empathetic manner. One key aspect of metacognition in communication is self-reflection. Taking the time to reflect on our own communication patterns, biases, and triggers enables us to gain insight into our strengths and areas for improvement. By examining our own thoughts and emotions during interactions, we can identify any unhelpful or biased assumptions we may hold and consciously work toward addressing them. This self-reflection helps us develop a greater awareness of how our communication style may influence others and allows us to make adjustments for more effective communication.

Metacognitive monitoring of communication involves actively observing and evaluating our own communication in real-time. This includes being aware of the language we use, our tone of voice, and our nonverbal cues. By monitoring these aspects, we can gauge the impact of our words and adjust our communication accordingly. For example, if we notice that our tone is becoming aggressive during a conflict, we can intentionally shift to a more calm and respectful tone to de-escalate the situation and promote constructive dialog. Another important metacognitive strategy for improving communication is perspective-taking. This involves consciously attempting to understand and empathize with the perspectives, feelings, and needs of others. By engaging in perspective-taking, we can move beyond our own biases and assumptions, and actively listen to others with openness and curiosity. This enhances our ability to communicate with empathy, validate others' experiences, and find common ground even in the midst of disagreement.

Research has demonstrated the benefits of applying metacognition to communication and conflict resolution. For example, a study by Hong and Mallorie [41] found that metacognitive awareness in communication was positively associated with relationship satisfaction and conflict resolution skills. Another study by Haberstroh et al. [42] highlighted the role of metacognitive monitoring in effective communication, showing that individuals who were more metacognitively aware exhibited better communication skills and perceived themselves as more competent in resolving conflicts. In conclusion, applying metacognition to improve communication and conflict resolution empowers us to become more mindful and intentional communicators. By engaging in self-reflection, metacognitive monitoring, and perspective-taking, we can enhance the quality of our interactions, foster empathy, and navigate conflicts more constructively. Incorporating metacognitive strategies into our communication practices promotes effective listening, understanding, and finding mutually beneficial resolutions, leading to stronger relationships and healthier communication dynamics.

2.5.2 Cultivating psychological flexibility in relationships: empathy, acceptance, and understanding

Cultivating psychological flexibility in relationships is essential for fostering healthy and fulfilling connections with others. Psychological flexibility involves being open, accepting, and adaptable in our interactions, allowing for empathy, acceptance, and understanding to flourish. By consciously integrating these qualities into our relationships, we can nurture deeper connections, enhance communication, and navigate conflicts with compassion and resilience.

Empathy is a foundational component of psychological flexibility in relationships. It involves actively seeking to understand and share the emotional experiences of others. By putting ourselves in someone else's shoes and genuinely listening to their perspective, we can develop a deeper sense of empathy. This allows us to respond with sensitivity and compassion, validating the emotions and experiences of our loved ones. Cultivating empathy fosters a sense of safety and trust within the relationship, promoting openness and vulnerability.

Acceptance is another crucial element of psychological flexibility in relationships. It entails embracing others for who they are, including their strengths, weaknesses, and unique qualities. Acceptance involves letting go of expectations and judgments, allowing individuals to feel valued and respected for their authentic selves. By practicing acceptance, we create an environment where individuals feel safe to express their true thoughts and emotions, enhancing intimacy and connection.

Understanding is an integral aspect of psychological flexibility in relationships. It involves actively seeking to comprehend the thoughts, feelings, and needs of our loved ones. Understanding goes beyond surface-level interactions and seeks to grasp the deeper layers of someone's experiences. By actively listening, seeking clarification, and reflecting back what we have understood, we demonstrate our commitment to understanding and validating the other person's perspective. This cultivates trust, reduces misunderstandings, and fosters a sense of mutual support and appreciation.

Recent research supports the benefits of cultivating psychological flexibility in relationships. A study by Wachs and Cordova [43] found that higher levels of psychological flexibility were associated with greater relationship satisfaction and reduced distress. Another study by Carnelley et al. [44] highlighted the importance of empathy, acceptance, and understanding in promoting relationship well-being and longevity. In conclusion, cultivating psychological flexibility in relationships through empathy, acceptance, and understanding enhances the quality and depth of our connections. By actively practicing empathy, we create a space for genuine understanding and emotional connection. Through acceptance, we foster an environment of unconditional love and support. By striving to understand the thoughts and emotions of our loved ones, we foster deeper intimacy and meaningful communication. Integrating these qualities into our relationships allows us to navigate challenges and conflicts with grace and resilience, promoting long-lasting and fulfilling connections.

2.5.3 Promoting growth-oriented interactions and fostering resilience in interpersonal connections

Promoting growth-oriented interactions and fostering resilience in interpersonal connections are key aspects of nurturing healthy and thriving relationships. Growth-oriented interactions involve creating an environment where both individuals feel supported and encouraged to learn, develop, and evolve. Fostering resilience within relationships entails building the capacity to adapt, bounce back from challenges, and grow stronger through adversity. By actively incorporating these elements into our interactions, we can cultivate dynamic and resilient connections with others. A fundamental aspect of promoting growth-oriented interactions is fostering a mindset of continuous learning and personal development. This involves embracing feedback, seeking new perspectives, and being open to constructive criticism. By encouraging growth and supporting each other's aspirations and goals, we create an environment that fosters personal and interpersonal growth. Growth-oriented interactions involve engaging in active and reflective communication, where individuals share insights, learn from each other's experiences, and challenge each other to reach their full potential.

Building resilience within relationships requires nurturing a sense of shared strength and support. Resilience involves the ability to navigate challenges, adapt to change, and maintain a sense of well-being and stability. By cultivating resilience together, individuals can face difficulties as a team, drawing upon their collective strengths and resources. Resilient relationships are characterized by effective problem-solving, flexible coping strategies, and a shared belief in the ability to overcome obstacles. Promoting growth-oriented interactions and fostering resilience within relationships are supported by recent research. A study by Karney and Bradbury [45] found that couples who approached their relationship with a growth mindset, viewing challenges as opportunities for growth and learning, had higher relationship satisfaction and longevity. Another study by Fredrickson et al. [46] highlighted the importance of resilience in relationships, showing that individuals in resilient relationships experienced greater well-being and psychological thriving.

In conclusion, promoting growth-oriented interactions and fostering resilience within interpersonal connections are vital for building thriving relationships. By cultivating a mindset of continuous learning, supporting each other's growth, and embracing feedback, we create an environment conducive to personal and interpersonal development. Additionally, by nurturing resilience, we equip ourselves and our relationships with the tools needed to navigate challenges and bounce back stronger. Integrating these elements into our interactions fosters dynamic and resilient connections, promoting growth, well-being, and long-lasting relationships.

2.6 MetaFlex framework in professional development and learning

2.6.1 Leveraging metacognition to enhance learning strategies and academic performance

Leveraging metacognition to enhance learning strategies and academic performance is a valuable approach for students seeking to optimize their educational journey. Metacognition, the awareness and regulation of one's own cognitive processes, allows individuals to reflect on and adapt their learning strategies, leading to improved comprehension, retention, and overall academic success. By intentionally incorporating metacognitive techniques into their study routines, students can enhance their learning experience and achieve their academic goals (**Figure 4**).

One way to leverage metacognition for enhanced learning is through setting clear learning goals. By clearly defining what they aim to achieve, students can align their efforts and focus their attention on the most relevant information. This helps them prioritize their studies and develop a sense of purpose, increasing their motivation and engagement. Additionally, regularly monitoring progress toward these goals allows students to assess their learning strategies and make necessary adjustments to stay on track.

Another key aspect of metacognition in learning is self-monitoring. This involves consciously observing and evaluating one's own understanding and performance during studying or academic tasks. By periodically checking their comprehension and identifying areas of weakness, students can direct their efforts toward areas that require further attention. Self-monitoring also enables students to recognize when they need additional support or resources, facilitating proactive seeking of assistance when needed. Metacognitive strategies, such as self-questioning and self-explanation,

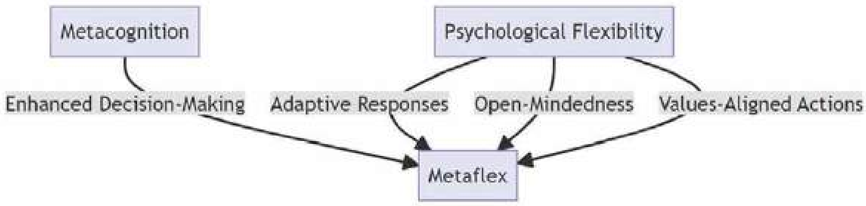

Figure 4.
MetaFlex framework for enhanced learning and development [47].

are effective tools for enhancing understanding and retention of information. Encouraging students to ask themselves questions about the material, summarize key concepts, and explain the content in their own words promotes deeper processing and strengthens their grasp of the subject matter. These strategies help students make connections between new information and existing knowledge, enhancing their overall comprehension and long-term retention.

Recent studies have provided evidence for the effectiveness of metacognitive approaches in improving learning outcomes. For example, a study by Dunlosky et al. [48] highlighted the positive impact of metacognitive strategies, such as retrieval practice and spaced repetition, on students' retention of information and their ability to transfer knowledge to new contexts. Another study by Schraw and Dennison [47] demonstrated that metacognitive awareness and regulation significantly correlated with academic performance, suggesting that students who employ metacognitive strategies are more likely to excel academically.

In conclusion, leveraging metacognition to enhance learning strategies and academic performance empowers students to take an active role in their education. By setting clear goals, self-monitoring their progress, and employing metacognitive techniques like self-questioning and self-explanation, students can optimize their learning experience and achieve higher levels of understanding and retention. Incorporating metacognitive strategies into study routines promotes self-awareness, efficient learning, and effective problem-solving skills, ultimately leading to improved academic performance and long-term success.

2.6.2 Harnessing psychological flexibility to adapt to workplace challenges and changes

Harnessing psychological flexibility is crucial for individuals to effectively navigate workplace challenges and adapt to changes in the professional environment. Psychological flexibility refers to the ability to maintain openness, adaptability, and resilience in the face of adversity or uncertainty. By cultivating psychological flexibility, employees can thrive in dynamic work settings, embrace new opportunities, and effectively manage stress and change.

One aspect of harnessing psychological flexibility in the workplace is embracing a growth mindset. A growth mindset involves viewing challenges and setbacks as opportunities for learning and growth rather than fixed limitations. By adopting this perspective, individuals can approach workplace challenges with a sense of curiosity and a willingness to explore new strategies and perspectives. This mindset encourages continuous improvement, innovation, and resilience in the face of obstacles.

Adaptability is another core component of psychological flexibility in the workplace. It involves being open to change, flexible in one's thinking, and willing to adjust strategies and approaches as needed. Adaptability allows employees to effectively respond to evolving work demands, shifting priorities, and new technologies. By embracing change and being open to new ways of doing things, individuals can remain agile and resourceful in navigating workplace challenges.

Psychological flexibility also encompasses emotional resilience. This involves developing the capacity to manage and regulate emotions in the face of workplace stressors and pressure. Resilience enables individuals to bounce back from setbacks, stay focused and composed during challenging situations, and maintain a positive outlook. By cultivating emotional resilience, employees can navigate workplace challenges with greater composure, making sound decisions and maintaining productive relationships with colleagues.

Recent studies have highlighted the benefits of psychological flexibility in the workplace. For example, a study by Bond and Flaxman [49] found that psychological flexibility was positively associated with job satisfaction, work engagement, and reduced psychological distress among employees. Another study by Biglan et al. [50] demonstrated that psychological flexibility predicted job performance and overall workplace well-being.

In conclusion, harnessing psychological flexibility in the workplace is essential for individuals to thrive amidst challenges and changes. By embracing a growth mindset, being adaptable, and cultivating emotional resilience, employees can effectively navigate workplace demands, embrace change, and maintain high levels of performance and well-being. Incorporating psychological flexibility into the workplace culture supports a positive and adaptive work environment, promoting individual and organizational success.

2.6.3 Nurturing a growth mindset for continuous professional development

Nurturing a growth mindset is vital for fostering continuous professional development. A growth mindset is the belief that skills, abilities, and intelligence can be developed and improved through effort, practice, and learning. By cultivating a growth mindset, individuals embrace challenges, persist in the face of setbacks, and actively seek opportunities for growth and learning in their professional lives.

One way to nurture a growth mindset for continuous professional development is by embracing a learning orientation. This involves seeing every experience, whether it be a success or a failure, as an opportunity for growth and learning. Instead of viewing setbacks as signs of incompetence, individuals with a growth mindset perceive them as stepping stones toward improvement. They recognize that mistakes and challenges are valuable sources of feedback and insights that can fuel personal and professional growth.

Another aspect of nurturing a growth mindset is seeking out new challenges and stepping outside of one's comfort zone. Embracing challenges helps individuals expand their skills, knowledge, and expertise. By actively seeking opportunities to learn and develop, professionals with a growth mindset are more likely to take on new projects, pursue additional training or certifications, and engage in continuous learning activities. They understand that growth happens outside of their comfort zones, and they are willing to push their boundaries to reach their full potential.

Continuous reflection and self-assessment are integral to nurturing a growth mindset for professional development. Engaging in regular self-reflection allows individuals to evaluate their strengths, areas for improvement, and professional goals. By honestly assessing their skills and identifying areas where they can grow, professionals with a growth mindset can develop targeted learning strategies and seek out resources or mentorship to support their development.

Recent studies have emphasized the importance of a growth mindset in professional contexts. For instance, a study by Dweck [51] found that individuals with a growth mindset were more likely to embrace challenges, persevere in the face of obstacles, and achieve higher levels of success in their careers. Another study by Hong et al. [52] demonstrated that a growth mindset positively influenced the adoption of learning goals and engagement in professional development activities.

In conclusion, nurturing a growth mindset is crucial for continuous professional development. By embracing a learning orientation, seeking out challenges, and engaging in reflection and self-assessment, individuals can foster a mindset that promotes growth, learning, and ongoing improvement in their careers. Incorporating a growth mindset into professional development efforts allows individuals to adapt to changing demands, seize new opportunities, and unlock their full potential for long-term success and fulfillment.

3. Discussion

The perspective chapter provides an in-depth examination of a new and promising methodology that integrates metacognition and psychological flexibility in order to facilitate personal development and improve psychological welfare. The paradigm presented in this study explores the junction of cognitive and emotional processes, providing valuable insights into the ways individuals can effectively navigate various problems in life and promote their own personal growth.

The framework is centered around the concept of metacognition, which encompasses the cognitive processes of reflecting on one's own thoughts, engaging in introspection, and cultivating self-awareness. The MetaFlex Framework facilitates individuals in cultivating introspection into their cognitive processes, emotional experiences, and behavioral patterns, so enabling them to attain a heightened level of self-awareness. Kessler [19] and Rickey et al. [20] showed that self-awareness permits people to detect and change unproductive cognitive processes, improve learning and actions, which can help human development.

Moreover, the incorporation of psychological flexibility into the theoretical framework underscores the significance of being adaptable and resilient when confronted with the difficulties of life. This notion places emphasis on the capacity to effectively navigate and adapt to stress, uncertainty, and adversity by employing a flexible and value-oriented approach. The concept promotes the importance of individuals striking a harmonious equilibrium between embracing acceptance and embracing change, so enabling them to effectively navigate and respond to dynamic situations while upholding their fundamental values and objectives.

Psychological flexibility predicted higher compassion satisfaction and lower levels of burnout and better quality of life [14, 15].

The chapter provides an overview of the theoretical underpinnings of the MetaFlex Framework as well as an examination of its actual implementations. The chapter provides significant insights into the interdependent connection between metacognition and psychological flexibility and offers recommendations on how to incorporate these ideas into one's everyday life. This instruction is applicable not just to individuals, but also to educators and professionals, who can integrate metacognitive techniques into their work in order to facilitate personal development, enhance resilience, and promote psychological well-being.

In summary, the MetaFlex Framework presents a persuasive viewpoint regarding the convergence of metacognition and psychological flexibility, showcasing their potential to be utilized for the purpose of augmenting individual development and overall welfare. Through the cultivation of self-awareness, adaptive thinking, and values-driven behavior, individuals have the ability to engage in a process of ongoing progress and resilience, effectively navigating the various difficulties and opportunities that life presents.

4. Conclusion

The MetaFlex Framework represents an innovative approach that combines the power of metacognition with the principles of psychological flexibility to foster personal growth, resilience, and well-being. This framework emphasizes the importance of developing metacognitive awareness and utilizing metacognitive strategies to enhance self-reflection, regulate emotions, and optimize learning strategies. By integrating psychological flexibility techniques, individuals can adapt to challenges, embrace change, and cultivate a growth mindset for continuous development.

The MetaFlex Framework offers a comprehensive and practical guide for individuals seeking to harness the power of metacognition and psychological flexibility in their personal and professional lives. It highlights the synergistic relationship between metacognition and psychological flexibility, demonstrating how they complement and reinforce each other to promote growth and well-being.

By developing metacognitive awareness, individuals gain insights into their own cognitive processes, including their thoughts, beliefs, and emotions. This heightened self-awareness enables them to identify and challenge unhelpful patterns of thinking, regulate their emotions effectively, and make conscious choices aligned with their values and goals. Through metacognitive monitoring techniques, individuals can assess their learning progress, identify areas for improvement, and make strategic adjustments to enhance their academic or professional performance.

Psychological flexibility, a core component of the MetaFlex Framework, allows individuals to adapt to the ever-changing demands and challenges of life. By cultivating a growth mindset, embracing challenges, and learning from setbacks, individuals foster resilience and open themselves to new opportunities for growth and development. Psychological flexibility also plays a pivotal role in interpersonal relationships, as it enables individuals to practice empathy, acceptance, and understanding, leading to more meaningful connections and improved conflict resolution.

The benefits of the MetaFlex Framework are supported by recent studies, which have shown that metacognitive strategies and psychological flexibility techniques contribute to improved learning outcomes, increased well-being, and enhanced performance in various domains. These studies provide empirical evidence for the effectiveness of integrating metacognition and psychological flexibility in promoting personal growth, adaptability, and resilience.

Overall, the MetaFlex Framework offers a holistic and integrative approach to fostering psychological flexibility and growth. By harnessing the power of metacognition to enhance self-awareness, regulate emotions, and optimize learning strategies, individuals can cultivate psychological flexibility, adapt to challenges, and foster personal growth and well-being. The MetaFlex Framework empowers individuals to navigate the complexities of life with greater self-awareness, resilience, and the ability to make intentional choices that align with their values and aspirations. By embracing this framework, individuals can embark on a transformative journey of self-discovery, growth, and enhanced psychological flexibility.

Author details

Sunder Kala Negi
Department of Humanities and Social Sciences, National Institute of Technology Hamirpur, Himachal Pradesh, India

*Address all correspondence to: sunderkala.negi08@gmail.com

IntechOpen

© 2024 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

References

[1] Sugiura Y, Sugiura T. Metacognition and cognitive flexibility: An fMRI investigation. PLoS One. 2018a;**13**(2):e0193032

[2] De Bruin AB, Thiede KW, Camp G, Redford J. Metacognition and the use of spaced retrieval practice in the classroom. Learning and Instruction. 2018a;**53**:31-41

[3] De Bruin EI et al. Examining the relation between self-reported metacognitive skills, metacognitive beliefs, and psychological symptoms in a sample of Dutch students in higher education. Frontiers in Psychology. 2018b;**9**:2353

[4] Sugiura Y, Sugiura T. Relationship between metacognitive awareness and psychological flexibility in healthy adults. Psychological Reports. 2018b;**121**(5):929-944

[5] Flavell JH. Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry. American Psychologist. 1979;**34**(10):906-911

[6] Brown A. Metacognition, executive control, self-regulation, and other more mysterious mechanisms. In: Weinert FE, Kluwe RH, editors. Metacognition, Motivation, and Understanding. Hillsdale, NJ: Lawrence Erlbaum; 1987. pp. 65-116

[7] Anar P, Ainash K, Nataliia F, Murshida N, Nazgul K. Assessment of students' metacognitive skills in the context of education 4.0. Frontiers in Education. 2023;**8**:1-9. DOI: 10.3389/feduc.2023.1182377

[8] Craig K, Hale D, Grainger C, Stewart ME. Evaluating metacognitive self-reports: Systematic reviews of the value of self-report in metacognitive research. Metacognition and Learning. 2020;**15**:155-213. DOI: 10.1007/s11409-020-09222-y

[9] Papadopoulos D, Puig de la Bellacasa M, Tacchetti M, editors. Ecological Reparation: Repair, Remediation and Resurgence in Social and Environmental Conflict. Bristol University Press; 2022

[10] Cabrera L, Sokolow J, Cabrera D. Developing and validating a measurement of systems thinking: The systems thinking and metacognitive inventory (STMI). In: Cabrera D, Cabrera L, Midgley G, editors. Routledge Handbook of Systems Thinking. London: Routledge; 2021. pp. 1-42

[11] Holt KJ. The Impact of STEM Integrated Instruction on Elementary Student Outcomes in Reading and Mathematics [Published Doctoral Dissertation]. Nashville: Trevecca Nazarene University; 2021

[12] Saavedra AR, Opfer VD. Teaching and Learning 21st Century Skills: Lessons from the Learning Sciences. A Global Cities Education Network Report. New York: Asia Society; 2012

[13] Dunlosky J, Bjork RA. The integrated nature of metamemory and memory. In: Dunlosky J, Bjork RA, editors. Handbook of Metamemory and Memory. New York: Psychology Press; 2008. pp. 11-28

[14] Garner EV, Moghaddam NG, Sabin-Farrell R. Psychological flexibility as a predictor of professional quality of life in newly qualified psychological therapy practitioners. Journal of Contextual Behavioural Science.

2023;**28**:139-148. DOI: 10.1016/j.jcbs.2023.02.005

[15] Garner EV, Golijani-Moghaddam N. Relationship between psychological flexibility and work-related quality of life for healthcare professionals: A systematic review and meta-analysis. Journal of Contextual Behavioral Science. 2021;**21**: 98-112. DOI: 10.1016/j.jcbs.2021.06.007

[16] Terneusen A, Quaedflieg C, van Heugten C, Ponds R, Winkens I. The many facets of metacognition: Comparing multiple measures of metacognition in healthy individuals. Metacognition and Learning. 2023:1-11

[17] Teng F, Qin C, Wang C. Validation of metacognitive academic writing strategies and the predictive effects on academic writing performance in a foreign language context. Metacognition and Learning. 2022a;**17**:167-190. DOI: 10.1007/s11409-021-09278-4

[18] Teng F, Wang C, Zhang LJ. Assessing self-regulatory writing strategies and their predictive effects on young EFL learners' writing performance. Assessing Writing. 2022b;**51**:100573. DOI: 10.1016/j.asw.2021.100573

[19] Kessler M. The longitudinal development of second language writers' metacognitive genre awareness. Journal of Second Language Writing. 2021;**53**:100832-100815. DOI: 10.1016/j.jslw.2021.100832

[20] Rickey N, DeLuca C, Beach P. Towards a new theory of student self-assessment: Tracing learners' cognitive and affective processes. Metacognition and Learning. 2023;**18**(3):945-981

[21] Hayes SC, Strosahl KD, Wilson KG. Acceptance and Commitment Therapy: The Process and Practice of Mindful Change. 2nd ed. New York: Guilford Press; 2012

[22] Hayes SC, Follette VM, Linehan M. Mindfulness and Acceptance: Expanding the Cognitive-Behavioral Tradition. New York: Guilford Press; 2004

[23] Bond FW, Hayes SC, Baer RA, Carpenter KM, Guenole N, Orcutt HK, et al. Preliminary psychometric properties of the acceptance and action questionnaire–II: A revised measure of psychological inflexibility and experiential avoidance. Behavior Therapy. 2011;**42**(4):676-688

[24] Gloster AT et al. Impact of the awareness and commitment therapy (ACT) model on severe subjective distress and functional disability in outpatients with treatment-resistant generalized anxiety disorder. Journal of Anxiety Disorders. 2017a;**46**:35-44

[25] Gloster AT et al. The relationship between metacognitive beliefs, attentional control, and symptoms of psychopathology. Journal of Experimental Psychopathology. 2017b;**8**(2):139-151

[26] Gillanders DT et al. Assessing the therapeutic potential of metacognitive therapy for anxiety and depression in cancer survivors. European Journal of Cancer Care. 2014;**23**(5):596-610

[27] Levin ME et al. Metacognition as a predictor and moderator of treatment outcome in cognitive-behavioral therapy for generalized anxiety disorder. Journal of Anxiety Disorders. 2018;**55**:31-38

[28] Negi SK, Rajkumari Y, Rana M. A deep dive into metacognition: Insightful tool for moral reasoning and emotional maturity. Neuroscience Informatics. 2022;**2**(4):10009

[29] Popandopulo A, Fominykh N, Kudysheva A. Do educators need metacognitive skills in today's educational environment? Thinking Skills and Creativity. 2021;**41**:100878. DOI: 10.1016/j.tsc.2021.100878

[30] Popandopulo A, Kudysheva A, Fominykh N, Nurgaliyeva M, Kudarova N. Assessment of students' metacognitive skills in the context of education 4.0. Frontiers in Education. 2023;**8**(2):1182377. DOI: 10.3389/feduc.2023.1182377

[31] Blackledge JT. An introduction to relational frame theory: Basics and applications. Journal of Contemporary Psychotherapy. 2007;**37**(2):87-94

[32] Wells A. Metacognitive Therapy for Anxiety and Depression. New York: Guilford Press; 2009

[33] Kashdan TB, Silvia PJ. Curiosity and interest: The benefits of thriving on novelty and challenge. In: Oxford Handbook of Positive Psychology. Vol. 2. 2009. pp. 367-374

[34] Dweck CS et al. Effective academic mentoring in STEM: Practicing a growth mindset. CBE—Life Sciences Education. 2019;**18**(2):ar20

[35] Blackwell LS, Trzesniewski KH, Dweck CS. Implicit theories of intelligence predict achievement across an adolescent transition: A longitudinal study and an intervention. Child Development. 2007;**78**(1):246-263

[36] Ortner CN et al. The benefits of monitoring and its discontents: A longitudinal investigation of the relation between monitoring, symptoms, and well-being. Cognitive Therapy and Research. 2020;**44**(5):893-907

[37] Morin A. A mindfulness-based program for improving cognitive flexibility in ruminators. Journal of Clinical Psychology. 2016;**72**(8):835-846

[38] Kivity Y, Huppert JD, Alony D, Bar-Haim Y. Enhancing emotional well-being through metacognitive reappraisal training. Behaviour Research and Therapy. 2020;**133**:103654

[39] Ortner CN, Kilner SJ, Zelazo PD. Mindfulness meditation and reduced emotional interference on a cognitive task. Motivation and Emotion. 2015;**39**(6):872-882

[40] Kashdan TB, Rottenberg J. Psychological flexibility as a fundamental aspect of health. Clinical Psychology Review. 2010;**30**(7):865-878

[41] Hong S, Mallorie L. Metacognitive awareness of communication: An integrative review and future research agenda. Journal of Applied Communication Research. 2018;**46**(4):468-491

[42] Haberstroh S, Dinger FC, Bögeholz S. A new perspective on communication competence: A metacognitive framework of communication quality. Communication Research Reports. 2019;**36**(3):176-186

[43] Wachs K, Cordova JV. Mindful relating: Exploring mindfulness and emotion repertoires in intimate relationships. Journal of Marital and Family Therapy. 2007;**33**(4):464-481

[44] Carnelley KB, Pietromonaco PR, Jaffe K. Depression, working models of others, and relationship functioning. Journal of Social and Personal Relationships. 2014;**31**(1):56-75

[45] Karney BR, Bradbury TN. Research on marital satisfaction and stability in the 2010s: Challenging conventional wisdom. Journal of Marriage and Family.

2020;**82**(1):100-116. DOI: 10.1111/jomf.12635

[46] Fredrickson BL, Mancuso RA, Branigan C, Tugade M. The undoing effect of positive emotions. Motivation and Emotion. 2000;**24**:237-258

[47] Schraw G, Dennison RS. Assessing metacognitive awareness. Contemporary Educational Psychology. 1994;**19**(4):460-475

[48] Dunlosky J, Rawson KA, Marsh EJ, Nathan MJ, Willingham DT. Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. Psychological Science in the Public Interest. 2013;**14**(1):4-58

[49] Bond FW, Flaxman PE. The ability of psychological flexibility and job control to predict learning, job performance, and mental health. Journal of Organizational Behavior Management. 2006;**26**(1-2):113-130

[50] Biglan A, Hayes SC, Pistorello J. Acceptance and commitment: Implications for prevention science. Prevention Science. 2008;**9**(3):139-152

[51] Dweck CS. Mindset: The New Psychology of Success. New York: Random House Publishing Group; 2006

[52] Hong Y, Chiu C, Dweck CS, Lin DM-S, Wan W. Implicit theories, attributions, and coping: A meaning system approach. Journal of Personality and Social Psychology. 2018;**115**(3):442-460

Chapter 9

Impact of Teacher Workload on Academic Excellence and Learners' Metacognition: A Case Study of Two High Schools in Chris Hani District

Amanda Joe and Nomxolisi Mtsi

Abstract

The workload of teachers greatly contributes to the quality and academic performance of the learners. This paper sought to investigate the impact of teacher workload on academic excellence and metacognition of learners in two high schools in Chris Hani district in the Eastern Cape province of South Africa, with the view of coming up with measures to inform appropriate teacher workload to improve learners' metacognitive skills and academic excellence. The study was guided by Symbolic Interactionism theory. The study used an Interpretivist research paradigm, followed a qualitative approach, and adopted a case study design. Purposive sampling was used to select 6 participants, data were analysed using semi-structured interviews and were analysed thematically. The findings revealed that excessive workloads cause stress and prevent teachers from completing the syllabus on time. It also established that teachers are faced with too much administrative work, which causes an increase in teacher work overload and negatively impacts learners' metacognition and academic excellence. The study recommends that various stakeholders should come up with new strategies that will improve the workload that teachers are given. It further recommends appointment of new teachers in schools to reduce teacher workload.

Keywords: teachers, learners, workload, academic excellence, metacognition

1. Introduction

Teachers are leaders and pillars of education; hence, their workload is vital as it affects the desired outcomes for both teachers and learners. This study defines workload of teachers as the quantity of work that teachers carry out during the academic year. The work includes preparation of lessons, delivering lessons, tests, administrative work, and marking. Excessive workloads prohibit teachers from performing desirably and attending to learners effectively. Jomuad et al. [1] are also of the view that teacher performance is impacted by workload. The observable and quantifiable behaviour of a learner, as measured by the results of assigned activities, be they formative or summative assessments, can be seen as the academic performance of a learner [2]. Teachers' excessive workload impacts learners' metacognition which is discussed in detail in the next paragraph.

Metacognition is a fundamental property when looking at the impact of excessive workload of teachers, by definition metacognition is awareness and management of one's thought [3]. It includes self-awareness, self-reflection, and the capacity to develop and modify effective learning procedures [4]. Therefore, this study refers to metacognition as awareness of one's individual thought processes, along with the capacity to control and manage them. The learners' metacognition might be significantly impacted by a teacher's excessive workload where the development of the learners' metacognition may be negatively affected in several ways when teachers have excessive workload.

As stated by [5], in Indonesia, lecturers' and teachers' workloads amount to 48 hours a week of face-to-face teaching, which is too much. Tahseen [6] conducted a study in Saudi Arabia revealed that teachers had too much paperwork and high workloads, and they had to sacrifice their relaxation time, which contributed to stress. In addition, Akhtar Malik [7] submits that loss of physical and emotional vitality results from work overload as an element that contributes to teacher burnout. According to the 2013 National Policy on Education of Nigeria, the teacher-student ratio in elementary schools should be 1:25 and in secondary schools it should be 1:30 to prevent overcrowding in classrooms [8]. In public schools in South Africa, classrooms are designed to support 31 learners and one teacher for secondary schools and 40 learners and one teacher in primary schools [9]. Nevertheless, because of overcrowded classrooms in public schools, learner-teacher ratios, particularly those in countryside areas and locations, exceeds average. In addition, South Africa demonstrates that teachers often have very heavy workloads and very low morale [10]. The challenge is very high in both rural and urban public schools.

The researcher concurs with the above views; thus, the researcher undertook this study based on the gaps identified. The paper looks at the impacts of teachers' workloads on learner's metacognition and academic excellence of learners in two high schools in Chris Hani District in the province of the Eastern Cape.

2. Literature review

2.1 Impact of excessive administrative work and workload of teachers on learner metacognition and academic excellence

Too much administrative work has a "blanket" impact on every school setting, and it seriously threatens to take away teachers' professional concentration on instruction and student learning [11]. The impact of too much administrative and official tasks related to system imperatives, for example, requirements for complying with standardised reports and recording of progress, that includes learner progress, has been an increase in the workload of teachers [11]. In recent studies, there has been an increased emphasis on the workload of teachers as a component of a larger concern about the hiring, retention, wellbeing, and support of "quality" teachers [11]. To better understand the mechanism of learner metacognition and its effects literature confirms that highlights that reduced feedback and guidance can hinder learners' ability to reflect on their learning processes and make needed changes [12]. Moreover, teachers who are loaded with administrative duties may have limited time and energy to offer timely and constructive feedback to their learners. Given the ultimate impact that teachers have on learning and accomplishment of learners [13], it is crucial to comprehend the variables that affect their potential to "teach to their best and well" [14]. Self-analysis and introspection about one's learning experiences are also common components found in metacognition research for teachers with excessive workloads. Overworked and aggravated teachers are unlikely to engage learners in metacognitive activities such as reflection or dialogue [15]. Considering the above statement, limited reflection opportunities negatively affect learners' academic excellence since it prevents them from knowing where they can improve. The education profession entails being subjected to a variety of employment expectations, which frequently support an impression of a severe workload [1]. They add that other examples of workplace demand such as several meetings interfere with teachers' preparation time. Teachers with a heavy workload may choose to plan and assess lessons quickly aimed at memorization rather than encouraging critical thinking and metacognitive skills in learners [16]. This hinders learners' progress. According to [11], Australian (lower secondary) teachers "report working on average 43 hours per week, 5 higher than the average for TALIS countries," and they spend similar numbers of hours per week on a variety of work-related tasks.

Manuel et al. [11] further found that key drivers for increased workload for primary and secondary school teachers were administration, including high volumes of email workload; curriculum reform; data tracking, and marking and assessment are. In addition, reports are consistent regarding working hours of teachers, the complexity and time strains of their workload, the degree of compliance and additional "time consuming, cumbersome" administrative tasks consuming their teaching and learning time [17, 18]. In the study [17], 61% of teachers agreed that their jobs were stressful most of the time or frequently in the least. Therefore, this study sought to determine the impact that excessive administrative work and teacher workload have on learner metacognition and their academic excellence.

2.2 Impact of shortage of teachers and overcrowded classrooms on academic excellence and metacognition of learners

Overcrowded classrooms make it difficult for teachers to produce desired results because most of the time they are unable to fully track learners' progress and to give proper attention to each learner needs as they are faced with large numbers of learners in small classrooms. According to Biyela [10], the quality of teaching and learning appears to be compromised by overcrowded classes with limited educators. Furthermore, Marais [19] study revealed that there is no individual support and no proper assessment in overcrowded classrooms. As Johnson [20] suggests, overworked teachers may adopt one-size-fits-all strategies without considering metacognition differentiation. Biyela [10] study emphasises the need for personalised learning experiences, highlighting the negative impact of one-size-fits-all teaching methods on learners' metacognition and academic excellence in overcrowded classrooms. In addition, most government secondary schools do not have sufficient teachers [21]. Ogunode et al. [21] submits that there is a problem of lack of academic staff in universities, whilst learner numbers are very large. Moreover, there is not enough time to provide all learners meaningful feedback, and providing individual coaching is not an option in overcrowded classrooms [19]. In addition, and importantly so, [10], established that teachers lacked the necessary skills to instruct in overcrowded classes as neither the district officials nor the Department of Basic Education provide teachers with enough training or support.

Marais [19] reports that learners lack motivation in overcrowded classrooms, as most learners do not participate in learning activities since they mainly feel tired because of high temperatures and noise in overcrowded classrooms, thus affecting academic excellence of learners. Marais [19] adds that there is disruptive behaviour and lack of resources in overcrowded classrooms, which contribute to lack of motivation of learners and poor focus on learning activities, particularly where many learners share one desk due to limited space and furniture. Furthermore, in overcrowded classrooms, teachers face a variety of difficulties, including fighting among students, loud classrooms, and student cheating brought on by stress from cramped seating and lack of space [10]. According to reports, common basic education institutions, often known as primary schools, lack trained teachers [21]. According to Ogunode et al. [21], efficiency of teaching and learning in an overcrowded classroom is threatened, learner performance is reduced and, subsequently, teachers are demoralised. Overcrowded classrooms breed stress and anxiety, which adversely impacts learner metacognition, and leads to heightened stress in teachers. Stress, learning setting, and metacognitive progress can be hampered. Learners may be distracted by the visible stress of educators, as stated by [22]. According to Manuel et al. [11], efficiency of teaching and learning in an overcrowded classroom is threatened; learner performance is reduced and, subsequently, teachers are demoralised.

3. Theoretical framework

See **Figure 1**.

Symbolic Interactionism is a theoretical hypothesis for exploring human conduct and life [23]. The framework uses an individual's experience as the foundation for researching and interpreting a social group or system. A good fit for examining teacher behaviour faced with excessive workload to inform analysis of participants experiences, Symbolic Interactionism was utilised throughout this paper. The researcher focused on the creation of identity through interacting with others and investigated how people respond to one another from a symbolic interactionist approach and used this approach to inform the analysis of the participants' experiences throughout the study.

4. Research question

What is the impact of teacher workload on academic excellence and learners' metacognition?

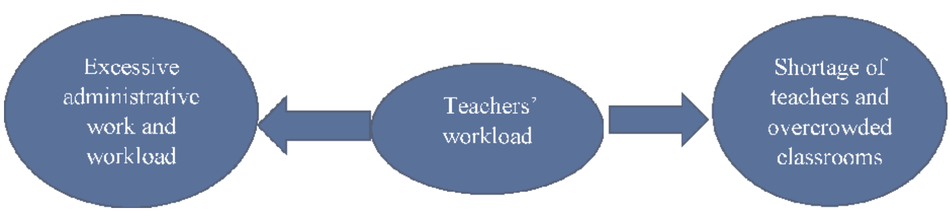

Figure 1.
Conceptual framework.

5. Aim and objectives

The motive of the study was derived from the researcher's personal experience, including witnessing the excessive workload of teachers. Not only are they expected to teach but they are also expected to perform administrative duties. The objective of the paper was to investigate the effects of teachers' workloads on learner academic excellence and metacognition in two high schools.

6. Research and methodology

A qualitative research approach was adopted in the study. An interpretivist approach was followed in this study. The interpretive framework was appropriate as the researcher shared information on various effects of teachers' workload on learners' academic performance. Data analysis involved reducing and interpreting data that were gathered through audio-taped interviews. Given that the researcher wanted a detailed reflection on schools, and to ensure confidentiality, participants were interviewed individually, which also gave them a chance to express themselves freely. The researcher used semi-structured individual interviews to collect first-hand data regarding the effects of teacher workloads on learner academic excellence. Population consisted of 26 teachers from school A, 16 females, 10 males and 30 teachers in school B, 18 female teachers and 12 males. Purposive sampling helped identify information-rich cases related to teacher workloads. The sampling comprised 4 teachers and 2 principals from the two selected schools.

7. Ethical considerations

Ethical consideration consisting of informed consent letters, confidentiality and for anonymity pseudonymization were utilised by the researcher. The researcher also guaranteed no harm or risk would be put exposed or subjected to the participants because of their participation.

8. Findings

On the issue of the effects of excessive administrative work and the workload of teachers on learners' academic excellence and metacognition, the following were shared:

> *The workload is too much; there is not much time to finish the syllabus and at the same time do daily preparations. We rarely receive free periods; there is a lot of paperwork that must be completed and most of the time due dates for submissions are not met.* (Teacher A.)

Contrary to what Teacher A said, a principal stated that:

> *The reason why some teachers end up having too much workload is because they submit their work to the SMT's late.* (School Principal A.)

However, another teacher also emphasised that teachers were overloaded, adding that:

> *We are expected to teach subjects that we do not specialise in whilst teaching our own subjects which increases the workload because one must do preparations on all these subjects that are allocated to us. Hence, we sometimes submit assessments late to the Head of Departments for moderation. The administrative work that we must do as teachers is also too much now, we also expected to record marks on SASMS by ourselves.* (Teacher C.)

Teachers B and D concurred with some issues that were highlighted by Teacher C indicated in the above excerpt. Below is what the teachers said:

> *The subject allocations that we are given by our SMT do not allow us to finish on time nor submit on time tasks that are needed because we are faced with too many preparations, marking, and recording of that work."* (Teacher B.)

> *The rotation of learners that the schools faced during the Lockdown has also added on teachers' workloads, because teachers had to go back to teaching what they taught learners the week that they had come to school because learners had forgotten what was taught or they did not do their tasks that they were given that week.* (Teacher D.)

The participants were all in agreement that teachers had excessive workloads and administrative work, which affected their teaching time and metacognition.

Regarding the effects of shortage of teachers and overcrowded classrooms on academic excellence and metacognition of learners, below is what participants responded:

A principal indicated that:

> *Teachers cannot expect to have too many free periods whilst the school has a shortage of teachers that would lead to a much higher rate of learner failure.* (School Principal A.)

However, a teacher reiterated that:

> *Shortage of teachers causes stress and a burden to us, as we are expected to assist in teaching those subjects without teachers.* (Teacher C.)

Another teacher highlighted that:

> *Some teachers tend to neglect subjects that they are given that aren't within their area specialisation which leaves learners unattended to and that leads to them failing.* (Teacher A.)

Teacher B agreed with what Teacher A, and highlighted that:

> *With the big classes that we are given to teach and the number of subjects that we are allocated as teachers, it is difficult for us to finish the syllabus on time.* (Teacher B.)

Further comments are capture below:

> *With the Covid-19 Lockdown and closure of schools, we have high numbers of learner failure. The repeating learners add to the number of new entrants of progressed learners, which increases the numbers in our classes.* (Teacher C.)

> *We have been requesting for more appointment of educators from the Department of Education, but we are told that we do not meet the quorum as we have just appointed two teachers in our school, but we are still short of teachers as we have huge numbers of learners that need to be taught* (School Principal B.)

Understaffing seems to be one of the major causes of work overload for teachers, pointing to the need for the Department to closely monitor teacher-learner ratio.

9. Discussions and recommendations

9.1 Effects of excessive teacher administrative work and teaching workload on learner metacognition and academic excellence

The study revealed that teachers have excessive administrative work and teaching workloads. This resonates with the main conclusions of the work by [17] and that by [19], which indicate that the complexity and time strains of teachers' workloads, the degree of compliance and additional "time consuming, cumbersome" administrative tasks are consuming their teaching and learning time. Adams [16] discovered that inadequate planning and assessment of teachers with over workload hinders learners progress as these teachers may choose to quick lesson planning and assessment that aim at memorization rather than encouraging critical thinking and metacognitive skills in learners. Where metacognition is concerned, Smith [12] highlights that reduced feedback and guidance can hinder learners' ability to reflect on their learning processes and make needed changes, hence teachers who are loaded with administrative duties and grading may have limited time and energy to offer timely and constructive feedback to their learners. The researcher is of the view that teachers are overly worked and have excessive administrative work, which affects learner academic excellence.

9.2 Effect of shortage of teachers and overcrowded classrooms on academic excellence and metacognition of learners

The study revealed that schools have a shortage of teachers and that they teach overcrowded classrooms. It also discovered that overcrowded and shortage of teachers causes stress to teachers. According to Manuel et al. [11], efficiency of teaching and learning in an overcrowded classroom is threatened; learner performance is reduced and, subsequently, teachers are demoralised. Just like it is indicated by [10], the quality of teaching and learning appears to be compromised by overcrowded classes with limited educators. Furthermore, Ogunode et al. [21] found that most government secondary schools lacked sufficient teachers. Ogunode et al. [21] claimed that there was a problem of understaffing in higher education institutions. Consequently, due to stress, the classroom environment and learner metacognitive development can be hindered as learners may be distracted by the educators' visible stress [22]. Thus, it is clear from the findings that overcrowded classrooms and shortage of teachers have impacted learners' metacognitive skills and academic excellence negatively.

10. Recommendations

- The study recommends that the Department of Basic Education and policy makers should review the teacher-learner ratio to reduce teacher workload and overcrowding of classrooms.
- The study also recommends that the Department of Basic Education should release the Post Level 1 Bulletin yearly so that more educators can be employed to reduce teacher workload.
- Another recommendation of the study is that the Department of Basic Education should revisit the policy of upgrading schools' infrastructure, so that additional classrooms can be built so that the standard teacher-learner ratio can be maintained in schools.
- Lastly, the study recommends that adequate training of teachers to perform administrative duties should be conducted and it should be done during school holidays to prevent loss of teaching and learning time, which later affects learner progress.

11. Conclusion

The study investigated the impacts of teachers' workload on learners' metacognition and academic excellence to suggest processes that could be implemented to improve the negative impacts of teachers' workload. Based on the discussions that were raised by participants on teachers having excessive administrative and teaching work does hamper learner's metacognition and academic performance, hence the researcher came up with possible recommendations on how these matters can be addressed.

Acknowledgements

I would like to extend my appreciation to the higher degree community, the Department of Basic Education, for allowing us to conduct this study. Also, would like to acknowledge my supervisor, family, mentor, and everyone who contributed to making this study a success.

Declarations

The author of this study declares that all the content is their own work, referencing has been made in areas where needed as to acknowledge the original authors that have been cited in this study.

Author details

Amanda Joe* and Nomxolisi Mtsi
Walter Sisulu University, Komani, South Africa

*Address all correspondence to: ajoe@wsu.ac.za

IntechOpen

© 2024 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

References

[1] Jomuad PD, Antiquina LMM, Cericos EU, Bacus JA, Vallejo JH, Dionio BB, et al. Teachers' workload in relation to burnout and work performance. International Journal of Educational Policy Research and Review. 2021;**8**(2):48-53

[2] Kates AW, Wu H, Coryn CL. The effects of mobile phone use on academic performance: A meta-analysis. Computers & Education. 2018;**127**: 107-112

[3] Kuhn D, Dean D Jr. Metacognition: A bridge between cognitive psychology and educational practice. Theory Into Practice. 2004;**43**(4): 268-273

[4] Flavell JH. Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. American Psychologist. 1979;**34**(10): 906-911

[5] Mukamazimpaka MC, Gaikwad P. Social capital and compensation package as predictors of teacher retention in Rwanda. International Forum Journal. 2019;**22**(1):124-150

[6] Tahseen N. Work-related stress among teacher-educators: Evidence from Punjab. Pakistan Journal of Psychological Research. 2015;**30**(2):357

[7] Akhtar Malik N. Occupational Stress and Burnout among University Teachers in Pakistan and Finland. 2019

[8] Ogunode NJ, Johnson AG, Olatunde-Aiyedun TG. Education crisis in Nigeria and way forward. In: Kresna Social Science and Humanities Research Proceedings of the International Conference on Sustainable Development: Problems, Analysis and Prospects. 2022. pp. 33-47

[9] South Africa. Department of Education and Department of Education South Africa, 2004. Education Statistics in South Africa at a Glance. South Africa: Government Printer

[10] Biyela BN. Leading teaching and learning in an overcrowded classroom: Experiences of four teachers in two secondary schools [doctoral dissertation]. 2019

[11] Manuel J, Carter D, Dutton J. As much as I love being in the classroom...': Understanding secondary English teachers' workload. English in Australia. 2018;**53**(3):5-22

[12] Smith P. The role of feedback in metacognitive development. Journal of Educational Research. 2017;**28**(1):67-82

[13] Engzell P, Frey A, Verhagen MD. Learning loss due to school closures during the COVID-19 pandemic. Proceedings of the National Academy of Sciences. 2021;**118**(17):e2022376118

[14] Day C. Teachers' Worlds and Work: Understanding Complexity, Building Quality. 1st ed. Routledge; 2017. DOI: 10.4324/9781315170091

[15] Brown A. Metacognition and learning: Conceptual and methodological considerations. Educational Psychology Review. 2019;**31**(2):183-195

[16] Adams J. Teacher workload and its impact on student learning. Educational Research Quarterly. 2016;**39**(2):39-53

[17] McGrath-Champ S, Wilson R, Stacey M, Fitzgerald S. Understanding Work in Schools: The Foundation for Teaching and Learning. 2018

[18] Weldon PR, Ingvarson L. School Staff Workload Study: Final Report to the Australian Education Union–Victorian Branch. 2016

[19] Marais P. "We can't believe what we see": Overcrowded classrooms through the eyes of student teachers. South African Journal of Education. 2016; **36**(2):1-10

[20] Johnson L. Personalized learning and metacognition: Strategies for effective teaching. Journal of Educational Psychology. 2020;**45**(3):321-335

[21] Ogunode NJ, Jegede, Musa A. Problems facing academic staff of Nigerian universities and the way forward. International Journal on Integrated Education. 2021;**4**:230-239

[22] Robinson S et al. Teacher stress and its impact on classroom environments: Implications for student outcomes. Educational Psychology. 2018;**33**(4): 421-437

[23] Blumer H. Symbolic Interactionism: Perspective and Method. University of California Press; 1986. p. 5

Section 3

Metacognition, Transformative Learning, ICT

Chapter 10

Transformation through Metacognition

Nida Ayaz, Muhammad Naeem Butt
and Sayyeda Jawerya Ayaz

Abstract

Metacognition is result-oriented process that refreshes and involves cognitive processes. Metacognition is a process, which involves fruitful knowledge not only about different processes of cognition but also how to use and regulate these processes for result-oriented outcomes; especially, in the processes of learning. This chapter highlights transformation and motivation through awareness and application of metacognition. This chapter introduces metacognition, the value of metacognitive awareness, and how it can be used to improve students' learning and their academic performance. It further opens the doors for the study of the elements of metacognition; moreover, it focuses on the effects of metacognition on learning. This chapter recommends awareness and the use of metacognition in education as it enables the learners to think big. In order to meet the student's needs for metacognitive support in learning, this chapter also recommends an interdisciplinary course on educational psychology at different levels of education. In addition, research studies on metacognition, its awareness, and its effects especially in the context of developing countries are recommended.

Keywords: metacognition, elements of metacognition, metacognitive knowledge, metacognitive self-regulation, transformation

1. Introduction

Research and awareness of metacognition can play the role of motivational boost for learners. It can help learners to come out from dark phases of life, to be on the right track, and to never ever give up. Our experiences are a real example of the role of metacognition in personal as well as academic lives.

I was student of Bachelor of Education since 2014. I was given a task of presentation on metacognition in educational psychology class by my teacher. I searched different articles, publications, blogs, books, thesis, and the latest content on metacognition. My interest developed and I decided to conduct research on awareness of metacognition in the area of Khyber Pakhtunkhwa, Pakistan, where there was no awareness of this innovative concept. This research helped me not only in my academic development but also in my personal development.

I was passing through a dark phase of my life. I started married life in the recent past and had the responsibility of a kid that made it difficult for me to continue my studies. At that time, health, family, and life issues were the dark side, and the option of never ever giving up was the bright side of my life. Finally, I decided to never give up and got admission in M. Phil. (Education) and conducted research, and published a research paper on the effects of metacognition [1]. This research also improved me as a human being, my learning strategies, and my personality. It gave me an awareness of my own potential and strength. Now it was time to work in the field and apply all the learned knowledge in the real classrooms. I had adopted the teaching profession, the best way to give this fruitful knowledge to the learners of my society. Metacognitive awareness and strategies introduce my students to their true versions and help them to best utilize their own potentialities. Finally, I conducted action research at the primary level in PhD Education (in process) at Abdul Wali Khan University of Mardan to improve the classroom learning environment, develop students' interest, and enhance reading comprehension the students [2].

Metacognition is a concept that helps a girl from a rural area (Mardan, Khyber Pakhtunkhwa, Pakistan) to be aware of her true version, to polish her potentiality through metacognitive strategies, and to overcome her weakness effectively. So metacognition is a concept that has the ability to transform learners into smart workers and big thinkers.

Traditional educational institutions were teacher-centered, with teachers determining how to advance learning. Learners are given less opportunity to engage in reflective thinking about their learning experience. In this didactic form of learning, they have fewer opportunities to govern, monitor, and assess their learning. It also hampered the student's ability to take ownership of their learning. Our educational environment needs to shift from traditional teacher-centered to learner-centered [3]. Learner-centered education has a long history dating, back to the time of Socrates [4]. In learner-centered learning procedures, learners assume responsibility for obtaining knowledge and become more metacognitive in the learning process. Lifelong learning and/or autonomous learning are assisted by the application of acquired metacognitive skills, which Sternberg [5] views as being at the heart of education.

> *"The crucial thing to obtain from the training was not textbook factoids, but rather the learning to learn abilities and the skills in accessing a knowledge base that constitute the heart of Metacognition."*

According to Benson [6] *"Learners who are asked or forced to take greater control of their learning may be able to self-manage their learning, but they will not necessarily have the cognitive competencies that will make self-management systematic and effective."*

Cognition is essentially intelligence, reasoning, knowledge, and classification. Cognition refers to *"what you know and think"* [7]. It also includes symbols, fantasies, lower mental processes, organized muscular motions, and senses. "Separate functioning" that has been studied through interactional research is cognition with other variables such as emotions, motivation, and social cognition [8–10]. Cognition is an umbrella term that includes metacognition; in summary, metacognition is a type of cognition [11]. Terrecone [12] defines metacognition as "second-order cognition", which provides a ground to know aware, control, and monitor information throughout processes of cognitive processing.

Garner [13] defined the distinction between cognition and metacognition as follows: Performing a task necessitates the use of vital skills known as cognitive skills; however, understanding how this job was completed necessitates the use of a required component known as metacognition.

2. Metacognition

Until 1976, metacognition did not appear in the literature; however, studies on theories of mind in the fields of cognitive sciences, psychology, and education had been conducted [14]. Flavell conducted a study on meta-memory capacities and coined the term "meta-memory" in his work [15, 16]. The productive effect of the 1976 study of Flavell's gives the right track to the introduction of metacognition. Flavell defines meta-memory as "*one's own cognitive processes and outputs, as well as everything associated to them*." Metacognition is the understanding of one's processes of mind and the use of that information to regulate one's own mental processes [17–19]. According to the authors, executive control is a concept in cognitive psychology that consists of two dimensions: monitoring and self-regulation. Other studies have raised the same point in their analyses [20, 21]. Studies on metacognition in numerous aspects have recently increased [22]. Metacognition refers to the process of learning about and managing individuals' brains or cognitive systems for learning [23].

3. Definitions of metacognition

> *"The knowledge and control that children have over their own thinking and learning activities" [24].*

> *"The monitoring and control of thoughts" [25].*

> *"Awareness and management of one's own thought" [26].*

> *"A higher-order agent that oversees and governs the cognitive system while also being a part of it" [27].*

He defined metacognition as a list of self-instructions for task control and execution, with cognition serving as a vehicle for self-instructions. Furthermore, for a better grasp of the idea of metacognition, regard it as two-way mental processing [28]. Metacognitive Model of Consciousness and Cognition. He distinguished between "object-level" (cognitions about external objects) and "meta-level" (cognitions about external objects) processes and his metacognitive model explained that "any lower-level cognition can itself be the subject of a higher-level cognition."

4. Elements of metacognition

Metacognition is made up of several sub-elements, each with its own set of characteristics. Flavell's [29] gave an introduction to two dimensions of metacognition: metacognitive knowledge and metacognitive regulation [30, 31].

4.1 Metacognitive knowledge

Metacognitive Knowledge is essential for independent learning because "*it represents the knowledge base that students draw on as they make decisions about their learning*" [32]. It included learner knowledge about the self, completed tasks, and strategies used for fruitful learning. It entailed being conscious of one's mental processes, cognitive aims, and experiences [29, 33, 34].

Metacognitive knowledge is important for obtaining productive outcomes. Learners with knowledge of cognition are found quick and smart in learning. The following forms of metacognitive knowledge have been defined:

4.1.1 Person knowledge

Person knowledge refers to being aware of one's own and other people's mental processes. Knowledge of how learning processes occur, how information is processed in the learning process, and knowledge of specific thinking is called personal knowledge. Knowledge regarding diverse ways of processing information in people (listening, seeing, touching) and which mode of processing knowledge is optimal for learning for specific individuals is an example of this. Wenden demonstrated that the development of language can also be affected by personal abilities. Flavell [29] separated this aspect into the following sections.

a. Intra-personal: Awareness of one's own mental processes, abilities, learning styles, IQ, and potential.

b. Interpersonal: General awareness of others' knowledge and talents.

4.1.2 Strategic knowledge

Awareness of different strategies and their uses is also very crucial in education. Strategic knowledge gives not only details of different strategies but also when to use which one strategy. It enables us to make a choice of selecting a strategy rather than a chance of using any strategy. It makes the learning process simple and outstanding through a choice, not a chance [35]. Strategic knowledge is actually knowledge about these tasks differently at the appropriate time and its utilization in the best way. These all components affect the processes of the mind involved in learning [27]. It refers to different methods or procedures [27, 30]. It provides a mirror of how procedures are followed or used.

4.1.3 Task knowledge

Task knowledge includes information about the task's aims, how it will affect one's learning, the nature of the task (difficulty or ease), and the needs for it. Knowledge about the task provides a right and systematic way toward the achievement of goals. In this case we have two tasks, one in biology, which is mitoses and another one in the periodic table of chemistry. The requirements and demands for both tasks are different.

If we explain the example of mitoses of cells it will be preferable to select understanding processes of cognition. Understanding can be through diagrams and postal presentations. In the case of the periodic table, it is preferable to memorize the names of elements mentioned in the periodic table. Different activities are used to memorize it. One of the examples is to make a statement from the rows and the columns of the periodic table and memorize it. It will become interesting and easy for learners to memorize rows and columns. It shows the requirements of the tasks which are different.

5. Regulation of cognition

Metacognition also involves cognition regulation, which is the second most essential component [36].

Metacognitive self-regulation is primarily concerned with controlling one's own thinking or learning processes [34]. It was divided into three parts: planning, monitoring, and assessment.

5.1 Planning

Planning is a necessary component before doing the work efficiently. Prior to conducting the work, it is critical to select acceptable task strategies and to determine the fruitful influencing strategies and activities on the performance of learners.

In reading comprehension, the planning strategy is to predict the text and make clues from the pictures and the topics. Guess the meaning of the difficult words etc. These strategies help us to understand the text effectively.

5.2 Monitoring

Individual's immediate cognitive awareness of a task is monitoring. It helps the learner to be on the right track, utilize cognitive processes through smart work, and to never ever give up until you learn what you want to learn.

I would to share my own experience of using metacognitive strategies with children to enhance their reading comprehension. The monitoring strategy in reading is to reread the text to understand the difficult words and concepts. Asking questions during reading also helps in the understanding of the text. To guess the next content is also one strategy to monitor own reading.

5.3 Evaluation

Assessing learning results is also essential for best learning. One self-regulates learning processes, and decisions concerning learning processes are made in this step [34]. After completing the activity, the learner determines whether or not the task was beneficial to the learner.

For understanding reading, the best assessment strategy is to summarize the reading content.

6. Academic achievement and metacognition

Metacognition effects on the academic accomplishment of learners have been discovered, which is why metacognition is the topic of numerous studies [37–42]. Cognition and metacognition were identified as crucial variables for efficient learning [43]. Students' academic progress has been influenced by their metacognition since learning is an easier and less arduous process for them; they utilize strategies smartly and learn through big thinking [44]. Researchers [45–47] have constructed models and taxonomies for describing metacognition [48, 49]. Flavell [29] classified cognition monitoring into four components: (i) metacognitive information, (ii) metacognitive experiences, (iii) aims or tasks, and (iv) actions or tactics.

In the literature, knowledge about cognition and cognition regulation are also two domains of metacognition [34, 50]. Kuhn [45] further categorizes knowing as metacognitive and meta-strategically knowing. The components that are grouped include metacognitive knowledge, metacognitive judgments, monitoring, control, and regulation of cognition [30]. The Metacognitive Awareness Inventory is divided into three categories for measuring metacognition: metacognitive knowledge, metacognitive abilities, and metacognitive attitude. These dimensions are also available in the inventories as sub-dimensions.

7. Metacognition development over time

Metacognition develops over time; through experiences, one replaces inefficient mental techniques with optimum cognitive methods [45]. Many researchers believe that metacognitive abilities are polished, improve, and evolve with an increase in age [21, 51]. Metacognitive development progresses as follows: the knowledge component occurs first, children as young as six years old are aware and capable of reflecting on their mental processes, and these skills are used by the age of eight to ten. Following that is the regulation of mental processes, which can be seen in the form of planning in children aged ten to fourteen. Two remaining steps (monitoring and assessment) were established gradually and remained unfinished until adolescence.

According to Schneider and Locki [21], there is a link between metacognition development and declarative meta-memory development, and the first evidence is children's knowledge of mental verbs such as "remember," "think" terms are familiar to pre-schoolers but they have limited memory. Four-year-old children can use and explain mental processes through memory verbs. Before six years of age, children believe that performance is more closely related to effort than it is, and they overestimate the performance of their memory. Between the ages of six and eleven, children gain an understanding of procedural meta-memory. Task features and the application of techniques are considered key tools by children aged 9–10 years to make remembering easier. Students aged 12 years gain the capacity to efficiently govern themselves; they can plan their time and attention, and comprehend the effectiveness of tactics. Although age does not a significant role in general metacognition, it does not improve with age. Sperling et al. [52] created and administered a self-report test to assess general metacognitive knowledge and regulation in youngsters.

8. Academic achievement

Academic achievement is a wide term that refers to the amount to which a person has achieved specific goals. Indicators are used to quantify academic performance and define academic achievements. Mostly, general indicators such as procedural and declarative knowledge are gained. Curriculum-based criteria include grades and educational degrees. Academic accomplishment, as evaluated by the GPA (grade point average), is used for a variety of purposes. In the study [2], cumulative GPA was utilized to assess students' academic achievements. In a brief summary of academic achievements, many views for individuals and society, as well as psychological and educational studies, have been highlighted. Academic successes determine whether or not a person can pursue higher education, and degrees obtained through academic achievements can also influence one's professional future following education [53]. According to Woolfolk [44], textbooks on the determinants and measurement of academic achievement have contributed theoretical and empirical knowledge. Individual, home, and scholastic factors of academic accomplishment were identified by Hattie [54]. Individual correlates of university students' performance, according to Richardson et al. [55].

9. Discussion

This chapter on metacognition discusses the transformation of academic and social life through metacognition by introducing, defining, and explaining the components of metacognition. Metacognition was introduced by Flavell [56]. He did research on the metamemory of children and updated the literature of education psychology with a new concept of metacognition. Metacognition has a great impact on the academic achievements of the students of English literature [1]. The same is found by other researchers as well [38, 52, 57, 58].

Metacognition had a strong and good impact on children's reading awareness and comprehension. Independent language learning necessitated the acquisition of metacognitive knowledge [59]. Building learners' autonomy at various phases of language learning is vital for improving their good points in second language learning and controlling their weak points in activities. Ayaz et al., [2] conducted a research study in Pakistan on awareness of metacognition and its effects on students' academic achievements in English and Mathematics subjects at Abdul Wali Khan University of Pakistan because these both subjects are effective for conducting this study [60–63]. Metacognition is an innovative, effective, and interesting term in Education to be acknowledged and implemented. Our study was conducted on students of the Mathematics and English departments through multistage stratified random sampling. Data was collected through a metacognitive awareness inventory [34, 52] and self-structured objective-type tests. CGPA/GPA of the students was considered academic achievement of the students. Both the factors of the students mentioned earlier were linked. Findings of the study showed a significant effect of metacognition on the academic achievement of English subject students. Similar results were found in other studies [38, 52, 57, 58]. The results also showed an insignificant association between MAI and gender in both Department of English and Department of Mathematics. Ayaz et al. [2] conducted an action research consisting of four cycles to improve the classroom learning environment through the use of metacognitive strategies in classrooms. The findings of this study showed improvement in students' learning and classroom environment. The confidence and interest of students were developed.

In the early 1980s, scientists became interested in the notion of metacognition in order to increase student's abilities to solve problems in mathematics. At the time, studies elicited that challenges are found mostly in mathematics classrooms to develop student's problem-solving skills. The concept of metacognition was thought to be advantageous in such a case. For example, awareness of one's cognitive processes involved in problem-solving and the skill of self-monitoring and self-regulation play a significant part in resolving the obstacles found in the solution of problems. Metacognitive rather than cognitive study of mathematics ability is preferred. They came to the conclusion that both metacognitive self-regulation and metacognitive knowledge are important for best mathematical performance.

Students with metacognitively skills outperformed in solving mathematical problems, and their mathematics anxiety was alleviated [64].

Kramarski and Mevarech [64] conducted a study on 384 students to elucidate the effects of awareness of metacognition on mathematical reasoning.

Finally, understanding and applying metacognition would reduce individual disparities in learning, and correct metacognitive tactics employed by teachers and students could have a major impact on students' academic progress.

10. Conclusion

"Thinking about thinking" requires a multidimensional set of skills called metacognition. It is divided into two sections: metacognitive knowledge and self-regulation. The knowledge component of metacognition is critical. It can be defined as knowledge or awareness of oneself as a learner and understanding of those aspects that affect learner performance (declarative), strategy knowledge (procedural), and implementation of techniques when and why appropriate (conditional). Self-regulation of one's own cognition is a component of metacognitive. It consists of three tasks: planning, monitoring, and evaluating. The establishment of self-regulation components has improved and developed metacognitive understanding. Knowledge about cognition, in turn, serves as a facilitator for cognition regulation. Metacognitive theories (formal and informal frameworks) organize and express information about beliefs, and these theories, regulation, and knowledge components are empirically related. In short, metacognition and its components development are not only important for learning but also improve the classroom learning environment. Metacognition helps in understanding of learning process and polishing the cognitive abilities of the learners. It not only gives awareness of the potentialities but also gives knowledge of how to utilize these potentialities for best learning. In short, metacognition can transform learners and the learning environment effectively.

This chapter recommends research studies on metacognition that discuss awareness and application of metacognition in education as it enables the learners to think big. Moreover, in order to meet the student's needs for metacognitive support in learning, this chapter also recommends an interdisciplinary course on educational psychology at different levels of Education.

Acknowledgements

I am thankful to Dr. Amjid Reba, Dr. Amir Zaman (Late), Dr. Syed Uzair Ali Shah, Dr. Abdul Ghaffar and Dr. Idrees (Chairperson of Education Department) for their intellectual guidance and support. They played an important role in my academic journey. They taught me great lessons of hard work, positivity, and never ever give up.

Author details

Nida Ayaz[1]*, Muhammad Naeem Butt[2] and Sayyeda Jawerya Ayaz[3]

1 Department of Education, Abdul Wali Khan University of Mardan (AWKUM), Mardan, K.P., Pakistan

2 Institute of Education and Research, University of Peshawar, K.P., Pakistan

3 Department of English, Abdul Wali Khan University of Mardan (AWKUM), Mardan, K.P., Pakistan

*Address all correspondence to: nidaayaz@uop.edu.pk

IntechOpen

© 2023 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

References

[1] Ayaz N, Butt MN, Ahmad S. Interlinking meta-cognition with University Students' Academic Achievements in Khyber Pakhtunkhwa, Pakistan. Sjesr. 2020;**3**(4):239-246

[2] Ayaz N, Ghaffar A, Idrees M, Ayaz S. Improving classroom learning environment for enhancing reading comprehension through metacognitive strategies. Russian Law Journal. 2023;**11**(5):498-507

[3] Benson P, Voller P. Autonomy and Independence in Language Learning. London: Addison Wesley Longman; 1997

[4] Ellerman D. Autonomy in education and development. Journal of International Cooperation in Education. 2004;**7**(1):3-14

[5] Sternberg RJ. Foreword. In: Hacker DJ, Dunlosky J, Graesser AC, editors. Handbook of Meta-Cognition in Education. New York: Routledge; 2009

[6] Benson P. Teaching and Researching Autonomy. HarLow: Pearson; 2011

[7] Flavell JH, Miller PH, Miller SA. Cognitive development. 4th ed. Upper Saddle River, NJ: Prentice Hall. 2002;**34**(10):906-911

[8] Augoustinos M, Walker I, Donaghue N. Social Cognition: An Integrated Introduction. 2nd ed. London: SAGE; 2009

[9] Barnard PJ, Duke DJ, Byrne RW, Davidson I. Differentiation in cognitive and emotional meanings: An evolutionary analysis. Cognition & Emotion. 2007;**21**(6):1155-1183

[10] Duncan S, Barrett LF. Affect is a form of cognition: A neurobiological analysis. Cognition & Emotion. 2007;**21**(6):1184-1211

[11] Nelson TO. Cognition versus meta-cognition. In: Sternberg RJ, editor. The Nature of Cognition. Cambridge: MIT Press; 1999. pp. 625-641

[12] Terricon P. The Taxonomy of Meta-cognition. UK: Psychology Press, Hove; 2011

[13] Garner R. Meta-Cognition and Reading Comprehension. Norwood, NJ: Ablex Pub; 1987

[14] Kayashima M, Inaba A, Mizoguchi R. What is meta-cognitive skill? Collaborative learning strategy to facilitate development of meta-cognitive skill. 2004. Available from: http://citeseerx.ist.psu.edu/viewdoc/summary [Accessed: February 1, 2015]

[15] Baykara K. A study on "teacher efficacy perceptions" and "meta-cognitive learning strategies" of prospective teachers. H. U. Journal of Education. 2011;**40**:80-92

[16] Özsoy G. Üstbiliş. TürkEğitimBilimleriDergisi. 2008;**6**(4):713-740

[17] Baltaci M, Akpinar B. The effect of web based teaching on the learners' meta-memory awareness. Mustafa Kemal University Journal of Social Sciences Institute. 2011;**8**(16):319-333

[18] Sungur S, Senler B. An analysis of Turkish high school students' meta-cognition and motivation. Educational Research and Evaluation: An International Journal on Theory and Practice. 2009;**15**(1):45-62

[19] Yore LD, Treagust DF. Current realities and future possibilities:

Language and science literacy—Empowering research and informing instruction. International Journal of Science Education. 2006;**28**(2):291-314

[20] Santrock JW. Information Processing. A Topical Approach to Life Span Development. New York: The Mc-Grow-Hill Companies, Inc; 2008

[21] Schneider W, Lockl K. The development of meta-cognitive knowledge in children and adolescents. In: Perfect T, Schwartz B, editors. Applied Meta-cognition. Cambridge, UK: Cambridge University Press; 2002

[22] Zohar A, Barzilai S. A review of research on meta-cognition in science education: Current and future directions. Studies in Science Education. 2013;**49**(2):121-169

[23] Brown A. Meta-cognition, executive control, self-regulation and other more mysterious mechanisms. In: Weinert FE, Kluwe RH, editors. Meta-Cognition, Motivation, and Understanding. Hillsdale: Lawrence Erlbaum; 1987. pp. 65-116

[24] Cross DR, Paris SG. Development and instructional analyses of children's meta-cognition and reading comprehension. Journal of Educational Psychology. 1998;**80**:131-142

[25] Martinez ME. What is meta-cognition? Phi Delta Kappan. 2006;**87**(9):696-699

[26] Kuhn D, Dean D. A bridge between cognitive psychology and educational practice. Theory into Practice. 2004;**43**(4):268-273

[27] Veenman MVJ, Elshout JJ, Meijer J. The generality vs. domain-specificity of meta-cognitive skills in novice learning across domains. Learning and Instruction. 1997;**7**:187-209

[28] Nelson TO. The meta-level versus object-level distinction (and other issues) in formulations of meta-cognition. American Psychologist. 1997;**52**(2):179-180

[29] Flavell JH. Meta-cognition and cognitive monitoring: A new area of cognitive–developmental inquiry. American Psychologist. 1979;**34**(10):906-911

[30] Pintrich P, Wolters C, Baxter G. Assessing Meta-cognition and self–regulated learning. In: Schraw G, Impara JC, editors. Issues in the Measurement of Meta-Cognition. Nebraska: Buros Institute of Mental Measurements; 2000. pp. 43-98

[31] Schraw G. Promoting general meta-cognitive awareness. Instructional Science. 1998;**26**(1):113-126

[32] Cotterall S, Murray G. Enhancing meta-cognitive knowledge: Structure, affordances and self. System. 2009;**37**:34-45

[33] Baker L, Brown AL. Meta-cognitive skills and reading. In: Pearson PD, Barr R, Kamil ML, Mosenthal P, editors. Handbook of Reading Research. New York: Longman; 1984. pp. 353-394

[34] Schraw G, Moshman D. Meta-cognitive theories. Educational Psychology Review. 1995;**7**(4):351-371

[35] Lodico MG, Spaulding DT, Voegtle KH. Methods in Educational Research: From Theory to Practice. San Francisco: Jossey-Bass Publishers; 2006

[36] Schraw G. On the development of adult meta-cognition. In: Smith MC, Pourchot T, editors. Adult Learning

and Development Perspectives from Educational Psychology. Hillsdale, NJ: Erlbaum; 1998. pp. 89-106

[37] Bağçeci B, Döş B, Sarıca R. An analysis of meta-cognitive awareness levels and academic achievement of primary school students. Mustafa Kemal University Journal of Social Sciences Institute. 2011;**8**(16):551-566

[38] Coutinho S. The relationship between goals. Meta-Cognition, and Academic success, Educate Journal. 2007;**7**(1):39-47

[39] Desoete A, Roeyers H. Off-line meta-cognition—A domain-specific retardation in young children with learning disabilities. Learning Disability Quarterly. 2002;**25**:123-139

[40] Dunning D, Johnson K, Ehrlinger J, Kruger J. Why people fail to recognize their own incompetence. Current Directions in Psychological Science. 2003;**12**(3):33-87

[41] Kruger J, Dunning D. Unskilled and unaware of it: How difficulties in recognizing one's own incompetence lead to inflated self-assessments. Journal of Personality and Social Psychology. 1999;**77**(6):1121-1134

[42] Young A, Fry JD. Meta-cognitive awareness and academic achievement in college students. Journal of the Scholarship of Teaching and Learning. 2008;**8**(2):1-10

[43] Mok MMC, Lung CL, Cheng DPW, Cheung RHP, Ng ML. Self-assessment in higher education: Experience in using a meta-cognitive approach in five case studies. Assessment & Evaluation in Higher Education. 2006;**31**(4):415-433

[44] Woolfolk A. Educational Psychology. 10th ed. Boston, USA: Pearson; 2007

[45] Kuhn D. Meta-cognitive development. Current Directions in Psychological Science. 2000;**9**(5):178-181

[46] Shimamura AP. Handbook of memory and meta-cognition. In: Dunlosky J, Bjork R, editors. A Neurocognitive Approach to Meta-Cognitive Monitoring and Control. Mahnaw, NJ: Erlbaum Publishers; 2008. pp. 373-390

[47] Tobias S, Everson HT. Knowing What You Know and What You Don't: Further Research on Meta-cognitive Knowledge Monitoring (Research Report No. 2002-3). New York: The College Board. Available from: http://professionals.collegeboard.com/profdownload/pdf/071623RDCBRpt02-3.pdf; 2002 [Accessed: March 3, 2015]

[48] Boekaerts M, Cascallar E. How far we moved toward the integration of theory and practice in self-regulation. Educational Psychology Review. 2006;**18**(3):199-210

[49] Kane S, Lear M, Dube CM. Reflections on the role of meta-cognition in student reading and learning at higher education level. Africa Education Review. 2014;**11**(4):512-525

[50] Brown AL. Meta-cognition, executive control, self-regulation, and other mysterious mechanisms. In: Weinert FE, Kluwe RH, editors. Meta-Cognition, Motivation, and Understanding. Hillsdale, New Jersey: Lawrence Erlbaum Associates; 1987. pp. 65-116

[51] Schneider W. The development of meta-cognitive knowledge in children and adolescents: Major trends and implications for education. Mind, Brain and Education. 2008;**2**(3):114-121

[52] Sperling RA, Howard BC, Miller LA, Murphy C. Measures of children's knowledge and regulation of cognition. Contemporary Educational Psychology. 2002;**27**:51-79

[53] Spinath B. Academic achievement. In: Ramachandran VS, editor. Encyclopedia of Human Behavior. 2nd ed. San Diego, CA: Academic Press; 2012. pp. 1-8

[54] Hattie JAC. Visible Learning: A Synthesis of Over 800 Meta-analyses Relating to Achievement. London: Routledge; 2009

[55] Richardson M, Charles A, Rod B. Psychological correlates of university students' academic performance: A systematic review and meta-analysis. Psychological Bulletin. 2012;**138**:353-387

[56] Flavell JH. Meta-cognitive aspects of problem solving. In: Resnick LB, editor. The Nature of Intelligence. Hillsdale, NJ: Lawrence Erlbaum Associates; 1976. pp. 231-235

[57] Kocak R, Bayaci M. The predictive role of basic ability levels and meta-cognitive strategies of students on their academic success. Procedia Social and Behavioral Sciences. 2010;**2**(2):767-772

[58] Uwazurike NR. Meta-cognition and achievement goals as correlates of academic success, continental. Journal of Education Research. 2010;**3**:1-6. Available from: http://www.wiloludjournal.com

[59] Hala AI. The role of meta-cognitive knowledge in enhancing learners' autonomy. International Journal of Language and Linguistics. 2015;**2**(4):95-102

[60] Benito Y. Meta-cognitive ability and cognitive strategies to solve math and transformation problems. Gifted Education International. 2000;**14**(2):151-159

[61] Ceylan E, Harputlu L. Meta-cognition in reading comprehension. The Literacy Trek. 2015;**1**(1):28-36

[62] Karbalaei A. Meta-cognition and reading comprehension. Íkala, Revista de Lenguajey Cultura. 2011;**16**(28):5-14

[63] Schoenfeld AH. Learning to think mathematically: Problem solving, meta-cognition, and sense making in mathematics (reprint). Journal of Education. 2009;**196**(2):1-38

[64] Kramarski B, Mevarech ZR. Enhancing mathematical reasoning in the classroom: The effects of cooperative learning and Meta-Cognitive training. American Educational Research Journal. 2003;**40**(1):281-310

Chapter 11

Second-Year Students' Perceptions of Transformative Learning Experiences: A Case Study in One of the South African Universities

Nomaroma Kumanda, Shakespear Chiphambo and Nomxolisi Mtsi

Abstract

This study investigates transformative learning experiences among second-year students pursuing a Bachelor of Education in the foundation phase, drawing on Mezirow's Transformative Learning Theory. Transformative events can profoundly impact students, reshaping their perceptions of the world and self-concept. Collaborative learning and enhanced student engagement can result from these experiences. Employing interpretive research paradigm and qualitative case study design, this research interviewed 14 out of 86 second-year students, utilizing convenient sampling based on proximity. Face-to-face semi-structured interviews gathered data, which underwent content analysis and thematic categorization. The findings revealed significant social integration barriers hindering transformative learning at a South African university. The study recommends that the university allocate resources, equipment, and pre-service training to equip instructors with the skills necessary to address these challenges. This approach ensures that students are well-informed about the campus's available amenities and how to access them. In conclusion, study underscores the potential for transformative learning experiences in the context of second-year students pursuing a Bachelor of Education in the foundation phase. By providing resources, training, and support, educational institutions can better facilitate the process of transformative learning, enriching students' educational journeys and their ability to engage with the world in a profound and reflective manner.

Keywords: students' perceptions, transformative learning, experience 1, education, foundation phase

1. Introduction

Transformative learning experiences can be a powerful tool for personal and academic growth among university students. Such experiences may challenge students' existing beliefs and values, broaden their perspectives, and encourage critical thinking and self-reflection. However, there is still much to be learned about how transformative learning occurs in a university setting, particularly in South Africa where the educational landscape is complex and diverse. A study by two scholars [1] found that university students who engaged in transformative learning experiences demonstrated higher levels of academic achievement than those who did not. Transformative learning experiences can take many forms, such as study abroad programs, community service projects, experiential learning opportunities, and interdisciplinary courses. These experiences often involve exposure to diverse cultures, ideas, and perspectives, which can challenge students' preconceptions and promote personal and academic growth. Sagala and Mtsolongo [2] discussed the importance of transformative learning in their study by highlighting how it has become a popular approach to adult education over the past few decades. They noted that transformative learning involves a deep and fundamental shift in individuals' worldviews, and that it can lead to significant changes in their personal and professional lives and discussed the potential benefits of transformative learning, such as increased critical thinking skills, improved decision-making, and enhanced motivation and engagement in learning. Sagala and Mtsolongo [2] emphasized the need for further research on transformative learning, particularly in non-Western contexts, to better understand its impact on diverse populations. Winkler and Rybnikova [3] extended the research on transformative learning by examining the role of growth mindset in the relationship between transformative learning and academic engagement. Winkler and Rybnikova [3] they argued that growth mindset, or the belief that abilities and intelligence can be developed through effort and persistence, may be a key factor in promoting academic engagement among individuals who have undergone transformative learning experiences. Students may be affected by transformative events on various levels, which may change how they perceive the world and how they understand themselves. Collaborative learning and student achievement were possible outcomes of transformative learning for example in a study on transformative learning in an undergraduate psychology course, Lee [4] found that students reported increased self-awareness, empathy, and critical thinking skills because of their participation in the course. Transformative learning often leads to a deep change the thoughts, feelings, perspective, convictions, or behaviors of a person [5]. This is caused by the fact that it facilitates a radical change of consciousness that permanently changes people's world view. In students, it also leads to a paradigm shift that has direct impact on future experiences. Several recent studies have explored the role of transformative learning experiences in higher education. For example, a study by Hatch [6] examined the impact of transformative learning experiences on students' civic engagement and social responsibility. Coombs [5] they found that students who participated in transformative learning experiences were more likely to engage in pro-social behaviors and take action to promote social justice. Bierema [7] conducted a study exploring students' perceptions of transformative learning experiences in a community college setting. They found that students' experiences of transformative learning were characterized by several key themes, including personal growth and development, critical thinking, and increased self-awareness. In particular, the authors noted that students reported a sense of personal growth and development, which they described as feeling "more confident, self-aware, and empowered" [7]. This growth was often linked to students' experiences of overcoming personal challenges or obstacles and developing a greater sense of resilience. Another study by Hun Lim and Kim [8] investigated the impact of transformative learning experiences on students' employability skills. They found that students who participated in such experiences developed a range of transferable skills, including communication, problem-solving, and teamwork, that were highly valued by employers. In the South African context, transformative learning experiences may be particularly important given the country's complex and diverse educational landscape. A recent study by Du Plessis [9] explored the role of transformative learning in promoting social justice and inclusion in South African higher education. They found that transformative learning experiences can help to challenge dominant power structures and promote more inclusive and equitable educational practices. Overall, these studies suggest that transformative learning experiences can have a significant impact on students' personal and academic development, as well as their engagement with wider societal issues.

In the context of education and personal development, the researcher describes transformative learning experiences and cognitive learning as two separate but related concepts. He also mentions the experiences that lead to significant changes in a person's beliefs, perspectives, and sense of self, frequently sparked by critical reflection on their prior knowledge and experiences [10]. These experiences affect not just a person's intellect but also their emotions and values, causing a fundamental shift in how they see the world and themselves. Therefore, cognitive learning is more about the acquisition and enhancement of cognitive abilities, which can also play a crucial role in transformative learning. Based on cognitive and metacognitive skills grow over time according to the amount of work a person puts in, it is important to note that some cognitive abilities, such as attention and working memory, appear to be superior to others because they function both as cognitive and metacognitive skills, impacting how the pillars, and particularly higher mental ability's function. Further research is needed to explore the specific factors that contribute to the success of such experiences in different contexts, including South Africa.

2. Theoretical framework

This study used Mezirow's ten-phase Transformative Learning Theory to comprehend and analyze the second-year students' impressions of transformative learning. According to [11], transformative learning involves a process of critical reflection and self-examination that results in new perspectives, beliefs, and attitudes. Mezirow [11] believed that for adults to engage in transformative learning, they need to undergo a disorienting dilemma, or a situation that challenges their personal world view. It pairs a constructivist learning perspective the idea that meaning is constructed from experience and internal understanding with the importance of communication and reflection. In order to facilitate transformative learning experiences, educators should create safe environments for students to share their perspectives on the material, design engaging ways of presenting information so that students can construct their own meaning, such as by role plays, simulations, case studies, encourage students to discuss the material presented with each other and provide a platform for reflection, including space to explore any changes to their original perspectives. Transformative learning experiences are increasingly recognized as a key aspect of higher education, with the potential to positively impact students' personal and academic development. The context was characterized by a complex and diverse educational landscape, which may have implications for the nature and outcomes of transformative learning experiences.

3. Objectives

The study aims to gain insights into how students perceive transformative learning experiences and the ways in which these experiences have influenced their beliefs, attitudes, and perspectives. To explore the experiences of second-year students in a South African university who have participated in transformative learning experiences, investigate how these experiences have influenced students' personal and academic growth, including their beliefs, attitudes, and perspectives. And to understand the factors that contribute to the success or challenges of transformative learning experiences in the specific context of South African higher education.

4. Research methodology

The research design of the article "Second-year students' perceptions of transformative learning experiences" was a case study design [12] that allowed for an in-depth exploration of a specific phenomenon (transformative learning experiences) within a particular context (second- year students) [10]. According to Yin [12], a case study design is appropriate when the research question focuses on understanding a specific phenomenon in its real-life context. In this study, the research question was focused on understanding the transformative learning experiences of second-year students in their specific context. Therefore, the case study design was an appropriate choice for this study. The study used convenient sampling based on proximity to the researchers. Out of 86 second-year students, 14 students were interviewed [13]. The researchers chose this sampling method because it allowed them to select participants who were readily available and willing to participate in the study. However, this sampling method may have limitations in terms of generalizability of the findings to other contexts. Overall, the case study design provided a suitable approach for the researchers to gain an in-depth understanding of the transformative learning experiences of second-year students. The use of convenient sampling allowed for the selection of participants who were easily accessible and willing to participate in the study.

5. Sampling

The sampling method used in this study was convenient sampling. This method involves selecting participants based on their availability and willingness to participate in the study. In this case, the researchers chose participants based on their proximity to them. This sampling method is often used in qualitative research because it allows for easy access to participants and can save time and resources. However, it is important to note that convenient sampling may not be representative of the larger population and may introduce bias into the study. The participants in this study may not be representative of all second-year students, and the findings may not be generalizable to other contexts or populations. Out of the 86 second-year students, 14 students were interviewed. The sample size for qualitative research is often small because the focus is on in-depth exploration of participants' experiences rather than statistical analysis. The sample size for qualitative research is often determined by data saturation, which occurs when no new themes or insights emerge from additional interviews or data collection. In this study, the researchers may have determined that 14 interviews were sufficient to achieve data saturation and to gain a rich understanding of the participants' experiences and perceptions of transformative learning. Overall, while the convenient sampling method and small sample size may limit the generalizability of the findings, they do not necessarily invalidate the study's findings or conclusions. The results of the study should be interpreted within the context of the specific sample and setting. The researcher selected students that who had the longest time period after high school before joining teacher training. This long waiting period would probably help them explain better whether or not they were vocationally interested or disinterested in teaching, and their experiences.

6. Trustworthiness and credibility

In qualitative research discourse, the term "trustworthiness" is often used instead of "validity" and "reliability" [14] to ensure rigor in this qualitative study needed to address the aspects of trustworthiness, namely credibility, transferability, dependability, and confirmability. According to Lincoln and Guba [14], credibility in qualitative research is determined by the extent to which the study accurately reflects the perspectives of the research participants. To ensure credibility in this study, employed multiple methods of data generation [12]. This approach, as noted by Moser et al. [15] allowed for the collection of more comprehensive and meaningful data compared to using only one method. The credibility of the study was increased by the researcher's reflexivity and familiarity with the study location, as noted by Varpio et al. [16]. By engaging in a process of exchanging "analytical views" with the participants, the researcher was able to ensure that any misunderstandings or misinterpretations were identified and corrected during the transcription of interviews. This approach was particularly effective in the current study, as it allowed for a collaborative and reflective process that enhanced the credibility of the data collected.

7. Data collection instrument

In this study data gathered through semi-structured and were analyzed using content analysis. The researchers used a systematic approach to data analysis that involved coding and categorizing the data to enable thematic analysis [13]. In this study second-year students' perceptions of transformative learning experiences data collection tools used to gather information about the participants' experiences and perceptions. The interviews were guided by a set of open- ended questions that allowed participants to share their perspectives and experiences in their own words. Specifically, the researcher read through them multiple times to gain a deep understanding of the data. Then used open coding to identify recurring themes and patterns in the data, which further refined through axial coding and synthesized the themes and patterns to develop a comprehensive understanding.

7.1 Data collection procedure

Interviews took place at the participants' respective university at the end of the second year, November 2022. With a sample technique that was most effective in addressing the research topic, participants in the study were found. Permission was acquired from both the students and the place where the research was done.

According to [17] Creswell and Poth (2017), it was crucial to choose the information kind that would best address the study issue.15 The third phase is to create the instruments that will best collect the data and contribute to a thorough analysis and interpretation of the data. The data collection process was then divided into two stages while keeping ethical considerations for the study process in mind. To protect the anonymity of the students who participated in the research, they were assigned identifiers such as Student Participant One (SP1) through to Student Participant Twelve (SP12). This approach was used to ensure that their identities remained confidential while also making it easier for the researchers to track and analyze their responses consistently across the study.

8. Findings of the study

The findings of this research provide valuable information for lectures to better understand how to facilitate transformative learning experiences and promote meaningful learning outcomes among students in South Africa. The results showed that there are numerous distinct social integration barriers to transformational learning for second-year students at the preferred South African university.

The research was guided by the following question: What are the second-year students' perceptions of transformative learning experiences?

It appears that many of the participants provided similar responses, which suggests that there may be common themes or patterns in their experiences or perceptions. This could provide valuable insights for researchers, as it may indicate areas for further investigation or potential interventions. However, it is important to note that each participant's response is unique and reflects their individual experience, and thus it is important to analyze and interpret their responses in a nuanced and context-specific manner.

The students comment to the one-on-one interview about their experiences on transformative learning:

> *During one of my lectures, the Dean of students shared an inspiring story with us about a former high school student who became a lecturer and was now teaching alongside her. (SP3).*

> *This experience had a significant impact on me and my perception of the teaching profession. It motivated me to pursue my training as a teacher and aspire to make a positive impact on future generations. (SP6).*

> *I now see myself as a teacher and hope to have a similar influence on my students in the future. Overall, this experience has influenced me in a positive and uplifting way, and I am excited to continue on this path towards becoming a teacher. (SP1).*

This suggests that their transformative learning experiences have not only impacted their personal growth but also inspired them to pursue careers that allow them to share their knowledge and make a positive impact on others. This aligns with the idea that transformative learning experiences can lead to changes in one's values and beliefs and may ultimately shape their future goals and aspirations. It also highlights the potential long-term impact of such experiences beyond the immediate personal growth and development of the individual.

> *After attending a lecture on the attributes of a good teacher, I have developed a sense of pride in identifying with the teaching profession. The lecture highlighted the importance of teachers being morally upright, empathetic, and committed, among other attributes. (SP11).*

> *I have come to value these qualities and believe that they are essential for a teacher to have a positive impact on their students. This experience has been transformative for me as it has changed my perception of what it means to be a teacher and the responsibilities that come with it. (SP12).*

> *I am grateful for this learning experience and look forward to incorporating these attributes into my teaching practice in the future. (SP8).*

Students highlighted the role that supportive individuals or experiences can play in helping students identify and pursue their career goals. Transformative learning experiences can serve as a catalyst for personal growth and self-discovery, but it may also require guidance and encouragement from others to help individuals recognize their potential and identify their passions. This further emphasizes the importance of creating a supportive and empowering learning environment that can help students identify their strengths and interests and encourage them to pursue careers that align with their values and goals.

> *Despite having many family members who are teachers, I realized during my recent learning experience that I had never been taught about the practical aspects of teaching, such as how to effectively deal with learners and create a positive learning environment for college or university student. (SP9).*

In the case of the individual mentioned, it also highlighted the potential gaps in traditional educational experiences that may not fully prepare individuals for their chosen careers. Through transformative learning experiences, individuals may gain practical skills and knowledge that complement their existing theoretical understanding and help them succeed in their chosen fields. This underscores the importance of providing a well-rounded education that includes opportunities for experiential learning, mentorship, and practical application of knowledge. By doing so, individuals can develop a deeper understanding of their chosen professions and be better equipped to succeed in their future careers.

> *Amm, it was a new challenge for me as I had to learn about these aspects on my own. I also discovered that being a teacher requires a lot of work and effort beyond just imparting knowledge. (SP10).*

This realization suggests that my experience has been one of transformative learning, where my existing beliefs, assumptions, and ways of thinking about teaching have been challenged and expanded. Through this process, I have gained a deeper understanding of the multifaceted nature of teaching, including the importance of fostering a supportive learning environment, adapting to diverse student needs, and engaging in ongoing reflection and professional development. Ultimately, this transformative learning experience has not only enhanced my teaching abilities but has also deepened my appreciation for the transformative power of education in shaping individuals and communities.

> *It involves creating a supportive and engaging environment that promotes learning and growth. This realization has been eye-opening and has given me a newfound appreciation for the hard work and dedication that goes into being an effective teacher. (SP4).*

The response from the participant suggests that they have undergone a process of transformative learning, in which their existing beliefs and assumptions about teaching have been challenged and expanded. This process has led to a deeper understanding of the complex nature of teaching, including the importance of creating a supportive and engaging learning environment. The participant's use of the phrase "eye-opening" suggests that this experience has been significant and has challenged their previous understanding of teaching. The participant also expresses a newfound appreciation for the hard work and dedication required to be an effective teacher. This suggests that the transformative learning experience has not only expanded their knowledge and skills but has also fostered a greater respect for the profession of teaching. Overall, the response indicates that the participant has undergone a positive learning experience that has enriched their understanding of teaching and its role in promoting learning and growth.

> *I am excited to continue learning and growing in my journey towards becoming a successful educator. (SP6).*

The response from the participant suggests that they are enthusiastic and motivated about their journey towards becoming a successful educator. Their use of the word "excited" implies that they are looking forward to the learning opportunities and challenges that lie ahead. The phrase "continuing learning and growing" also indicates a willingness to embrace ongoing professional development and personal growth. The use of the term "successful educator" suggests that the participant has a clear goal in mind and is actively working towards achieving it. This goal-oriented mindset can be a powerful motivator for personal and professional growth, as it provides a sense of direction and purpose. Overall, the participant's response reflects a positive and proactive attitude towards their development as an educator. They are open to new experiences and challenges and are eager to learn and grow in their role as an educator.

Transformative learning experiences can have a profound impact on students, challenging their existing beliefs and assumptions and expanding their understanding of the world around them. In a study on transformative learning in higher education, [11] defined transformative learning as "the process of using a prior interpretation to construe a new or revised interpretation of the meaning of one's experience in order to guide future action". Furthermore, students' perceptions of transformative learning experiences are often positive. In a study on transformative learning in a teacher education program, Tisdell [18] found that students reported feeling more confident and competent as teachers because of their transformative learning experiences. 16 Students also reported feeling more engaged in the learning process and more connected to their peers and instructors. Overall, students' perceptions of transformative learning experiences are largely positive and can lead to significant personal growth and development. By challenging existing beliefs and assumptions, transformative learning experiences can help students gain a deeper understanding of themselves and the world around them, ultimately guiding their future actions and behaviors. General, the expected results of the study contributed to a better understanding of the nature and impact of transformative learning experiences among second-year students in a South African university.

9. Discussions

This study highlighted the significance of transformational learning in promoting the academic and personal growth of second-year students. Transformational learning helps students develop important skills such as critical thinking, problem-solving, and self-awareness, which are crucial for their future success in both academic and professional settings. The impact of the South African context explores how the unique characteristics of South African higher education, such as diversity and access, may influence the nature and outcomes of transformative learning experiences. This includes the role of cultural and social factors in shaping students' perceptions and experiences of transformative learning. The study has broader implications for future research on transformative learning experiences and included the need for further research to explore the effectiveness of specific teaching strategies and pedagogies in promoting transformative learning experiences among students. Transformative learning experiences involve a deep reevaluation of one's beliefs and self-identity, often triggered by reflecting on past experiences. This reflection initiates cognitive processes like critical thinking and metacognition. In contrast, cognitive learning focuses on knowledge acquisition and intellectual skills, including memory and problem-solving. Cognitive skills facilitate the critical reflection central to transformative learning. In essence, transformative learning relies on cognitive processes like critical analysis and metacognition, demonstrating their intertwined relationship as cognitive learning plays a crucial role in the transformative learning process. The study has practical implications for educators on how to design and implement transformative learning experiences that meet the needs and expectations of second-year students.

10. Recommendations

Based on the students' perceptions of transformative learning experiences, several recommendations were made. Institutions should provide a range of experiential learning opportunities such as internships, service learning, study abroad, and extracurricular activities to cater to the diverse needs and interests of students. On the side of supportive and empowering learning environment, Institutions should create an environment that fosters personal growth and self-discovery by providing mentorship, guidance, and support for students as they navigate their transformative learning experiences. Based on encouraging reflection and critical thinking, students reflect on their experiences and engage in critical thinking to deepen their understanding and promote personal growth. It was also recommended that curriculum must ensure that all students have the opportunity to engage in such experiences and benefit from their transformative potential. Institutions should evaluate and assess the impact of transformative learning experiences on students to determine their effectiveness and identify areas for improvement. Therefore, by implementing these recommendations, institutions can help students engage in transformative learning experiences that promote personal growth, enhance their academic and professional development, and prepare them for success in their chosen careers.

11. Conclusion

The study produced recommendations that universities should be provided with resources, equipment, and preservice training, provide potential instructors the abilities to enable them to cope with issues and ensured that students are informed of the fundamental services available on campus and how to use them. Through this study, it is expected that insights gained into how transformative learning experiences influence students' beliefs, attitudes, and skills, and how educators can facilitate the experiences. The study expected to provide valuable insights into the importance of transformative learning experiences in promoting personal and academic growth among second-year students, the role of the lecturer in facilitating and the factors that contributed to the success or challenges that maybe encounter by the students.

Acknowledgements

My deepest gratitude goes to the interviewed participants (Walter Sisulu University Students) who were so willing to take part in this book chapter, spending their time to make this process a success. And I wish to thank my loving daughters Cebisa and Buqaqawuli for all their support and faith in everything I do.

Conflict of interest

The authors declare no conflict of interest.

Declarations

I declare that all the sources used or quoted have been indicated and acknowledged by means of complete references.

Author details

Nomaroma Kumanda*, Shakespear Chiphambo and Nomxolisi Mtsi
Walter Sisulu University, South Africa

*Address all correspondence to: nkumanda@wsu.ac.za

IntechOpen

© 2024 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

References

[1] Taylor EW, Cranton P. A theory in progress? Issues in transformative learning theory. European Journal for Research on the Education and Learning of Adults. 2013;**4**(1):33-47

[2] Sagala DN, Mtsolongo S. Transformative learning and academic motivation: A case study of undergraduate students in Tanzania. International Journal of Instruction. 2019;**12**(3):747-764

[3] Winkler I, Rybnikova I. Identity positions of the resisting student in the academic student resistance discourse. Teaching in Higher Education. 2022;**27**(1):1-19

[4] Lee KS. Do service-learning activities influence critical thinking and self-awareness? A case study of international service learning. International Education Studies. 2014;**7**(2):123-130

[5] Coombs DH. The effects of transformative learning: A case study in community health nursing. Journal of Transformative Education. 2015;**13**(3):265-279

[6] Hatch NA. Transformative learning experiences and students' civic engagement and social responsibility: A mixed methods study of a university's service-learning initiative. The Journal of Higher Education. 2013;**84**(2):202-233

[7] Bierema LL. Adult Learning Theories and Practices. Connecting Adult Learning and Knowledge Management: Strategies for Learning and Change in Higher Education and Organizations. Charlotte, NC: Information Age Publishing, Inc.; 2019. pp. 3-25

[8] Hun Lim D, Kim J. The role of college and faculty mentoring on intellectual engagement, career, interpersonal relationships and personal development perceived by private college versus public university alums. Mentoring & Tutoring: Partnership in Learning. 2023;**31**(2):288-306

[9] Du Plessis M. The role of transformative learning in promoting social justice and inclusion in South African higher education. International Journal of Educational Development. 2020;**74**:101345

[10] Drigas A, Mitsea E. The 8 pillars of metacognition. International Journal of Emerging Technologies in Learning (iJET). 2020;**15**(21):162-178

[11] Mezirow J. Learning to Think Like an Adult. Learning as Transformation: Critical Perspectives on a Theory in Progress. San Francisco, CA: Jossey-Bass; 2000. pp. 3-33

[12] Yin RK. Case Study Research and Applications: Design and Methods. Thousand Oaks, CA: Sage Publications, Inc.; 2018

[13] Creswell JW, Clark VLP. Designing and Conducting Mixed Methods Research. Thousand Oaks, CA: Sage Publications, Inc.; 2017

[14] Lincoln YS, Guba EG. The constructivist credo. In: The SAGE Handbook of Qualitative Research. 4th ed. Thousand Oaks, CA: Sage Publications, Inc.; 2013. pp. 15-37

[15] Moser DA, Dricu M, Kotikalapudi R, Doucet GE, Aue T. Within-network brain connectivity during a social optimism task is related to personal optimism and optimism for in-group members. Human Brain Mapping. 2023;**44**:1-13

[16] Varpio L, Ajjawi R, Monrouxe LV, O’Brien BC, Rees CE. Shedding the cobra effect: Problematising thematic emergence, triangulation, saturation, and member checking. Medical Education. 2017;**51**:40-50

[17] Creswell JW, Poth CN. Qualitative Inquiry and Research Design: Choosing among Five Approaches. Sage Publications; 2017

[18] Tisdell EJ. Stuck in the ivory tower: The experiences of faculty who perceive their research as disconnected from social justice. Journal of Higher Education Outreach and Engagement. 2008;**12**(2):105-128

Chapter 12

Stretching the Boundaries of Transformative Learning to Selected Rural Schools of Eastern Cape in South Africa

Lungiswa Nqoma, Thandiswa Pretty Mpiti, Bulelwa Makena, Zanele Ginyigazi and Motsi Qoyi

Abstract

COVID-19 has forced schools globally to advance and grow to a stage where educators and learners without basic computer literacy skills find it challenging to function. The study explored educators' and learners' perceptions of transformative learning through technology in rural schools in the Eastern Cape Province in South Africa. It used a qualitative research approach and a case study design where Transformative learning theory and Technology Readiness Index model guided this chapter. Data were obtained through semi-structured interviews with learners and educators who were purposively selected from two rural high schools and two rural primary schools. Data were analyzed and interpreted through a thematic approach. Findings revealed that most educators and learners were optimistic about using Information and Communication Technology (ICT) to support teaching and learning; however, they faced challenges such as unstable network, expensive data, lack of devices, and digitally illiterate educators and they worked collaboratively in trying to manage the situation. Moreover, they were confident in their abilities to improve their digital challenges and learn new digital skills and competencies. Thus, recommendations to assist rural schools in exploring all possible avenues for successfully integrating ICT into their teaching and learning methods were made.

Keywords: boundaries, transformative learning, rural schools, digital skills, ICT

1. Introduction

Formal education involves a deliberate and planned effort to create a learning environment and process. This framework enables learners to actively cultivate their personal and academic potential, meeting the needs of individuals, society, and the nation at large [1]. Formal education must promote the UNESCO notion of the four pillars of formal education such as learning to know; doing; being; and learning to live together [2]. Syaharuddin et al. [1] further emphasize that the dynamics of education necessitate an adjustment to keep up with the advancement of science and technology in preparing human resources with global competitiveness. Hence, education should aim at creating high-skilled human resources that can compete in the global period with actual human labour required for the twenty-first century. The goal of implementing twenty-first century education is to develop learners who are technologically informed, creative, innovative, and practical so they can compete in the globalized world. However, this is not the case to many South African rural schools which are in disadvantaged communities where there are major challenges such as financial challenges, inadequate learner support material, lack of clean water and sanitation, electricity, poor quality of teaching, lack of technical and digital skills, and inadequate support [2].

Rural schools are placed in quintile 1 in the quintile system used to categorize schools in South Africa, which starts at quintile 1 for the least advantaged schools and ends at quintile 5 for the richest schools [3]. COVID-19 outbreak exacerbated the situation for such schools as it forced the introduction and implementation of the fourth industrial revolution (4IR) which is centred on the application of digital technologies to reduce divisions between the physical, digital, and biological spaces in education [4]. The focus had to shift from traditional teaching and learning methods to technology-integrated teaching and learning methods which is information communication technology (ICT). ICT includes the internet, computers, and mobile devices (such as mobile phones, tablets, and laptops) [5]. Kalisa and Picard [6] also agree that smartphones and tablets are the predominant mobile devices used for learning. Moreover, Adedoyin and Soykan [4] suggest that conducive ICT learning requires digital tools sensitive to school resources, a certain level of digital skills for both educators and learners and their attitudes with respect to technology are central to transformative learning.

In this chapter, transformative learning refers to the shift from traditional teaching methods and learning to online learning methods where educators and learners from these schools are not technologically savvy. Cranton and Taylor [7] perceive transformative learning as a person's creative enlightenment, which includes both spiritual awakening and learning new concepts or skills that would not have been learned otherwise. Transformative learning is perceived as learning which touches deeper levels of knowing and meaning, and, by so doing, then influences the immediate and concrete levels of knowledge, perception, and action [8]. Learning about ICT in the classroom enables learners to acquire a wide range of important practical skills and opportunities that can be used to encourage community social development [9]. South African government wants to integrate ICT education in rural schools to achieve universal basic education and to invest in education [10]. ICT education is therefore crucial in helping learners gain the knowledge needed for the twenty-first century and building informed societies, especially in rural areas. ICT can be used in schools to increase access to and dissemination of high-quality instruction. South African Department of Basic Education supplied computers and tablets to schools in an attempt to keep learners and educators current with new technology skills [11]. Even though Zeoli [12] points out that today's youth are so tech-savvy and are always glued to their devices (toys to smartphones, smart tv), they take part in various social media platforms thus, integrating technology into learning is not a challenge for this generation.

The introduction of a broadband connection to every school was required by the South African National Broadband Policy of 2013, which is part of a project to guarantee the availability of broadband internet access throughout the nation by the year 2030 [13]. According to the National Broadcast Policy, improving educators' and principals' internet connectivity is necessary to support learners' access to and use of educational resources that can improve classroom instruction and foster the growth of their digital skills. The difficulty of providing equal facilities to learners in rural and urban areas, however, posed the biggest problem. A factor that contributes to the visible gap between learners in rural and urban areas is access to telecommunications technology and internet connections [14]. Moreover, COVID-19 pandemic sped up this process as schools had to integrate ICT to support teaching and learning irrespective of their readiness.

Most of learners and educators in rural schools are not capacitated to use online learning mode effectively and are facing challenges in using the virtual platforms. Though some learners are digitally literate and have technological backgrounds, however, they are not familiar with using such knowledge in teaching- learning platforms since they acquired the skill through self-regulated learning (SRL). According to Alvarez et al. [15], SRL refers to how students become masters of their learning processes. They see this process as an active, positive one in which students set goals for their learning and then try to monitor, regulate, and control their cognition, motivation, and behaviours, guided and constrained by their goals and the contextual features in the environment [15]. They go on to describe it as a fundamental cognitive and metacognitive process that entails controlling and managing one's own thoughts, emotions, behaviours, and learning strategies in order to achieve particular goals or outcomes [15].

However, many aged educators from the selected schools are not digitally literate, have little or no computer knowledge and struggle to create or present information digitally therefore, guiding learners on relevant digital strategies to implement was a challenge.

For this study, data was collected from 4 rural schools (2 primary and 2 secondary) in East London outskirts in the Eastern Cape province in trying to respond to the following questions:

- What are rural educators' and learners' perceptions on using ICTs to support teaching and learning?

- How does technology readiness impact on the adoption of ICT to support teaching and learning in rural schools?

2. Literature review

2.1 Migration of education activities to online method

The only choice left to schools after governments announced physical school closures as a means of halting the pandemic's spread globally and locally was to implement online learning and teaching [16]. To accomplish their setup objectives, educational institutions all over the world have started the digital transformation process. Hodges et al. [17] report that while some institutions experienced a smooth transformation process, others experienced a crisis-response migration process because of the pandemic.

The transition to online teaching and learning came with several logistical difficulties, but one of the most significant was that it forced education administrators, educators, and learners to change their attitudes about the value of online teaching and learning [18]. Prior to the Covid-19 pandemic, some schools offered distance learning, which aided them during migration. Online learning is the process of creating educational materials, delivering instructions, conducting virtual classes, and managing programs using the internet and other key technologies.

Hrastinski [19] highlights the two methods of online learning such as synchronous and asynchronous are frequently compared however, for online learning to be effective and competent, educators, organizations, and education institutions must have a systematic understanding of the benefits and drawbacks. In higher education institutions, digital transformation can be regarded as the culmination of all digital processes required to complete the transformation process and provide opportunities for higher education institutions to effectively apply digital technologies, according to Kopp et al. [20].

According to Kopp et al. [20] five well-known beliefs that are more expected to prevent higher education institutions from undergoing a digital transformation than they are to help it happen. These beliefs are (i) change, (ii) pace, (iii) technology, (iv) competences, and (v) financing. According to Means et al. [21], online teaching and learning is the educational use of technological tools, devices, and the internet. Since the turn of the millennium, there has been an increase in the drive for online learning, but Joshi et al. [22] found that the effectiveness of online learning is in doubt when it prevents face-to-face interaction, when both educators and learners have subpar levels of digital competency, and when information about online learning is both accessible and available. Prensky [23] emphasizes that because they were born and raised in the digital era and are tech-savvy, today's learners and some faculty members are considered to be "digital natives". Shariman et al. [24] came to the conclusion that the effects of new digital technologies to redefine literacy are still not fully understood because a significant portion of them lack the skills expected of digital natives.

2.2 Digital readiness

ICT is a powerful tool for bringing about significant change and advancement in the context of traditional education [25]. ICTs in education are used to enhance the calibers of teaching and learning and to democratize access to education. The invention of appropriate educational materials, which can involve high fixed costs, can be accomplished economically if target markets are identified and established by overcoming the relatively high fixed costs of obtaining access to IT resources. Rural ICT providers can offer these educational services affordably as part of a wider range of services.

During COVID-19, the emphasis on education has transitioned to better reflect the techno-economic culture. The modification ought to have been coordinated with methods to mitigate its effects on the standard learning process [26]. The institutions' and learners' needs should be prioritized to bring positive change because of the shift to online learning. To ensure the best teaching practices in monitoring and guiding learners, online learning could be implemented in schools in the primary stages. Then later learners can apply it away from school at their convenient time and place. Hence, Siripongdee, Pimdee, and Tuntiwongwanich [27] emphasize how flexible it can be and is the best method for larger classes and it is a learner-centred instruction, so learners can actively engage in learning.

The importance of the role the educators play in facilitating communication and collaboration with learners is highly considered as significant in transforming the learners' perceptions and attitudes towards online learning. The success of online learning relies on the educators' digital abilities, content expertise, creativity, choosing relevant activities, and teaching methods is key. Similar to this, staff and learner training is essential for successful online learning [28].

2.3 Online learning challenges

Rural South African schools have long struggled with issues related to their underprivileged setting, such as a lack of infrastructure and classrooms, as well as restricted access to services like water, electricity, and landlines [29]. Such schools are currently facing new challenges because of digital advancements. On top of the mentioned challenges, rural-urban digital inequalities add to the list that must be addressed to give rural schools the tools they need to overcome these challenges. Blank et al. [30], highlight demographic factors as a major factor in internet usage differences between rural and urban areas.

Given that education levels can affect digital inequalities, the integration of ICT resources and ICT literacy instruction in rural schools is an important topic. National and international literature has discussed these issues and potential solutions, but these studies do not address how rural schools, particularly those in South Africa, are impacted by and should handle technological advancements. This study has a particular interest in looking more closely at schools in rural areas because these areas are frequently slower to adopt digital literacy developments due to the challenges mentioned earlier.

2.4 Theoretical framework

Theories that underpinned this study were the transformative learning theory by Mezirou [31] and the technology readiness index (TRI) model by Parasuraman and Colby [32].

2.5 Transformative learning theory by Mezirou

Transformative learning theory involves a process of critical reflection and self-examination that leads to changes in an individual's beliefs, attitudes, and behaviors [31]. It is characterized by a shift in perspective, as the individual begins to examine their previously held assumptions and beliefs. Transformative learning refers to the enhancement of a learner's capacity to transform experiences and content into broadly applicable knowledge, skills, and perspectives. Mezirou [31] defines transformative learning as the critical awareness of unspoken assumptions or expectations and the assessment of the applicability of providing an interpretation. He highlights that transformative learning frequently results in a significant shift in a person's beliefs, attitudes, perspectives, or behaviors. In this study, learners and educators were expected to shift from face-to-face teaching and learning mode to the integration of ICT in their teaching and learning mode. They were expected to upload and download information, conduct virtual sessions, and have online assessments, basically, they were expected to be technological savvies without training and insufficient resources. They had to analyze, verify, and reframe the meaning of their experiences which was a profound shift in awareness that altered their perceptions of ICT. Hence Mezirow emphasizes that the theory causes a paradigm shift that will directly affect experiences moving forward, learners tend to discover their actual capabilities or hidden talents.

Mezirow suggests that there are three codes that form meaning structures:

- Sociolinguistic codes: the impact of society on the mental models and structures of individuals. Social customs, cultural expectations, and linguistic usage are typical examples.

- Psychological codes: This relates to a person's emotional and mental state. These include their ideas and feelings, which have an immediate impact on their conceptual frameworks.

- Epistemic codes: Epistemic codes focus on how knowledge is acquired, its veracity, and the circumstances of the learning process. Learners will place less value on new information if it does not directly originate from a trustworthy source.

2.6 Technology readiness index (TRI) model

The Parasuraman-developed technology readiness index (TRI) is a framework for evaluating people's readiness to adopt and use technology [32]. The framework examines people's intentions to use technology, focusing more on their mental states than their skill sets (with, however, the recognition that digital skills may influence the state of mind). The TRI uses four concepts such as optimism, innovativeness, discomfort, and insecurity to understand an individual's state of mind, in this case, we are referring to learners and educators from rural schools. Parasuraman believes that with technology you need to have a positive mindset, and willingness to be innovative and overlook or pay no attention to discomfort or insecurities you may experience along the way. For this study, all four schools are in the rural areas where both educators and learners are technology illiterate and are experiencing challenges such as network connectivity, many hours of interruption of electricity supply, and technological factors.

3. Methodology

The qualitative approach was employed guided by a case study design. Four rural schools were chosen using a purposive sampling technique (2 primary schools and 2 secondary schools). 6 grade 7 educators (3 from each school), and 12 grade 7 learners (6 from each school) were purposively selected from 2 primary schools as well as 6 grade 12 educators (3 from each school) and 12 grade 12 learners (6 from each school) were selected from 2 high schools. The choice for these grades was that they are both the exit grades of which these learners were expected to demonstrate the acquired technical skill in the next level. To gather qualitative data, semi-structured group interviews were conducted with grade 7 and grade 12 learners from all schools, and semi-structured one-on-one interviews were used with all educators from all schools.

Thematic analysis approach was utilized to analyze data, a method for analyzing qualitative data that involves reading through a set of interviews or transcripts looking for patterns in the meaning of the data to find themes. It is a qualitative research method commonly used with interviews and focus group data to understand the experiences and perceptions of rural school educators and learners about ICT teaching and learning methods. The response patterns from participants' direct quotes were listed to identify common patterns and systematically categorized into codes that were translated into themes.

4. Results and discussion

This study explored how educators and learners in rural schools in South Africa's Eastern Cape province perceived transformative learning through technological support. The participants had to adapt their traditional teaching and learning methods to ICT-based or blended teaching and learning methods. The COVID-19 pandemic has sped up the process of implementing the 2030 vision, 4IR in education and other sectors. Findings revealed that digital inequalities still exist amongst rural and urban schools in the province and this has impacted negatively towards rural schools. Pillay [2] emphasizes the numerous issues confronting schools in rural areas such as unstable electricity, high dropout rates, inadequate classroom infrastructure, a lack of technologically savvy educators, poor network connectivity, and a lack of teaching and learning resources. Many learners highlighted the problem with network coverage, and how hard for them to even access online the learning materials provided by the Department of Basic Education. They were frustrated that their geographic area does not allow them to fully participate online, saying this style of delivering teaching is proper for learners who are staying in cities where there is always full network coverage.

The study found out that schools in rural areas struggle with teaching resources as they do not have computer laboratories and cannot even afford to have the luxury of having ICT resources. Learners from such schools have fewer opportunities to interact with digital devices even at home, as they come from low socioeconomic backgrounds and they often show reluctance towards computers. According to Mestry and Ndhlovu [3], this has an impact on the role of schools, which are in charge of both teaching learners on how to responsibly use ICT equipment and demonstrating to them the value of learning digital skills. The study also showed that rural poverty is one of the biggest issues South Africa is dealing with, and as a result, schools in rural areas face difficulties in providing an effective education. Inadequate state funding, a lack of resources, and overcrowded teaching have an impact on the quality of education [29].

Many learners expressed their mixed emotions when educators informed them about infusing technology in teaching-learning even after COVID-19. They welcomed the initiative as they realize the need to be relevant and be equipped with the digital skills required for the twenty-first century however, they were anxious that they could not afford any devices. Some are only able to have access to tablets and internet at school, after school hours is a challenge as they do not own smartphones and must borrow to access any announcements some educators might post after hours. In addition to the lack of devices, the research participants also reported that many educators do have laptops with data uploaded monthly however, the aged ones are unable to use the devices, and they do not know online learning applications, websites, or software applicable to their contents which makes it challenging for these educators to assist learners. "*In my school, some of the colleagues cannot even use the laptops government gave us. They were trained as educators 30 years ago when computers were not common in South Africa or in rural areas and now, we are expected to use them, it is a hustle for some of us*". And participant 2 added that "*some educators are not familiar with these things, in my* *school, I always assist my educators with software or application for various things, and relying on such educators to help with online teaching will be a waste of time".*

Findings also revealed that many educators in rural schools especially the aged lack advanced digital skills, and there is a risk that they are merely using ICT equipment incorrectly or not all, since they do not fully realize its potential in addressing learners' needs [33]. *The department gave us laptops and provided data on a monthly basis, integrating my lessons with technology is interesting, I can see that from my learners, they enjoy it so much. It is convenient as technology does most of the work for you, however it is not easy to find your way, but we are learning small-small.* Hence, World Bank [34] highlights how educators' lack of digital literacy impacts on learners' digital knowledge gap and accessibility. Insufficient digital skills on educators hinder learners' research abilities and hinder them from using websites to find relevant academic articles [34]. The fact that in these schools, many educators are elderly and lack the necessary digital expertise to guide or assist the learners was also mentioned by the learners as not providing them with much guidance or assistance. They emphasized that they learned digital skills on their own to deal with COVID-19. The World Bank [34] also emphasizes that learners who are already proficient and knowledgeable about using technology tools to support their learning and online sources, who have adequate access to good bandwidth and connected devices, and who are supported by their family and peers, will be able to make the best use of online learning. Therefore, the effectiveness of any curriculum implementation depends on the user system's capabilities thus if educators' training has been compromised, the curriculum will be implemented ineffectively.

5. Conclusion

The research paper explored the experiences and attitudes of educators and learners in rural schools regarding the incorporation of ICT into the teaching and learning process. It is believed that the integration of ICT entails the use of cognitive and metacognitive processes, which encompass selecting the most suitable method for delivering content, employing interactive tools, and offering opportunities for reflection and self-regulation to enhance the effectiveness of teaching and learning. Consequently, despite the enthusiasm of educators and students from these schools for integrating ICT into education and their efforts to acquire the necessary digital skills to improve academic performance. They encountered numerous obstacles that impeded progress and hindered advancements in the teaching and learning process, as well as in the academic performance of students. These challenges included difficulties in selecting appropriate content delivery methods as they primarily relied on WhatsApp, inconsistent network connectivity, high data costs, a lack of access to digital devices, and educators who lacked digital literacy.

Recommendations were also made in assisting rural schools to explore all possible avenues to successfully integrate ICT in their teaching and learning methods. Moreover, they were optimistic that they would be able to improve their digital challenges and learn new digital skills and competencies.

6. Recommendations

Based on the findings the researcher has made the following recommendations:

- The Department of Education and School Management must ensure that all necessary measures are put in place in supporting rural schools in an attempt to close the gap of digital inequalities as well as rural–urban educational inequalities.

- It is critical that the Department of Education provide more learning centres in rural areas at which learners can access online material free of charge, or on a limited amount.

- Provide learners with a tailor-made data for learning purposes to ensure that all learners can access learning material at their convenient times.

- Interesting and educational online programs should be organized quarterly to stimulate interest of rural learners and educators towards digitalization.

Author details

Lungiswa Nqoma*, Thandiswa Pretty Mpiti, Bulelwa Makena, Zanele Ginyigazi and Motsi Qoyi
Walter Sisulu University in the Eastern Cape Province, South Africa

*Address all correspondence to: lnqoma@wsu.ac.za

IntechOpen

© 2024 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

References

[1] Syaharuddin S, Mutiani M, Handy MRN, Abbas EW, Jumriani J. Putting transformative learning in higher education based on linking capital. Journal of Education and Learning (Edu Learn). 2022;**16**(1):58-64. DOI: 10.11591/edulearn.v16i1.20373. ISSN: 2089-9823

[2] Pillay I. The impact of inequality and COVID-19 on education and career planning for south African children of rural and low-socioeconomic backgrounds. African Journal of Career Development. 2021;**3**(1):a36. DOI: 10.4102/ajcd.v3i1.36

[3] Mestry and Ndhlovu (2014). This has an impact on the role of schools, which are in charge of both teaching learners on how to responsibly use ICT

[4] Adeyn OB, Soykan E. COVID-19 Eigen and S4. CRAN R Package. 2020;**1**(7):15-23

[5] Kabir FS, Kadage AT. ICTs and educational development: The utilization of mobile phones in distance education in Nigeria. Turkish Online Journal of Distance Education. 2017;**18**(1):63-76

[6] Kaliisa R, Picard M. A systematic review on mobile learning in higher education: The African perspective. TOJET: The Turkish Online Journal of Educational Technology. 2017;**16**(1):1-18

[7] Cranton P, Taylor EW. Transformative learning. In: The Routledge International Handbook of Learning. Routledge; 2011. pp. 214-223

[8] Mezirow J. Transformative learning as discourse. Journal of Transformative Education. 2003;**1**(1):58-63. DOI: 10.1177/1541344603252172

[9] Mkimbili ST, Ødegaard M. Learner motivation in science subjects in Tanzania, including learners' voices. Research in Science Education. 2019;**49**(6):1835-1859

[10] Phahlamohlaka LJ, Carina DV. A research-anchored e-entrepreneurship empowerment approach to building a smart community. In: Approaches to Building a Smart Community: An Exploration through the Concept of the Digital Village. United Kingdom: Cambridge Scholars Publishing; 2021. p. 34

[11] South African Department of Education. Curriculum. 2017. Available from: https://www.education.gov.za/Curriculum/National CurriculumStatementsGradesR-12/tabid/419/Default.aspx

[12] Zeoli D. Recursive adaptation and interdependent communication: a grounded approach to the integration of new/mobile technology and the K-2 educator [thesis]. USA: University of Oklahoma; 2019

[13] Mwapwele SD, Marais M, Dlamini S, Van Biljon J. Educators' ICT adoption in south African rural schools: A study of technology readiness and implications for the South Africa connect broadband policy. The African Journal of Information and Communication. 2019;**24**:1-21

[14] Hasin I, Nasir MKM. The effectiveness of the use of information and communication technology (ICT) in rural secondary schools in Malaysia. Journal of Education and e-Learning Research. 2021;**8**(1):59-64

[15] Álvarez RP, Jivet I, Pérez-San AM, Scheffel M, Verbert K. Tools designed to support self-regulated learning in online

learning environments: A systematic review. IEEE Transactions on Learning Technologies. 2022;**15**(4):508-522. DOI: 10.1109/TLT.2022.3193271

[16] Watermeyer R, Crick T, Knight C, Goodall J. COVID-19 and digital disruption in UK universities: Afflictions and affordances of emergency online migration. Higher Education. 2021;**81**:623-641

[17] Hodges CB, Fowler DJ. The COVID-19 crisis and faculty members in higher education: From emergency remote teaching to better teaching through reflection. International Journal of Multidisciplinary Perspectives in Higher Education. 2020;**5**(1):118-122

[18] Ribeiro R. How University Faculty Embraced the Remote Learning Shift. 2020. Available from: https://edtechmagazine.com/higher/article/2020/04/how-university-faculty-embraced-remote-learning-shift

[19] Hrastinski S. Asynchronous and synchronous e-learning. Educause Quarterly. 2008;**31**(4):51-55. Available form: http://educause.edu/ero/article/asynchronous-and-synchronous-e-learning [Accessed: January 08, 2024]

[20] Kopp M, Gröblinger O, Adams S. Five common assumptions that prevent digital transformation at higher education institutions. In: INTED2019 Proceedings. 2019. pp. 1448-1457. DOI: 10.21125/inted.2019

[21] Means B, Toyama Y, Murphy R, Bakia M, Jones, K. Evaluation of Evidence-Based Practices in Online Learning (NED Publication Number ED-04-CO-0040). U.S.: Department of Education; 2009. Available from: http://www.ed.gov/rschstat/eval/tech/evidence-based-practices/finalreport

[22] Joshi O, Chapagain B, Kharel G, Poudyal NC, Murray BD, Mehmood SR. Benefits and challenges of online instruction in agriculture and natural resource education. Interactive Learning Environments. 2020:1-12. DOI: 10.1080/10494820.2020.1725896

[23] Prensky M. Digital natives, digital immigrants part 2: Do they really think differently? On the Horizon. 2001;**9**(6):1-6

[24] Shariman TPNT, Razak NA, Noor NFM. Digital literacy competence for academic needs: An analysis of Malaysian students in three universities. Procedia-Social and Behavioral Sciences. 2012;**69**1489-1496

[25] Nimodiya AR, Ajankar SS. “ICT in rural development: Application and challenges—A review”. International Journal of Scientific Research in Science and Technology (IJSRST). 2021;8(6):464-472. DOI: 10.32628/IJSRST218664

[26] Gurukkal R. Will COVID 19 turn higher education into another mode? Higher Education for the Future. 2020;**7**(2):89-96. DOI: 10.1177/2347631120931606

[27] Siripongdee K, Pimdee P, Tuntiwongwanich S. A blended learning model with IoT-based technology: Effectively used when the COVID-19 pandemic? Journal for the Education of Gifted Young Scientists. 2020;**8**(2):90

[28] Cheng G, Guan Y, Chau J. An empirical study towards understanding user acceptance of bring your own device (BYOD) in higher education. Australasian Journal of Educational Technology. 2016;**32**(4):1-17

[29] Du Plessis P, Mestry R. Educators for rural schools–a challenge for South

Africa. South African Journal of Education. 2019;**39**:51-59

[30] Blank G, Graham M, Calvino C. Local geographies of digital inequality. Social Science Computer Review. 2018;**36**(1):82-102

[31] Mezirow J. Transformative learning theory. In: Contemporary Theories of Learning. London: Routledge; 2018. pp. 114-128

[32] Parasuraman A, Colby CL. An updated and streamlined technology readiness index: TRI 2.0. Journal of Service Research. 2015;**18**(1):59-74

[33] Dube B. Rural online learning in the context of COVID 19 in South Africa: Evoking an inclusive education approach. REMIE: Multidisciplinary. Journal of Educational Research. 2020;**10**(2):135-157

[34] World Bank. Guidance Note: Remote Learning and COVID-19. 2020. Available from: https://documents.worldbank.org/en/publication/documents-reports/documentdetail/531681585957264427/guidance-note-on-remote-learning-and-covid-19

Chapter 13

An Examination of Peer-to-Peer Scaffolding as Metacognitive Support for Learning

Wen Wen and Jill Castek

Abstract

This descriptive study examines peer-to-peer scaffolding implemented in an undergraduate, online digital literacies course for future educators. It identifies the different features of students collaboration processes and how these processes function as peer scaffolding to support their learning. Analyses of students' collaborative dialog and reflections on their collaboration processes. By analyzing dialog, this study examines how collaborative discussion that is high quality can act as a form of peer-to-peer scaffolding that encourages metacognition. Peer-to-peer scaffolding not only provides just-in-time support, but also triggers students' regulation thus helping them to refine their understanding and enhance self-awareness of their learning processes. Findings suggest that productive collaboration can serve as a useful means of peer-to-peer scaffolding marked by five specific features: 1) complementing each other's expertise, 2) co-constructing knowledge, 3) collaborating to problem-solve, 4) encouraging reciprocal support, and 5) triggering regulation. Findings further explore students' perspectives on collaboration. Students felt they benefited from peer-to-peer collaboration when the collaboration yielded the development of new ideas and understanding, offered support for problem solving, and provided opportunities for self-reflection. These markers of quality collaboration assisted students in achieving their learning goals. Recommendations outlined in this chapter offer guidance for educators by describing ways to promote productive collaboration when designing and implementing instruction.

Keywords: online learning, digital literacies, reflective thinking, collaboration, peer support

1. Introduction

We live in a world where digital collaboration is ubiquitous, however educators may not think about how collaboration elicits peer-to-peer dialog that could serve as scaffolding. This study aims to understand how peer-to-peer online collaboration can support metacognition and encourage the learning process.

The purpose of this chapter is to illustrate dialogic examples of peer-to-peer collaboration that serve as scaffolding within an online course for future educators. The analysis yields rich descriptions of the characteristics of quality collaboration that scaffold learning [1, 2] and encourage both cognitive and metacognitive development [3–5]. The analysis looks closely at dialogic interactions to understand the nuanced exchanges that occur between learners. By examining the nature of dialog, distinct markers of peer-supported scaffolding can be identified.

The analysis described in this piece identifies markers of high-quality collaboration that can yield metacognitive support. Given the interconnectedness of peer scaffolding, metacognition, and learning, this study looks specifically at vignettes where productive collaboration occurs and demonstrates how collaborative dialog offers peer-to-peer support to complete digital projects.

Through the examination of dialog from different instances of collaboration among students, the study shows how educators can better take advantage of the strengths that different learners bring to collaboration and ways these strengths and collaboration can ultimately support metacognition.

This chapter examines the literature on metacognition to explore possibilities for ways that peer dialog can serve as metacognitive support for learning. In our highly collaborative digital world [6, 7] collaboration takes many forms, one of which is peer scaffolding. During peer scaffolding, individuals assist each other's learning by offering guidance, suggestions, and resources. As a result, learners' metacognitive knowledge is activated and enhances the learning experiences for both learners. The connection between peer-to-peer scaffolding and metacognition is demonstrated in the following two sections.

1.1 Peer-to-peer scaffolding

In educational settings, the concept of scaffolding derives from the socio-cultural theory of Vygotsky [8] and his philosophy about learning and development, which contends that learning occurs when individuals interact and cooperate with adults and/or peers. Learners ultimately develop their internal mental abilities to become more independent problem solvers. The essence of scaffolding lies in the guidance one person offers another which enables the other to achieve goals that would be otherwise unattainable if unassisted [8, 9].

Scaffolding can occur between experienced learners and novices [8–10], and between peers who are at similar stages of developing their understanding [3, 11]. Peer scaffolding emphasizes the mutual benefits that both participants gain from a shared learning experience [1]. Thus, peer collaboration may be the prerequisite for peer scaffolding, but not all peer collaboration represents scaffolding.

1.2 Peer- to-peer scaffolding and metacognition

Metacognitive knowledge constitutes cognitive knowledge and cognitive regulation [12–16]. It includes "knowledge about oneself as a learner and the factors that might impact performance, knowledge about strategies, and knowledge about when and why to use strategies" [17, p.2].

Peer-to-peer scaffolding may not be regarded as a form of metacognition itself, however, it can facilitate metacognitive processes for several reasons. First, when peers engage in collaborative dialog, they engage in explicit articulation. Speaking one's thoughts and ideas in a collaboration context prompts learners to be aware of their own comprehension and learning while sharing ideas with others. Second, peer-to-peer scaffolding brings together people with diverse expertise and perspectives. In the process of sharing perspectives, different ways of thinking are surfaced.

This additional input that comes from gaining new perspectives encourages learners to consider other ideas and reflect on their own learning. Third, through the act of peers working together to exchange ideas, clarification regularly occurs. Exchanging ideas and clarifying serves to help learners regulate and monitor their understanding. Finally, through the dialog that occurs during collaboration, learners are encouraged to share their thinking, expertise, resources, and problem-solving methods, which surfaces metacognitive awareness by both speaking one's own thinking and listening to peer's thinking.

The Literature Review section that follows provides an overview of empirical studies that connect: 1) human interaction and language exchange as a means of scaffolding, and 2) peer collaborative discussion as an approach to examine metacognition [18].

2. Literature review

This study draws on two interconnected areas of literature. The first area illustrates the importance of verbal exchange in scaffolded learning. The second focuses on peer collaborative discussion, which examines how dialog among peers can assist learners in achieving learning goals. In each of the studies reviewed, scaffolding is not limited to interactions between novice and experts, but also among peers [1, 3]. Together, these two bodies of research form the foundation to connect how peer collaboration can function as a scaffold that facilitates cognitive processes and metacognition.

2.1 Language as scaffolding

This study draws upon research that examines how language can be a powerful tool to assist learners in achieving learning goals [9, 10, 19, 20]. In early studies, Wood et al., [9] directly employed the scaffolding metaphor to explicitly describe the interactive tutorial process in a dynamic, face-to-face situation in which adults engaged in verbal intervention, direction, and correction to assist children to carry out a task, solve a problem, and achieve a goal. Cazden [21] demonstrated how language was used in classrooms and homes to assist children in speech development. Bruner [10] argued that the dialogs that happened between adults and children were vital to foster children's mental development.

In more recent studies, language interactions that were used as a form of educational scaffolding were also explored. For instance, Fennema-Bloom [20] illustrated that code-switching could serve as a scaffolding technique in facilitating science content learning involving bilingual teachers and students. Similarly, de Oliveira [19] proposed a language-based strategy to enhance content instruction, emphasizing that collaborative interactions and oral discourse were crucial for developing academic literacy. Choi et al., [3] proposed peer-questioning strategies used as meaningful discussion tools which served as scaffolding to facilitate reflective thinking among peers.

Language scaffolding also occurred among peers. Castek [22] documented ways that students pooled information and ideas informally as they worked collaboratively. Students supported each other in meeting their goals and frequently discussed strategies on how to achieve them. Strategies were shared during spontaneous conversations as they worked in collaboration.

Each of the studies reviewed demonstrates how interactions and language exchanges are an important means for educational support. Collectively, this literature base highlights that dialog between teachers and students, and among students themselves, serves as scaffolding and can have an impact on enhancing educational experiences [23].

2.2 Collaborative discussion

This study is informed by research that analyzed collaborative discussion among learners [24–27]. The findings of these selected studies demonstrated that peer collaborative discussion promoted learners' high-level thinking skills [26–28]. Peer-to-peer collaboration acted as scaffolding and created new opportunities to co-construct meaning. Shared discussions encouraged joint problem solving and idea exchange that fostered efficient and productive comprehension of online informational texts [29].

Sekeres and Castek [26] examined elementary grade students who collaboratively engaged in a teacher designed inquiry task. Findings suggested that talking while productively collaborating acted as a marker for high-level thinking, which indicated students were more expressive with reasoning when they shared their ideas orally. Evidence of student learning included making inferences beyond the text, integrating information, and evaluating the quality of the information they found online. Combining verbal discussion with written responses during the completion of an online inquiry project provided concrete ways for students to strengthen their argumentative skills. Sekeres et al., [27] contended that students who paired up and engaged in academic discussion (e.g., elaborating, interpreting, and extending ideas) demonstrated substantial use of evidence-based reasoning to support their learning.

Another comparable study by Coiro et al., [24] focused on upper elementary students engaging in structured online inquiry. The study found that high quality dialog promoted the use of cognitive strategies such as making inferences, synthesizing, and evaluating information. When partners employed these cognitive strategies in their collaborative discussions, it enhanced their understanding of the content they studied.

Peer collaborative discussion also facilitates students' metacognitive development, which is related to understanding, regulating, and monitoring their own thinking and learning processes [24, 25, 28]. For example, Coiro et al., [25] observed metacognitive activities when students partnered to complete an online learning task. These metacognitive processes included collaborative task monitoring, shared understanding of the content, awareness of group behavior, and strategy adjustment and modification (e.g., switching to an alternative approach to solve a problem).

Coiro et al., [28] investigated two adolescents reading independently and collaboratively on the Internet. Findings suggested when reading collaboratively, learners engaged in increased instances of metacognition such as inferring, integrating, monitoring, and reflective processing than when they read independently. Opportunities for peer discussion and shared decision-making may serve to encourage knowledge construction and deeper levels of understanding [30].

Though these studies suggest positive benefits associated with collaborative meaning making, not all peer collaboration is productive and sparks metacognitive awareness. Wen [31] conducted a study that captured both more and less productive peer collaboration. Peer scaffolding occurred when two learners actively participated in collaboration and mutually supported one another across multiple learning tasks.

Findings showed that when students worked together to share information, some offered minimal assistance, often without providing explicit support and guidance to their peers. In other situations, one participant received more support from their partner than they gave in return. It was found that during collaboration, support may not be evenly distributed between the two participants. Instances of productive collaboration were also documented in Wen [31]. Evidence and outcomes of productive collaboration is described in this article.

2.3 Research questions

With the advancement of technological tools and virtual communication platforms, learners who are in different physical spaces can interact in real time and collaboratively share their thinking [32]. Drawing upon the findings from studies on peer-to-peer collaboration and scaffolding in K-12 settings, this study examines how undergraduate university students worked in collaboration to complete assigned learning tasks online. It aims to understand the role that collaborative discussion plays in learning and to document collaborative features that emerged from online interactions among students.

Two research questions guided this investigation:

- How can peer-to-peer scaffolding support metacognition?
- What are students' perspectives about peer-to-peer scaffolding and metacognition?

3. Methods

This study was nested within a larger investigation that examined multiple forms of scaffolding used in a fully online digital literacies course. Data was collected over the course of two implementation cycles with students who were completing a BA degree and wanted to go on to become an educator. The broader study explored online learning, various forms of scaffolding, and the processes and perspectives of students who completed two specific digital projects where collaboration and the creation of digital projects were key features of analysis [31].

3.1 Context

This study was conducted in a research-intensive university located in the Southwestern U.S. The data collection occurred within an asynchronous online course called *Teaching and Learning with New Technologies*. This course explored multiple ways that learners make and exchange meaning in the digital world. Educational implications for digital instruction and student involvement were emphasized. Through the lens of exploration and discovery learning, the course encouraged the use of a wide array of technologies and examined the ways these technologies shape the way people think, read, write, communicate, and collaborate in formal and non-formal learning.

The analysis undertaken for this study focused on one module of instruction that was implemented in this fully online course. This module was *Designing Immersive Virtual Field Trips,* which involved students: 1) exploring a variety of immersive virtual field trips to explore their design, content, and resources, 2) learning how virtual field trips prompt interest and engagement for learners of all ages, and 3) designing their own immersive virtual field trip using a free, online, browser-based technological tool to engage learners. Together, these objectives offered multiple opportunities for inquiry and exploration across the curriculum.

3.2 Participants

Twenty-two students voluntarily agreed to participate in the research [33]. These participating students came from different disciplines within and outside of the College of Education. In addition to being undergraduate students, some of the participants were non-traditional students with various teaching and tutoring experience in K-9 school settings such as substitute or guest teachers. Others held leadership roles in pre-school, after school, or intermural sports.

3.3 Learning task

Students were asked to work in pairs and record their online collaborative discussions to design their own immersive digital field trip. They formed pairs by mutual consent and scheduled online work sessions at times that were convenient for both partners. One option for collaboration partnership was to act as a “thought partner” for each other, stimulating deeper thinking about the project’s design and creation. The other option was that students could jointly design and construct the project together, making collaborative decisions that incorporated both of their ideas. The use of Zoom video conferencing allowed students to record their collaborative processes.

Students were required to use a multimodal technological platform that allowed the building of a visual tour which could include video, audio, and other resources. The content of the virtual field trip was open-ended and flexible. The design encouraged the inclusion of web-based, immersive, and interactive audio, video, and visual resources into the design of the learning experience [34]. To complete the project, students needed to go through the following steps: 1) chose a content area, location, or topic, 2) collect or create relevant media and resources to augment the project, and 3) compile and connect the resources together to tell a story about a place or experience.

Of the 22 students who voluntarily participated in the study, six students did not choose to work with a partner and two pairs were unable to record their collaboration processes. As a result, six online collaboration videos were analyzed in the final analysis.

3.4 Data sources

To corroborate findings through triangulation, data was collected from multiple sources which included students’ online collaboration videos, students’ reflections, and semi-structured interviews. Triangulation refers to the use of multiple data sources to develop a comprehensive understanding of phenomena [35]. The collection and analysis of triangulated data sources was part of the research design and led to a more complete understanding of collaboration coupled with reflection.

Zoom video conferencing software was used to collect video and audio data to examine how the two students collaborated as they worked together online. They engaged in discussions by exchanging ideas and providing feedback to each other as they worked through the construction of their immersive virtual field trip. Students’ online collaboration processes were self-recorded and shared with the researchers for analysis. The online collaboration videos captured students' authentic dialog which was used to identify markers of productive collaboration. An analysis of the dialog captured in the video was used to respond to Research Question 1.

Following the completion of the collaboration, students were asked to record a short oral reflection. In their reflections, students were asked to consider various aspects of their learning experiences, particularly to share how they collaborated online to complete their projects and to explain what they gained from the experience. Semi-structured interviews were collected to gain a deep understanding of students' perspectives about peer support. Students' reflections and interviews were examined to gain insights about their perspectives and inform the researchers about students' collaborative discussion. Students reflections and interview data were used to respond to Research Question 2.

3.5 Data analysis

Data consisted of students' collaborative dialog captured in video and written transcripts, oral reflections, and interview responses. This data elicited their perspectives on their learning and collaboration processes. To conduct the analysis, recordings were auto transcribed, corrected, and member checked. The transcripts then underwent further in-depth analysis. In addition, students' oral reflections were transcribed, and member checked. After cleaning the data, all data sources were organized and archived to address two research questions: 1) peer support and collaboration as a form of scaffolding, 2) students' perspectives on online collaboration.

Analysis of dialog is an important way to examine human interaction and scaffolding [9]. To address Research Question 1, the transcripts of each pair's dialog were carefully analyzed line by line independently by the researchers to better understand the quality of students' collaborative processes. Informed by the framework of collaborative online inquiry [25, 36], both researchers documented their initial insights and selected excerpts as instances that demonstrated pairs' productive collaborative processes. These instances included: 1) dialog about sharing sources, ideas, and knowledge, 2) dialog about negotiating responsibilities, rules, and ideas, 3) dialog about planning, executing, and making decisions, and 4) dialog about providing feedback, monitoring processes, and overall understanding.

Following independent analysis, the two researchers met together to discuss selected instances and further identified five markers that indicated high quality collaboration. These five markers addressed two important indicators of productive collaboration including: 1) how active collaboration occurred and 2) how the collaboration produced both process and product outcomes. The process outcome was instances of metacognition and the product outcome was the quality of the immersive virtual field trip project.

To answer Research Question 2, an inductive coding technique [37, 38] was employed during the data analysis process. First, two researchers worked independently to develop codes by reading and reviewing the transcripts of oral reflection and interviews multiple times. Then, two researchers met weekly to discuss the application of the codes, coding discrepancies, and emerging insights. During this process, the two researchers collapsed, expanded, and revised the codes, forming and fine-tuning the code categories [39]. Coding categories focused on reflections, affordances, and challenges of peer collaboration.

The analysis was made up of outcomes from coding, shared interpretations, categories, and the analytical reflections of two researchers [38]. Finally, two researchers aligned pairs' collaborative processes with their oral reflections and interviews to understand how students worked with partners and supported each other to achieve learning goals. Ultimately, the researchers arrived at emergent themes and identified illustrative quotes that anchored those themes. The themes revealed intricate relationships among the coding categories.

4. Findings

Three patterns of online collaboration were identified based on the analysis of students' Zoom recordings of their online collaboration. These patterns included: 1) collaborative situations with low or without scaffolding, 2) collaborative situations with unbalanced scaffolding, and 3) collaborative situations with peer-to-peer scaffolding [31]. This study reports solely on the third category, collaborative situations with peer-to-peer scaffolding. This choice was made because the analysis identified markers of productive online collaborative discussion and highlighted how students' metacognitive knowledge could be nurtured. Results of the study are organized around the two research questions in Sections 5.1 and 5.2.

4.1 How can peer-to-peer scaffolding support metacognition?

Scaffolding can occur among learners who are at similar levels of knowledge and abilities. Scaffolding t can also occur when students working in collaboration have different strengths and weaknesses. Five predominant markers were identified. The data suggested that no single pair's collaborative discussion possessed all these markers in one instance; the five markers were found across different pairs in various instances.

The six scenarios illustrated below demonstrate mutual scaffolding among students in a collaborative situation where they had different levels of knowledge, strengths, and weaknesses. Collaborative peer- to- peer scaffolding refers to interactions where two collaborators actively work together in a mutually supportive way to scaffold each other's learning and development. Both actively contribute to each other's progress.

Two pairs, Emily and Bella (pseudonyms), Kate and Amber (pseudonyms) are examples that represent collaborative mutual scaffolding. The following excerpts illustrate the characteristics of their mutual scaffolding and how the dialog indicates metacognition.

4.1.1 Complementing each other's expertise

When two students worked together, each offered up to the collaboration their knowledge, skills, and perspectives, and were open to listen and learn from their partner's expertise. **Table 1** illustrates how two students negotiated their tasks based on different expertise. Emily and Bella decided to co-design and construct an Immersive Virtual Field Trip project named *The Exploration of South Korea*.

During this instance of collaboration, Emily and Bella shared and negotiated the background knowledge they had about South Korea and what they could contribute to the mutual project (Lines 24, 27, 29, 30, 31, 32, 34). They had different experiences

Line	Participant	Dialogue
22	Emily	It's nice to know what you want to do. Like what's your preference?
23	Bella	I mean the only thing that I really know is the education part. I only really know it from what I did, but I feel that's different because I'm a foreigner.
24	Emily	So, I think that's perfect because you were in a study abroad program. Right?
25	Bella	Right! Okay!
26	Emily	I'm not trying to force you to do anything. Right?
27	Bella	No, no. That's okay, I think food would be easy for somebody who has not been there, and if you like Korean food, then that's good!
28	Emily	Yeah!
29	Bella	Do you know any history? I do not know that much but I know a little bit like...
30	Emily	I think I know a pretty good amount.
31	Bella	Okay! I only know about the King that invented the Korean language and stuff. I know that...
32	Emily	But I know a lot about the war between North and South Korea.
33	Bella	That's a good thing too!
34	Emily	I can do the history and then food okay? and then you do language and education.
35	Bella	I can do it!
36	Emily	Do you want to do customs? I mean I can try the customs.

Table 1.
Example of complemementary expertise.

and expertise and they offered complementary expertise to include within the shared digital project they created together. This collaborative project could not have been achieved without their shared expertise. When these two learners shared and exchanged their knowledge and skills, they were prompted to reflect on one's own expertise and skills, which led to reconsideration and reorganization of their mutual project. This learning instance encouraged students to reflect on what they knew and what they did not, as well as understanding what knowledge was needed to complete the project.

4.1.2 Co-construction of knowledge

When two learners were sharing ideas during the collaboration, they constructed meaning by stretching each other's thinking, ideas, and perspectives. **Table 2** demonstrates Emily and Bella's co-construction of ideas.

The interactions captured in **Table 2** showed how Emily and Bella were co-constructing an idea planning would design for their virtual field trip project. At the beginning, they brainstormed what resources and media they had to build the project (Lines 8, 9). However, they did not have a clear idea of what to do and how to do it. Then, Emily suggested they could find an example to refer to (Line 10). This suggestion was echoed by Bella (Line 11). Together, both figured out what they could do based on their mutual understanding of the example they found (Lines 16, 17). In this situation, students built on each other's ideas and filled in each other's thoughts. This iterative process is also an essential part of metacognition.

Line	Participant	Dialogue
8	Emily	…If you have your own media. Do you have a lot of pictures from when you went?
9	Bella	Um… I was thinking about that. This morning, I found some… Uh…it was not really like an outdoor thing, though. So, I guess, I mean it still counts. I guess, I just do not know how much stuff we have to have.
10	Emily	Right! Do we have an example of a Virtual Field Trip?
11	Bella	Yeah! like the Tornado one?
12	Emily	The Tornado one!!
13	Bella	Yeah, she has like…. I do not know!
14	Emily	She has like five scenes.
15	Bella	I was just trying to see how many scenes she has.
16	Emily	She has like five pictures. So, we'll choose five topics. Oh, like history…
17	Bella	Customs and education. We could just pick Korean looking pictures. How about those topics? Then [we] do the same thing that she did.

Table 2.
Example of co-construction.

4.1.3 Collaborative problem-solving

Collaborative problem-solving occurred when two learners tried to solve problems and tackle the difficulties during the collaboration. Amber and Kate worked on the virtual field trip project individually, however they scheduled an online meeting to work together as thought partners. **Table 3** shows how Amber and Kate solved a problem they both faced.

Line	Participant	Dialogue
218	Amber	You know if you are doing a lot of videos and additional graphics. I do not know if the voiceover would add anything.
219	Kate	[Do] you know some of the ones that had music or something I can do like [adding] underwater sounds?
220	Amber	I am not that tech savvy though. I do not know how they were adding noise to my first image. Let us go back. We will see. Do you know how to do that?
221	Kate	No. How about…? I think you can record.
222	Amber	Oh well, there is an upload audio button.
223	Kate	Then probably just downloaded one and then uploaded it.
224	Amber	Maybe I'll go back and add some audio, like some cannonball noises.
235	Kate	Yeah, I guess you just do it on a tag, but that's not a big deal.
236	Amber	Hmm. Maybe I'll go to check them. Yeah! I've completely forgotten about that until you said something.

Table 3.
Example of collaborative problem-solving.

The documented interactions illustrated in the discussion between these two learners focused on ways to make a virtual field trip more multisensory by adding sounds. Amber posed her question about how to add noise to the image (Line 220). Kate was also unsure about the answer, but proposed a suggestion (Line 221), which triggered Amber to explore more features within the technological design tool. Together, they both figured out how they could add sounds to the images. Tackling problems together required learners to prompt each other's thinking, seek for alternatives, and reflect on the effectiveness of multiple solutions, which was also central to metacognitive skills.

4.1.4 Reciprocal support

When these two students collaboratively scaffolded each other's ideas, they actively participated in discussion and provided support, feedback, guidance, affirmation to each other, which mutually benefited each of them. **Table 4** illustrates how Kate sought support from her collaborator Amber. With the guidance of Amber, Kate figured out some of the features of the technological tool to "create a tour".

Table 4 demonstrates how Kate sought support from Amber and Amber affirmed and extended Kate's approaches to connecting images together into a tour. In a reciprocal manner, **Table 5** illustrates how Amber sought and received support from Kate when she requested help. **Table 5** describes the suggestions and feedback that Kate offered to Amber to determine which option (360 image or aerial view) would work best for her project.

Line	Participant	Dialogue
17	Kate	So, the idea is like they can click around to know what lives here. And then, they could go deeper. And then, it takes them to the next page. I do not know if that's the right way to do it.
18	Amber	That's how I did mine for the ones that are supposed to go to another page. They just go to another image that has more hotspots.
19	Kate	Yeah! I just could not figure out how to get all the images together, so I was like... Oh, I guess...they have to be separate, and you just point them out, yeah that's what I did...
20	Amber	When you are clicking on those to go to the next image. Did you use the "create a tour" button?
21	Kate	Yeah!
22	Amber	Okay! That's what I did too. So, I mean if that's not the right way to do it, it's still doing the function to me.
23	Kate	Yeah! like I did this for mine.
24	Amber	You know what the next level to learn about. So, I think what you did is fine.
25	Kate	I do not have any part of it because I did not know. I was like the only way I found that I could link the images. Yes, "create a tour" and just upload things.
26	Amber	Yep, and for me, as I said, "create an image" or "create a tour". That did not do anything different from those others, like templates. You still have the same options as if it was just a flat image. So, Yay!
27	Kate	Right!
28	Amber	I did the exact same way as you did!

Table 4.
Example of reciprocal support (Kate seeking support from Amber).

Line	Participant	Dialogue
86	Amber	I wasn't sure what else I was supposed to do.
87	Kate	I think yours is way more advanced than it is supposed to be, but I was thinking, there are certain sites that allow you to download YouTube videos. I wonder if you could do that with 360 and then upload it to the technological platform. Because I know National Geographic has a bunch of underwater ones. Well, if you could figure out how to get that to work, that would be cool.
88	Amber	Yeah! That would be nice, especially for underwater. Um… for ones like this, I did not really see 360 being that big of an advantage, like this one, right here, I already have it. There was an aerial view that you can move around.
89	Kate	I think that's fine. The only thing I could think of is where that would be useful for you. It would be more like if you are inside of one building, like an old schoolhouse. …I feel like you already have plenty of things, even if they are just links.

Table 5.
Example of reciprocal support (Amber seeking suggestions from Kate).

Tables 4 and **5** illustrate how Kate and Amber mutually supported each other and pushed each other's progress in learning. In **Table 4**, the conversation was started by Kate who felt unsure if she did the right thing to link separate images together to become a virtual tour (Lines 17, 19). Amber confirmed that she did the same thing as Kate did. Then, Amber mentioned two features of that technological platform, "create an image" and "create a tour", which functioned the same when uploading flat images. Amber's feedback and support gave Kate confidence to continue the project. Meanwhile, **Table 5** shows how Amber sought suggestions from Kate. Kate gave Amber suggestions in a detailed way (Lines 87, 89), such as: what kind of media Amber could use; where Amber could get the resources she wanted; and what the most important thing to think about in creating a virtual field trip.

When examined together **Tables 4** and **5** demonstrate that the two students took turns sharing their concerns and questions, and they both actively participated in this conversation and learning process. They made sure each one was able to ask questions and received enough support. During the reciprocal support, peers can observe, monitor, and think about each other's work and provide feedback as well. The shared insights that are elicited from the conversations help individual learners reflect and adjust their project accordingly, which is a key representation of metacognitive skill.

4.1.5 Regulation

As seen in the analysis **Tables 3–5** Kate and Amber both regulated and monitored their working processes, and as a result, made sure that their work achieved the task goals. Regulation in this case refers to the knowledge of one's own ability to learn and monitoring refers to the awareness of one's own learning. **Table 6** shows an additional example of regulation from Emily and Bella who engaged in reflecting on what was needed to add into the project, and how their project could meet the instructor's expectation.

The interactions depicted in **Table 6** illustrate how Emily and Bella reflected on what images and media could be incorporated in their Immersive Virtual Field Trip project (Lines 55, 56). Emily suggested that they could use some media from the internet or YouTube. However, Bella reminded Emily about the instructor's

Line	Participant	Dialogue
54	Emily	Anything else we can use?
55	Bella	Um I have one of me at the beach, but it's not like that one…
56	Emily	That's right! You know, either we can find a 360 tour or something on YouTube. We can use whatever we want. It will always look well!
57	Bella	Yeah! but I mean, she [the instructor] said, "as long as it's something somewhat personal." I feel like she will give us some points.
58	Emily	Oh, as long as it's personal?
59	Bella	I think it's supposed to personalize your materials with your own creativity.
60	Emily	Oh yeah!
61	Bella	If we put them together using our own. I think it will be okay.

Table 6.
Example of regulation.

expectation regarding the choice of media. The instructor required that media choices be purposeful, personalized, or customized to advance the objectives the creator identified. Reflecting collaboratively illustrated metacognition and helped the two students monitor, revise, and regulate their work. They thought about their thinking in the process, connected the learning expectations and objectives to their content creation. This ability to regulate learning and reflect on oneself is also a crucial aspect of metacognition.

4.1.6 Summary

The six vignettes were offered to represent a close analysis of peer-to-peer dialog. Findings showed that high quality peer collaboration can act as a form of scaffolding and that peer-to-scaffolding plays an important role in exchanging ideas, providing support, and monitoring learning. Across various scenarios, pairs of students were captured engaging in online collaboration and prompted metacognitive awareness. The vignettes illustrated how peer-to-peer scaffolding can encourage metacognition.

4.2 What are students' perspectives on peer-to-peer scaffolding?

During oral reflections and semi-structured interviews, students expressed their opinions about the online peer-to-peer collaboration designed by the instructor in the module. It suggested that not every collaboration is supportive and leads to satisfactory outcomes. Some interactions connect individuals but were less supportive. Students felt they have benefited from peer- to-peer collaboration when the collaboration yielded: 1) development of new ideas and understanding, 2) problem solving, and 3) opportunities for self-reflection.

When two students collaboratively worked together, they actively participated in two-way dialog, expressing thoughts, exchanged ideas, and offered suggestions and constructive critiques in a reciprocal way. During this process, both students gathered different perspectives from their peers, learned from each other's insights, and collectively produced new understandings to improve their projects. The quotes below illustrate students' opinions on collaboration, captured in semi-structured interviews.

> *Before Kate I had never heard of Canva and ever since then that's all I use for my presentations and before collaborating with Kate, I probably would have finished my virtual field trip project, I turned it in, moved on with my life, but collaborating with her forced me to really look into the features of the technological platform, because we were troubleshooting together, searching back through our resources on how to add certain things.*
>
> *It was nice to have someone there to bounce ideas off and show them the project or get their feedback in real time. We also talked about how to build a field trip around a selected age range. So that you could make sure the complexity is not too far or below their comprehension levels.*
>
> *You get the benefit of having another person's perspective and their own creative ideas. It was a great way to discover things that we had not really thought of before. For work it was a nice way to get inspiration and come up with new ideas.*

By engaging in collaboration, students gained positive learning experiences because they were able to get assistance from peers and solve problems they encountered during project completion. In their oral reflections, students shared how with the support of their peers, untangle problems that they otherwise would not have been able to overcome. Amber said,

> *We spent a lot of time tinkering with the technological platform and Google Earth and different YouTube expeditions trying to figure out how to make certain features work to make a more seamless project. My partner helped me come up with some of the final touches that I needed to make my project seem more immersive, like the additional sound effects that I added to the icons.*

Collaborative discussion also prompted self-reflection because students could articulate their thinking while they exchanged ideas and feedback. Two students shared their perceptions about the affordances of collaborative discussion.

> *[During online collaboration], you need to explain your thoughts and work through any problems you are having. When you are talking through it, I think it can help your mind work through that process, and you can probably come up with new ideas that way.*
>
> *When I shared my project with my partner, I had to demonstrate it well, so that my partner could understand my project and provide me with the feedback I needed. From the feedback, I could make my project better.*

4.2.1 Summary

Collaborating with peers provided each learner with an opportunity to explain and talk through their own ideas while also having the chance to build on other's ideas by listening and incorporating a collaborator's suggestions. Not only did collaborative dialog appear to enhance individuals' understanding and thinking through an articulation of their own ideas, but also it strengthened metacognitive skills by prompting reflection on the learning process and product.

Students' quotes indicate supportive online collaboration, which is an example of peer-to-peer scaffolding peer-to-peer scaffolding. Students reflected on their learning experiences and improved their learning performance by considering peers' ideas and suggestions. By working collaboratively in pairs, students recognized different perspectives and creativity that their peers contributed and contributions coming from a peer's perspective were appreciated and built on collectively. Peers' constructive feedback helped refine and improve each other's understanding and learning products, which furthered both students' intellectual development. Peer-to-peer scaffolding held strong potential to promote metacognition.

5. Discussion

The concept of scaffolding originally emphasized the interactive process between learners and the more capable and experienced other [40, 41]. However, when learners with similar levels of knowledge and abilities, provide each other with support when they were engaged in collaborative work. The work involves collaborative discussion and mutual support among peers, where individuals contribute to the learning process. In an online learning environment, peer-to-peer scaffolding plays a crucial role for students' success in the course, since it is challenging for instructors to provide immediate and appropriate support, which naturally occurs in a face-to-face classroom setting. Peer-to-peer support requires collaborators to participate actively in the process, in which learning starts from the social (intermental) level to the individual (intramental) level [42].

Analysis of students' online scaffolding suggests that learners' can actively exchange ideas, share expertise, and collaboratively address problems while regulating their learning. This is further corroborated by students' self-reports on their perspectives on online collaboration. Moreover, online peer-to-peer scaffolding not only enhances students' learning experiences in terms of collaboration, communication, cognitive processing, but also fosters their metacognitive skills, including thinking and understanding of their own thinking and knowing [14], and monitoring of their cognition [12, 15, 16]. Metacognition requires learners to think about their own thinking, but how are students able to think about their thinking? Whole class meetings where communication is shared might be one of the vital ways to achieve this goal. Through collaborative discussion, learners check on each other's understanding, build on each other's ideas, and evaluate each other's perspectives. Thus, when learners engage in discussion, they can unlock deeper introspection and reflection.

Learners can be encouraged to assess their own thinking, understanding, and perspectives. By continuously reflecting on their own thinking, learners can identify gaps in their understanding and then adjust improve their learning. In addition, metacognition involves monitoring and regulation. Peer-to-peer scaffolding provides learners with the opportunity to collectively regulate their shared learning process through reminders and by offering suggestions and supportive critique. These findings echo previous research which argues that metacognition should go beyond looking at reflection on an individual level, but also to extend reflection from a group dimension. Examining collaborative processes provides opportunities for collective and individual reflection [18].

6. Conclusions

While it is recognized that the digital world is a collaborative world [6] and that collaboration may encourage metacognition, supporting quality collaboration involves more than just an invitation to students to go out and collaborate. Teachers play a critically important role in guiding instruction around collaborative dialog and steering peer-to-peer scaffolded dialog in productive directions that encourage reflection, cooperation, and quality collaborative talk. Promoting quality collaboration takes effort and careful planning. The analysis illustrates that peer-to-peer collaborative discussion that is high quality can act as a form of scaffolding, supporting metacognition. Such interactions not only provide immediate support for learning, but also facilitate learners' metacognitive processes in multiple ways, enhancing their self-awareness and ability to regulate their learning.

Findings from this study capture and document how pairs engaged in collaborative discussion to complete tasks and scaffolded each other's learning by exchanging expertise, co-constructing knowledge, collaboratively solving problems, offering reciprocal support, and regulating, across shared learning processes. The learning experiences highlighted here appear to provide students with opportunities to reflect on their thoughts and perspectives, articulate and monitor thinking, and bolster self-awareness, which promotes learners' cognitive skills and metacognitive knowledge. Metacognition does not only refer to an individual's inner reflective thinking, but also to distributed knowledge that travels across group members. Social interaction is an important means to activate an individual's metacognition.

This study suggests that productive peer collaboration leads to peer scaffolding, ultimately eliciting metacognition among learners. Thus, the findings ask researchers and educators to consider our own teaching practices for additional opportunities to enact collaborative learning and peer-to-peer scaffolding. Supporting collaboration and dialog can be strengthened by providing more opportunities for engagement in paired collaborative discussion. Learning tasks with this emphasis, enacted repeatedly with time for reflection, serves to equip learners with the necessary strategies to effectively collaborate in and out of school settings.

Findings from this study have important implications for scaffolding design and classroom implementation. The sections that follow are designed to provide guidance to instructors in ways to foster peer-to-peer scaffolding in teaching practices whether teaching online, in face-to-face settings, or through blended learning.

6.1 Recommendations

In the vignettes and dialog collected for analysis, no single instance of collaboration included all five of the identified features of peer-to-peer scaffolding. Still, the analysis identifies important opportunities for instruction where educators can guide collaboration to maximize the potential for encouraging metacognition.

6.1.1 Create a learning community that supports collaboration

Not all learning environments and assignments are designed with collaboration in mind. If an instructor chooses to implement collaboration, attention needs to be paid to cultivate a collaborative learning environment in which students feel comfortable to work together, share ideas, ask questions, and make suggestions that encourage learning together. Learning activities also need to be designed to prompt collaboration, such as group discussion, collaborative writing, and peer review. Fostering collaboration involves taking time to structure group tasks well so that collaboration can occur and to discuss what productive collaboration involves.

6.1.2 Articulate objectives and expectations of the collaboration

Assigning a collaborative task involves explicitly articulating expectations and objectives focused on collaboration as well as content. Beginning a lesson by pointing out previous instances of positive collaboration can encourage regulation and reflective practices among students. Instructors can work together with learners to generate a collaboration checklist that defines the characteristics of high-quality collaboration, roles and responsibilities for each collaborator and norms for participating in discussion with your peers. While some guidelines can be offered to students, generating the checklist with students encourages reflection and metacognitive awareness of these qualities while collaboration occurs.

6.1.3 Become knowledgeable about learners' background, expertise, and skills

When planning for collaboration, instructors can purposefully form groups to encourage collaboration. Knowing different students' expertise, personalities, characteristics, and skills of learners, instructors can balance group work and collaboration by pairing up learners strategically and explaining why those pairings were selected. The instructor can create an exit ticket, a formative assessment tool that a student completes before leaving the instructional setting, offering an ideal way to reflect and provide feedback to the instructor. Prompts about how collaboration pairings worked not only prompts reflection but also provides feedback about areas of strength and opportunities for growth.

6.1.4 Model collaboration strategies

Quality collaboration does not just happen, students need to learn strategies to become productive collaborators. Modeling using role-playing demonstrates how to turn collaboration situations around to become more productive. Offering tools that help students work in collaboration such as learning how to disagree productively, how to communicate effectively while sharing responsibilities, how to manage conflict, and how to provide constructive suggestions. Creating scenarios, acting them out, and encouraging reflection can help enhance attention to quality collaboration. Modeling can encourage students to enact an equal and reciprocal balance of talking and listening during collaboration. Instructional practices that provide practice opportunities include Socratic seminars, fish-bowl discussions, and planned discussion protocols where students who collaborate well can lead by example. An open discussion following how these activities can lead to a more balanced and reciprocal exchange and transferable metacognitive awareness.

6.1.5 Encourage learners' reflection on their collaborative processes

People learn from their reflection; reflection offers a means for individuals to think deeply about their experiences and thoughts. By reflecting on their collaborative processes, students gain insights from making connections, identifying unexpected outcomes, which help them adjust future performance.

The five recommendations stemming from this research offer some guidance to educators, however there are many other ways to promote positive collaboration opportunities. Encouragement with specific praise goes a long way to increase the likelihood of a student's metacognitive awareness of their own collaborative strengths.

Author details

Wen Wen[1]* and Jill Castek[2]

1 State University of New York at Oneonta, Oneonta, NY, USA

2 University of Arizona, Tucson, AZ, USA

*Address all correspondence to: wen.wen@oneonta.edu

IntechOpen

© 2023 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

References

[1] Hsieh YC. A case study of the dynamics of scaffolding among ESL learners and online resources in collaborative learning. Computer Assisted Language Learning. 2017;**30**(1-2):115-132

[2] Scardamalia M, Bereiter C. Knowledge building and knowledge creation: Theory, pedagogy, and technology. In: Sawyer RK, editor. The Cambridge Handbook of the Learning Sciences. New York: Cambridge University Press; 2014. pp. 397-417

[3] Choi I, Land SM, Turgeon AJ. Scaffolding peer-questioning strategies to facilitate metacognition during online small group discussion. Instructional Science. 2005;**33**:483-511

[4] Forman EA, Cazden CB. Exploring Vygotskian perspectives in education: The cognitive value of peer interaction. In: Wertsch JV, editor. Culture, Communication, and Cognition: Vygotskian Perspectives. New York: Cambridge University Press; 1985. pp. 323-347

[5] Webb NM, Palincsar AS. Group processes in the classroom. In: Berliner DC, Cafree RC, editors. Handbook of Educational Psychology. New York: Simon & Schuster Macmillan; 1996. pp. 841, 841-873, 873

[6] Jacobs G, Castek J. Collaborative digital problem solving: Power, relationships, and participation. Journal of Adolescent and Adult Literacy. 2022;**65**(5):377-387

[7] Leu DJ, Kinzer C, Coiro J, Castek J, Henry LA. New literacies: A dual-level theory of the changing nature of literacy, instruction, and assessment. In: Alvermann D, Unrau NJ, Sailors M, Ruddell RB, editors. Theoretical Models and Processes of Literacy. 7th ed. New York: Taylor & Francis; 2018. pp. 319-346

[8] Vygotsky LS. Mind in Society: The Development of Higher Psychological Processes. Cambridge: Harvard University Press; 1978

[9] Wood D, Bruner JS, Ross G. The role of tutoring in problem solving. Child Psychology & Psychiatry & Allied Disciplines. 1976;**17**(2):89-100. DOI: 10.1111/j.1469-7610.1976.tb00381.x

[10] Bruner J. Play, thought, and language. Peabody Journal of Education. 1983;**60**(3):60-69

[11] King A, Staffieri A, Adelgais A. Mutual peer tutoring: Effects of structuring tutorial interaction to scaffold peer learning. Journal of Educational Psychology. 1998;**90**(1):134-152. DOI: 10.1037/0022-0663.90.1.134

[12] Cross DR, Paris SG. Developmental and instructional analyses of children's metacognition and reading comprehension. Journal of Educational Psychology. 1988;**80**(2):131-142

[13] Flavell JH. Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. American Psychologist. 1979;**34**(10):906-911

[14] Kuhn D, Dean D. A bridge between cognitive psychology and educational practice. Theory into Practice. 2004;**43**(4):268-273

[15] Schraw G, Crippen KJ, Hartley K. Promoting self-regulation in science

education: Metacognition as part of a broader perspective on learning. Research in Science Education. 2006;**36**:111-139

[16] Whitebread D, Coltman P, Pasternak DP, Sangster C, Grau V, Bingham S, et al. The development of two observational tools for assessing metacognition and self-regulated learning in young children. Metacognition and Learning. 2009;**4**(1):63-85

[17] Lai ER. Metacognition: A literature review. Always Learning: Pearson Research Report. 2011;**24**:1-40

[18] Biasutti M, Frate S. Group metacognition in online collaborative learning: Validity and reliability of the group metacognition scale (GMS). Educational Technology Research and Development. 2018;**66**(6):1321-1338. DOI: 10.1007/s11423-018-9583-0

[19] de Oliveira LC. A language-based approach to content instruction (LACI) for English language learners: Examples from two elementary teachers. International Multilingual Research Journal. 2016;**10**(3):217-231

[20] Fennema-Bloom JR. Code-scaffolding: A pedagogic code-switching technique for bilingual content instruction. Journal of Education. 2010;**190**(3):27-35. DOI: 10.1177/002205741019000304

[21] Cazden CB. Peekaboo as an instructional strategy: Discourse development at home and at school. In: Papers and Reports on Child Language Development. Stanford, CA: Stanford University, Department of Linguistics; 1979. p. 17

[22] Castek J. How do 4th and 5th grade Students Acquire the New Literacies of online Reading Comprehension? Exploring the Contexts that Facilitate Learning. [Unpublished doctoral dissertation]. Storrs: University of Connecticut; 2008

[23] Palincsar AS. The role of dialogue in providing scaffolded instruction. Educational Psychologist. 1986;**21**:73-98

[24] Coiro J, Sekeres DC, Castek J, Guzniczak L. Comparing third, fourth, and fifth graders' collaborative interactions while engaged in online inquiry. Journal of Education. 2014;**194**(2):1-15

[25] Coiro J, Sparks J, Kiili C, Castek J, Lee C, Holland B. Students engaging in multiple-source inquiry tasks: Capturing dimensions of collaborative online inquiry and social deliberation. Literacy Research: Theory, Method, and Practice. 2019;**68**(1):271-292

[26] Sekeres DC, Castek J. Collaborative online inquiry: Exploring students' skills in locating, reading, and communicating information. Journal of Interactive Online Learning. 2016;**14**(2):58-79

[27] Sekeres DC, Coiro J, Castek J, Guzniczak L. Wondering + inquiry = learning: Designing collaborative online inquiries for elementary students. Phi Delta Kappan. 2014;**96**(3):44-48

[28] Coiro J, Castek J, Guzniczak L. Uncovering online reading comprehension processes: Two adolescents reading independently and collaboratively on the internet. In: Dunston P, Gambrell L, Headley K, Fullerton S, Stecker P, Gillis V, Bates C, editors. 60th Annual Yearbook of the Literacy Research Association. Oak Creek, WI: LRA; 2011. pp. 354-369

[29] Castek J, Coiro J, Guzniczak L, Bradshaw C. Examining peer

collaboration in online inquiry. The Educational Forum. 2012;**76**(4):479-496. DOI: 10.1080/00131725.2012.707756

[30] Mercer N. The Guided Construction of Knowledge: Talk amongst Teachers and Learners. Philadelphia PA: Multilingual Matters Ltd; 1995

[31] Wen W. Exploring Teaching and Learning in Undergraduate Online Digital Literacies Course: Instructor's Scaffolding, Students' Performance and Perspectives. [Unpublished doctoral dissertation]. Tucson: University of Arizona; 2023

[32] Hung BP, Nguyen LT. Scaffolding language learning in the online classroom. In: Sharma R, Sharma D, editors. New Trends and Applications in Internet of things (IoT) and Big Data Analytics. Cham: Springer; 2022. pp. 109-122

[33] Lavrakas PJ. Encyclopedia of Survey Research Methods. Thousand Oaks, CA: Sage Publications; 2008. DOI: 10.4135/9781412963947

[34] Oguilve V, Wen W, Castek J, Sanderson C, Pineda Z. Participatory learning: Educators designing media to expand global perspectives. In: Bastiaens T, editor. Proceedings of EdMedia + Innovate Learning; June 2022. New York City, NY, United States: Association for the Advancement of Computing in Education (AACE); 2022. pp. 1016-1025

[35] Flick O. An Introduction to Qualitative Research. 4th ed. London: Sage Publications; 2009

[36] Hao J, Liu L, von Davier A, Kyllonen P, Kitchen C. Collaborative problem solving skills versus collaboration outcomes: Findings from statistical analysis and data mining. In: Proceedings of the 9th International Conference on Educational Data Mining. Raleigh, NC: EDM; Jun 2016. pp. 382-387

[37] Miles MB, Huberman AM. Qualitative Data Analysis: An Expanded Sourcebook. 2nd ed. Thousand Oaks, CA: SAGE Publications Inc; 1994

[38] Saldaña J. The Coding Manual for Qualitative Researchers. Thousand Oaks, CA: SAGE Publication Inc; 2015

[39] Lew S, Yang A H, Harklau L. Qualitative methodology. In Phakiti A, De Costa P, Plonsky L, Starfield S. editors. The Palgrave Handbook of Applied Linguistics Research Methodology. London: Palgrave Macmillan; 2018. p. 79-101

[40] Stone CA. The metaphor of scaffolding: Its utility for the field of learning disabilities. Journal of Learning Disabilities. 1998;**31**:344-364

[41] Stone CA. Should we salvage the scaffolding metaphor? Journal of Learning Disabilities. 1998;**31**:409-413

[42] Stone CA. What is missing in the metaphor of scaffolding? In: Forman EA, Minick NM, Stone CA, editors. Contexts for Learning: Sociocultural Dynamics in children's Development. New York: Oxford University Press; 1993. pp. 169-183

Chapter 14

Chronicling Information Communication Technology into Teaching and Learning in the Eastern Cape Province, South Africa

Zikhona Selekez

Abstract

This study aimed to investigate the integration of Information Communication Technology (ICT) during the teaching and learning encounter in the Eastern Cape province of South Africa. The study employed a qualitative approach guided by a case study design. The population of the study comprised teachers of one secondary school and its feeder schools in the OR Tambo inland district. The sample size for this study was three principals and nine computer teachers of the senior secondary school and its two feeder schools. An open-ended interview schedule was used for the face-to-face, in-depth interviews on the extent of the implementation of computer integration into teaching and learning in the selected schools in the OR Tambo inland district. Schools must enable a culture of computer-integrated teaching and learning to meet diverse needs. ICT integration training, competence and appropriate software and materials need to be attended to in a considerable way.

Keywords: ICT, integration, teaching, learning, computer-integrated teaching

1. Introduction

Supporting school teachers to integrate technology into schools' self-efficacy can have a significant impact on future success and the proper use of technology within the school system for cognitive learning [1]. Klein and Richard [2] accentuate the phenomenon of the digital divide, which is conceived as 'a situation where some populations have access to ICTs while others have very little or no access at all which can impact negative on cognitive skills'. Mietule et al. [3] also assert that the use of ICTs in education is hoped to expand education to remote places and, consequently, help bridge the digital divide and thus enable positive metacognition, especially when adopting ICTs in teaching and learning. The twenty-first-century society is driven and shaped by computers, and thus, cognitive learning in chronicling ICT in teaching and learning is core. This has a huge impact on the way people live in modern society. For

IntechOpen

example, ICT has literally changed the way we study, work, entertain ourselves, conduct our business affairs, find information, etc. The present researcher developed an interest in this study to explore more on the selected schools which are still underprivileged and have limited computer facilities to implement computer-integrated teaching and learning.

Information technology can take over the traditional presentational and organisational roles of teachers. This has implications for both teachers and learners; it can provide an additional or alternative source of knowledge and information, which may reduce the dependency of learners on the teacher. The integration of computers into teaching and learning in schools will free up the teacher's time and enhance students' repertoire of learning skills; the integration will also enable greater student autonomy. This would also allow students to maximise their active role in learning.

Although computer integration has been implemented to rectify the past, most schools in the deep rural areas of the Eastern Cape Province of South Africa are still under-resourced as compared to schools in the urban areas. Hassan and Mirza [4], in their paper about digital literacy in Teachers of the Schools of Rajouri, reflect that there is no doubt that Information Communication and Technology can aid the instructional process and facilitate learners learning in the classrooms as metacognition in ICT adoption is carried through. This chapter, therefore, intends to investigate the integration of ICT during the teaching and learning encounter in the Eastern Cape province of South Africa.

2. Literature review

Around the world, globalisation and the increasing spread of ICTs have had an immense impact on all spheres of life, including education [5]. However, due to different levels of development, different countries across the globe have varying levels of capacity to take advantage of ICTs. In general, developed countries, such as the United States, countries in West Europe and countries in the East, can harness the potential of ICTs for both economic and social purposes (including educational development), whereas developing countries in South America and Africa are struggling to embrace the same technologies. The concept of the digital divide is often used to describe this phenomenon [6]. Africa is a developing continent. The lack of a developing infrastructure for information and communication technologies is widening the gap between Africa and the rest of the world [7]. In response to this underdevelopment, Jiboku and Osifo [8] argue that Africa has adopted a renewal framework, the New Partnership for Africa's Development (NEPAD), which identifies ICTs as central in the struggle to reduce poverty on the continent. Padayachee [9] argues that ICTs have the potential to overcome barriers causing social and geographical isolation, increase access to information and education, and enable the poor to participate, making an impact on their lives. With the advent of democracy in South Africa, the adoption of the country's new constitution provides a basis for curriculum transformation and development [10]. The constitution states that everyone has the right to further education, which the state, through reasonable measures, must make progressively available and accessible. However, more than 10 years into the new democracy, the legacy of apartheid continues to be felt in the education system [11]. In the apartheid regime, institutions were built under the previous administration on the basis of race, and apartheid theory and structural inequality were pervasive. As a result of the unequal distribution of resources, historically black schools are frequently under-resourced, whereas so-called historically white schools are frequently equipped with full-fledged resources. This situation negatively impacts on the quality of teaching and learning to the extent that employers and the higher education (HE) sector have no confidence in the programmes offered in further education and training (FET) institutions. In addition, how the official curriculum is delivered also needs to be addressed. Many teachers regard themselves as the only bearers of knowledge and, therefore, rely on teaching methods that do not engage learners in active learning. Teachers are often also preoccupied with the race to complete the syllabus in preparation for the examinations, resulting in learners' prior knowledge not being acknowledged sufficiently. The ultimate result is learning experiences that are uninspiring. The Thintana project aims to make educators computer-literate through School Net [12]. The Thintana I-Learn project operates in Gauteng, the Northwest, Kwa-Zulu Natal, the Eastern Cape, the Northern Cape, Mpumalanga and the Free State. Stilwell, C. Bel [13], in their paper on Information Needs of Learning at Emzamweni High School, Inadi, South Africa, provides an explanation that the Thintana project equips schools with infrastructure and technical programmes. So far, it has equipped more than 200 schools all over South Africa [14]. Thintana trains trainers in all provinces. They also conducted a mentoring course that trained 141 mentors. The Intel Project is an organisation that impacts free teaching and learning resources for learners worldwide [15]. Intel Corporation has invested over $1 billion worldwide in this education initiative. Intel enables the design and delivery of innovative technology solutions [16]. Intel offers classroom tools and resources that integrate technology to better equip learners with twenty-first-century skills. Interactive Learning provides quality multi-media learning resources free to students and teachers throughout the UK, Ireland and a few other countries, emphasising math and science from Grades 7 to 12. It also provides educational technology solutions by giving information on how schools can improve the quality and delivery costs of educational services through these solutions. At the OR Tambo inland schools in the Eastern Cape, the purpose of the Intel Project is to take computers to classrooms and teach academic subjects using computers. The vision of one of the selected schools in OR Tambo inland was to provide quality education to learners from Grade 10 to Grade 12, to uplift and empower them to play a responsible and meaningful role in society, both nationally and internationally. The researcher should see from the vision of one of the selected schools in OR Tambo inland to provide quality education to learners from Grade 10 to Grade 12. The school is committed to computer-assisted education, as providing students with opportunities for acquiring computer literacy skills was one of the primary objectives of the selected schools. To this end, those schools plan to introduce computer science as an academic subject for Grades 10–12 as part of their 2030 vision. The principal and staff are dedicated to these ideas, striving to give their best, providing the best opportunities and life experiences, and acting in a manner that is professional and caring. It is envisaged that on a weekly basis, learners from Grades 10 to 12 will have to attend compulsory one-hour computer classes, but this has not yet been implemented due to a lack of resources. In South Africa, as far as improving the quality of life of citizens is concerned, e-education assumes a pivotal role [17]. According to the draft white paper on e-education, it is about connecting learners and teachers and providing professional support services and platforms for learning. The South African education system is now undergoing dramatic changes [18]. The previous education system was ill-suited to the needs of its children. During the last few years, however, both the government and private organisations have come forward to make our education system a modern one. The government's Draft White Paper on e-Education has highlighted the contributions made by some organisations towards the South African education system [19]. This chapter will adopt the evolutionary model of the integration of computer-assisted education, as shown in **Figure 1**. An evolutionary model of the integration of computer-assisted learning with four phases is demonstrated in **Figure 1**. The integration of computer-assisted education is neither computer literacy nor computer awareness. It means using the computer which is the best medium to support the learning goal [20]. Ran and Secada [21] aver that integrating computer-assisted education implies a move towards a different kind of teaching. A whole-school awareness looks at the aims of general secondary education: meeting new demands of society in students skills, reforming the curriculum, training teachers in new skills, internal school organisation, hardware provision and maintenance, stabilising funding policies, support by technical staff, equity of access for all students, software development and provision, development and provision of complementary materials, and copyright policies of software.

3. Methodology

In this research, the qualitative method of research was used. The primary goal of the researcher using this approach was to define, describe, interpret and understand the behaviours of the participants regarding the extent of implementation of

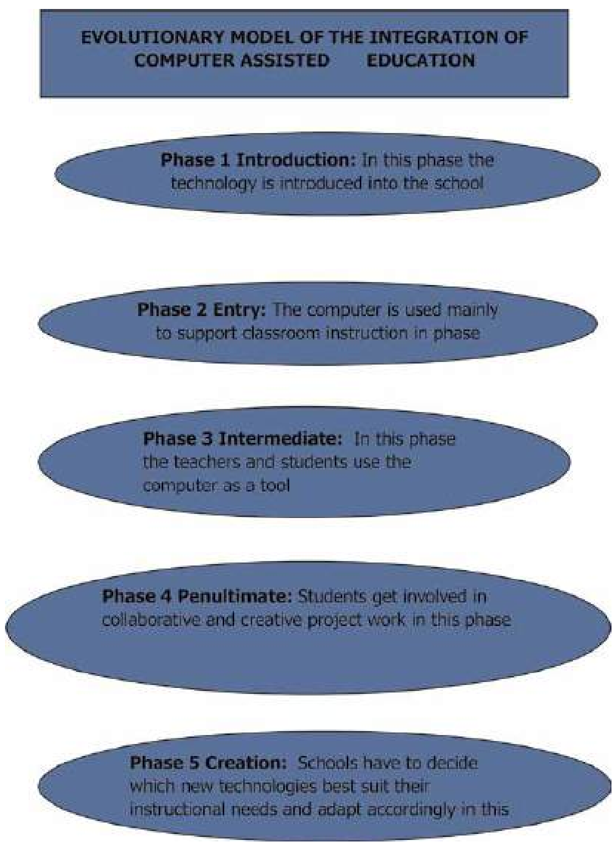

Figure 1.
This evolutionary model represents a gradual progression from conventional teaching methods towards a sophisticated integration of technology and metacognitive strategies in education.

computer integration into teaching and learning in selected schools in the Mthatha District. The researcher mainly used the qualitative research method of data collection. Hennink et al. [22] point out that when the researcher is interested in seeking to investigate a phenomenon that requires more descriptive data, the qualitative research method is usually used. It employs strategies of inquiry that involve collecting data to the best of a research problem. The qualitative research method is used as a major form of collecting data. The qualitative research design used in this study is a case study. Case study research provides a unique example of real people in real situations, enabling readers to understand ideas more clearly than by simply presenting them with abstract theories or principles [23]. The population for this study comprised all 15 teachers of one selected secondary school and 32 teachers of the selected junior secondary schools. The researcher used face-to-face, in-depth interviews. The interviews were used to gather in-depth information about the viewpoints and opinions of the respondents regarding the extent of implementation of computer integration into teaching and learning in selected schools in the Mthatha District. Archibald et al. [24] highlight that qualitative interviews may be used either as the primary strategy for data collection or in conjunction with observation, document analysis or other techniques. The researcher initially sought permission from the respondents to use an audiotape to collect data from them. The respondents agreed to take part in the study by signing informed consent forms to document their consent to participate in the study. The participants were interviewed, and their voices were captured through the use of an audiotape. Each interview took place at either the principal‘s office or the deputy principal‘s office, depending on the venue that was allocated to the researcher by the individual school management teams. These offices were used because of the quiet and comfortable environments they provided for the interviews. The researcher started the individual interview by establishing rapport with each of the interviewees. An explanation was given to each of the interviewees that the purpose of the interview was to investigate the integration of information and communication technology during the teaching and learning encounter in the Eastern Cape, South Africa. Hubbard [25] states that qualitative analysis involves working with data, organising it, breaking it into manageable units, synthesising it and searching for patterns. A qualitative data analysis process was followed to treat and analyse the data.

Question 1a: Could you please tell me if and how teachers in this school use computers to assist them in teaching and learning in the class?

About 83% (10) of the participants highlighted the following as the ways in which computers assist them in the teaching and learning processes in the classrooms: teachers use computers for investigating issues concerning teaching and learning in their learning areas; teachers use computers to assist them in setting questions for tests and examinations and teachers also use the Internet to surf and download question papers for classroom practices. The above is supported by the following excerpts. Respondent 1 (Principal): teachers use computers to set questions for class tests and to also do investigations on the Internet.

Respondent 1 (teacher): We download question papers from the Internet using computers. Two participants (17%) said teachers did not use computers to assist in the teaching and learning process in the classrooms. This is supported by the following examples:

Respondent 3 (Principal): We do not use computers to assist us in teaching and learning in this school. Respondent 7 (teacher): teachers do not use computers for teaching and learning in the class.

Question 1b: In what ways do learners use computers to assist them in the learning process in this school?

Seven participants (58%) clearly stated that learners in their classrooms did not use computers in the learning and teaching process in their schools. That is, only the teachers used the computers to type question papers. These participants also highlighted the point that learners did not use computers in the schools because there was no one with the skills or who was computer literate to teach them. The following examples support this:

Respondent 1 (Principal): Our learners do not use computers in this school. Respondent 5 (teacher): learners in this school do not use computers because they are not computer literate. Five participants (42%) said their learners used the Internet to Google information for their assignments, but that was not a regular occurrence.

Respondent 2 (Principal): Our learners use computers to help them type their assignments and to Google relevant topics and concepts. Respondent 3 (teacher): not regular because their computers are not enough.

Question 1c: What is the positive impact on and significance of computers for modern ways of teaching and learning in schools?

All 12 participants (100%) listed the following as the main reasons for the positive impact of computers on modern ways of teaching and learning in classrooms: computers help learners to do research and work independently of their teachers; computers help teachers and management to store and save important information about learners and teaching for future retrieval; computers make teaching and learning simple; computers also help both teachers and learners to access the world out there; the use of computers is easy and uses less time-consuming papers and resources. The excerpts below support these:

Respondent 3 (Principal): The significance of computers in our schools is that computers make teaching and learning easier, require less paperwork and learners love seeing us working on the computers.

Question 1d: What is the state of the availability of computer facilities for both teachers and learners in this school?

Ten out of 12 participants (83%) said their schools only had a few computers (e.g., only four computers for a whole school), and this number was insufficient; in addition, there were no Internet facilities. This is supported by the following examples of responses:

Respondent 2 (Principal): It is very limited; we have only eight computers, and out of these, only four are functioning.

Respondent 8 (teacher): The state of computer facilities is not in good condition; computers are also scarce in our schools. An insignificant number (17%) claimed there were no computers in their schools – not even one. The example below supports this: Respondent 9 (teacher): the state of computer facilities in this school is unhealthy; this is due to the fact that we do not have computers in this school.

Question 2a: What do you say about the view that rural schools are less empowered compared to schools in urban areas in terms of computer integration and learning availability?

All 12 participants (100%) attested to this statement, that is, rural schools were less empowered compared to schools in urban areas in terms of computer integration and availability. These participants went as far as to say that the government had ignored their schools and was not concerned about rural schools, and as such, no computer facilities were available in the rural schools for integration. They stated that most teachers become computer literate at tertiary institutions but cannot use these skills in rural schools because of a lack of computer facilities. The following comments support these views:

Respondent 1 (Principal): In this case, the rural schools are ignored completely by the government and other stakeholders. Respondent 5 (teacher): I strongly believe that rural schools are less empowered due to the fact that they are illiterate; they are ignorant about the wonders of computers, the lack of electricity and government support.

Question 2b: Could you please tell me if there is any assistance from the Department of Education in terms of computer integration in this school?

About 83% of the participants claimed there had never been any assistance from the Department of Education to integrate computers into teaching and learning in the schools, and that was ignorance on the part of the Department of Education. The following excerpts support this:

Respondent 3 (Principal): There is no assistance to teachers and learners in computer integration because we and the Department of Education lack the knowledge and skills in computer integration.

Respondent 3 (teacher): It is the wish of the department, but they do not assist at this school. Two (17%) of the participants believed the Department of Education had assisted schools by training a few teachers in computer literacy, but the challenge was that there were no computer facilities in the schools for these teachers to train others and that only one laptop was available in each of the schools. This is supported by the following opinion:

Respondent 2 (Principal): There are some teachers who have been trained to implement computer integration in the schools, but there are no computer facilities in the schools. Question 3a: What can you say about the training offered to teachers and learners concerning the integration of computers in schools? Has there been any training for teachers in computer integration by the department or any other organisation in the schools? This is supported by the following excerpts:

Respondent 1 (Principal): There has not been training for both teachers and learners yet, so they need to be trained.

Respondent 5 (teacher): No, in this school, only one teacher is computer literate, and she did this course in her private studies. The department did not assist her. Two participants (17%) said there had been training for a few teachers in order to integrate computers into their teaching and learning, but they categorically stated that there were no computer facilities for these teachers to implement the skills and knowledge obtained. Examples below support this:

Respondent 2 (Principal): Yes, there has been training, but the challenge is the implementation after they have been trained.

Question 3b: What plans are in place to implement and integrate computers into the teaching and learning process in this school?

Seven of the participants (58%) stated that there were plans to introduce computer-integrated learning in their schools and to employ an IT teacher, but the impediments were that there were neither computer facilities in the schools nor support from the department or other organisations. The examples below support this:

Respondent 2 (Principal): We intend to introduce computer applications in 2015, starting in Grade 8, but the challenge is that we do not have computer facilities in this school. Five of the participants (42%) said there were no plans in place for them to implement computer integration into the teaching and learning process in their schools because they lacked funds to purchase computers and that the government would not assist the schools. This is supported by the excerpts below.

Respondent 3 (Principal): We do not have any plans because we do not have the funds to buy computers, and we do not think the government will ever provide us with computers. It will be a plan that will not do us any good because there are no computers. Respondent 4 (teacher): There are no plans at the moment at this school.

Question 4a: What do you have to say concerning teachers' perceptions, resistance to and reluctance to implement computer integration in the classroom?

Five of the participants (42%) said there were signs of resistance and mentioned ignorance on the part of teachers who did not want to integrate computer-managed learning into their classes. Others said they did not want to be carrying around laptops (belonging to the department), which do not belong to them, and that the lack of computer facilities also contributed to teachers' reluctance and resistance to integrating computers into their schools. These participants also highlighted the view that some teachers claimed the use of laptops and overhead projectors in class was a waste of time because of the limited time per module in the class.

The following comments support the above opinions:

Respondent 2 (Principal): Yes, there is resistance due to the fact that we do not have computers in these schools and due to the fact that we are ignorant about the importance of computer integration. Seven of the participants (58%) believed teachers were not reluctant and resistant to integrating computer learning into their teaching and that teachers really wanted to integrate computers into the teaching and learning in the classes and were always calling for the repairs and installation of computers in the schools to facilitate teaching and learning. This is supported by the following:

Respondent 1 (Principal): No, there is no resistance because teachers are interested in implementing computers in their classes. Respondent 3 (teacher): Teachers are always calling for the servicing of the computers (installation of updated software) in the schools, which can draw the attention of the learners to also use the computers for easy teaching and learning.

Question 5a: Could you please mention the challenges that schools, teachers and learners face in their attempts to implement computer integration in schools?

All 12 participants (100%) mentioned the following as challenges faced by schools in implementing computer integration into the classrooms: lack of computer facilities and resources; lack of funds to buy computers and to train staff; lack of support from the department; lack of Internet facilities and the high cost of connecting to the Internet; software programmes; teachers' work overload and limited time; theft; lack of workshops and training in IT. The following excerpt supports this:

Respondent 2 (Principal): The challenges are facilities and resources, including computers and funds, to implement this.

Respondent 1 (teacher): There are no up-to-date computers in our schools; Internet connectivity too is expensive, and the government does not want to provide us with computer facilities.

4. Discussion

The findings revealed that the principals and the computer teachers had an understanding of the purpose of the research. They were honest in their responses. The main findings and themes are illustrated in **Figure 2**; the following will be the discussion.

Computers have a positive impact in schools: they help learners do research and work independently of their teachers. They also help teachers and school managers

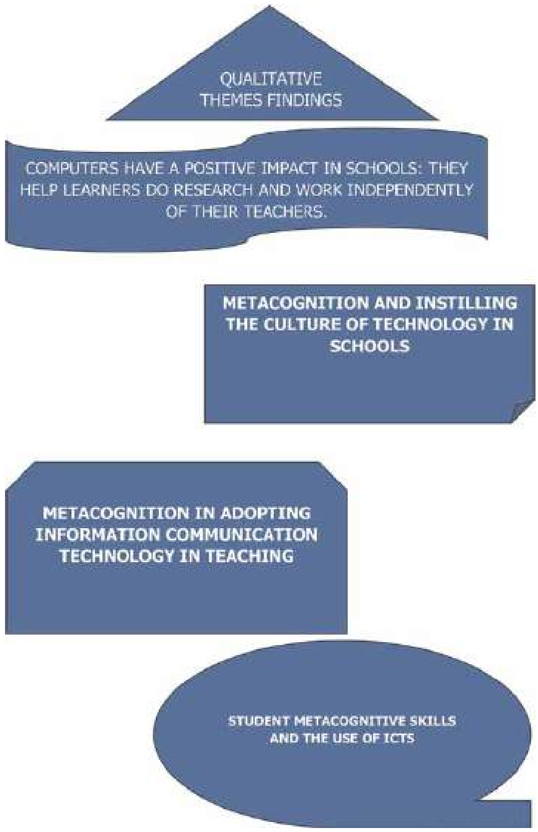

Figure 2.
Qualitative themes that serve as a framework for understanding the nuanced impacts, challenges, and opportunities associated with funding for metacognitive strategies in education, providing valuable insights into their effectiveness and potential areas for improvement.

store and save important information about learners and teaching. They are administrative tools. Schools had insufficient computers. Rural schools were less empowered as compared to schools in urban areas in terms of computer integration and availability. The Department of Basic Education (DBE) has ignored rural schools, and as such, no computer facilities were available in the rural schools for integration.

There had been hardly any training for teachers in computer integration in these schools by the Department of Education or any other organisation. There had, however, been training for a few teachers in integrating computers into teaching and learning, but there were no computer facilities for these teachers at schools to implement the skills and knowledge they had acquired. There were plans to introduce computers, but there were no computer facilities in the schools and no support from the Department of Education or other organisations. Schools lacked funds to purchase computers, and the DOE did not want to assist the schools. Many teachers were ignorant about computer integration into their classrooms. Teachers did not want to be carrying DOE laptops around. The lack of computer facilities contributed to teacher's reluctance and resistance to integrating computers into their schools. Teachers claimed the use of laptops and overhead projectors in class was a waste of time because lessons were too short.

4.1 Strategies that hold promise for improving school principals to guide rural education reform in implementing computers in teaching and learning

The challenges faced by schools in implementing computer integration into the classrooms were: lack of developing infrastructure for information and communication technologies is widening the gap between Africa and the rest of the world [7]; lack of computer facilities and resources; the complaint brought was that school principals are not guiding rural education reform in the implementation of computer-integrated education; therefore, practical strategies are to be brought to aid this venture. Lack of funds to buy computers and to train staff; therefore, Masum et al. [6] reflect that the concept of the digital divide is often used to describe the phenomenon guiding rural education reform in the implementation of computer-integrated education. Principals must aid in ensuring that rural reform in adopting ICTs is not compromised. There is a lack of support from the department; therefore, principals are the only trusted stakeholders in schools in channelling this to the ICT section of the basic education department to eliminate concerns that, more than ten years into the new democracy, the legacy of apartheid continues to be felt in the education system [11]. In this challenge, principals are to adopt strategies for the establishment of ties with the Department of Communication, but a guide on how each school principal will aid rural education reform in the implementation of Internet facilities in teaching and learning needs to be drawn. High cost of connecting to the Internet, teachers' work overload, lack of computer laboratories and lack of trained teachers to handle computer-integration implementations in schools; with regard to this, the researcher's view is if school principals are equipped with strategies for improving rural education reform in implementing computers in teaching and learning by their respective education specialist then ICT enhanced teaching and learning in schools will not be compromised this aligned researchers highlighting that South African education system is now undergoing dramatic changes [18].

4.2 Metacognition and instilling the culture of technology in schools

It is important to know that computers are efficient classroom tools that can enhance education if used to benefit student learning and achievement, Ran and Secada [21] aver that integrating computer-assisted education implies a move towards a different kind of teaching. Integrating technology and education provides students with a global approach to learning and communicating. This book chapter, however, revealed that very few teachers used computers in the schools to assist in the teaching and learning process in the classrooms. Padayachee [9] argues that ICTs have the potential to overcome barriers causing social and geographical isolation, increase access to information and education, and enable the poor to participate, making an impact on their lives. A teacher had this to say: teachers do not use computers for teaching and learning in class. There had been hardly any training for teachers in computer integration in these schools by the Department of Education or any other organisation. Learners in schools did not use computers in the learning and teaching process in the geographical area where the study was conducted. The study revealed that the teachers used the computers to type question papers for the classes. The book chapter also revealed that learners did not use computers in the schools because of a lack of skills, and few were sufficiently computer literate to teach others in the schools.

Learners in this school do not use computers because they are not computer literate. This sentiment was expressed by a teacher and highlighted the absence of skills required to teach learners to use computers. The researcher's opinion is that instilling the culture of technology in schools through amending school policies and being informed by an educational white paper on e-education in terms of how teachers are to utilise the school ICTs that are rollout by the Department of Education and monitoring of how those policies are implemented in school can instil the culture of technology-enhanced teaching in schools.

4.3 Rural schools lack computer-integrated skills

Schools had insufficient computers, and existing computers were not connected to the Internet. This was what a teacher had to say: a few computers are not in good condition, and these too are not connected to the Internet. The most common reason for not implementing technology-integrated lessons was that the necessary computers were not available regardless of pivotal role and benefit metacognition by using ICT to aid in twenty-first-century learning. Heimbürger et al. [17] noted that in South Africa, as far as improving the quality of life of citizens is concerned, e-education assumes a pivotal role. The most common reasons given for not implementing a technology-integrated lesson in most schools were that the necessary computers were not available, software was not available, there was no Internet connection, there was too little preparation time, and there was a lack of technical and administrative support.

4.4 ICT integration training, competence, equipment and appropriate software and materials

The challenges faced by schools in implementing computer integration in the classrooms appeared to be a lack of computer facilities and resources, a lack of funds to buy computers and train staff, a lack of support from the DOE, a lack of Internet facilities, and the high cost of connecting to the Internet. Teachers complained of work overload, a lack of computer laboratories, a lack of trained IT teachers to handle computer integration implementations in schools, a limited time possibility of theft, and a lack of workshops and training in IT. Mietule et al. [3] also assert that the use of ICTs in education is hoped to expand education to remote places and, consequently, help bridge the digital divide and thus enable positive metacognition, especially when adopting ICTs in teaching and learning. The department is not ready to furnish the schools with computers; there are no computer laboratories, and there is a lack of trained teachers to handle computer integration implementations in schools. This view was from a teacher.

4.5 Adoption of information and communication technology in teaching and learning activities

There had not been training for teachers in computer integration by the DOE or any other organisation in the schools. A principal had this to say: there has not been training for both teachers and learners yet, so they need to be trained. A teacher had this to say: it is the wish of the department, but they do not assist in this school. Bahrini and Qaffas [7] assert that the lack of a developing infrastructure for information and communication technologies is widening the gap between Africa and the rest of the world. It is important to highlight that few teachers have been trained to integrate computers into their teaching and learning processes, and in fact, there are no computer facilities for these teachers to implement their skills and knowledge.

There are some teachers who went for training, but practising the skills is where the challenge is. This was from a teacher.

5. Metacognition in adopting information communication technology in teaching

If teachers use computers effectively for teaching and learning to help learners, teachers would use computers for investigating issues concerning teaching and learning in their learning areas, teachers would use computers to assist them in setting questions for tests and examinations, and teachers would also use the Internet to surf, download question papers for classroom practice, and access the global world. Computers would help learners to do research and work independently of their teachers; computers would help teachers and school managers to store and save important information about learners and teaching for future retrieval and computers would make teaching and learning simpler and easier. They also help to save time, paper and resources. Teachers will appreciate the use of laptops and overhead projectors, not considering them a waste of time. Teachers would also not be reluctant or resistant to integrating computers into their teaching.

6. Student metacognitive skills and the use of Information and Communication Technologies (ICTs)

There could also be the availability of funds to buy computers and to train staff, provided support from the department is given, which can possibly lead to the availability of Internet facilities. This may have the potential to improve student metacognitive skills when adopting ICTS. Teacher's work overload would also be considered to cater for student cognitive development when adopting ICT in learning. Lack of computer laboratories and lack of trained teachers to handle computer integration implementation in schools would be addressed carefully, and student metacognitive skills could be taken seriously by the DOE.

7. Conclusion

This book chapter sets out to investigate the integration of information and communication technology during the teaching and learning encounter in the Eastern Cape, South Africa. Although computer integration has been implemented to rectify the past, schools in deep rural areas in the OR Tambo inland seem to be less equipped as compared to schools in urban areas. Schools in education must enable the culture of computer-integrated teaching and learning through workshops for diverse needs. Strategies that hold promise for improving school principals to guide rural education reform in implementing computers in teaching and learning to assess the viability of their own activities and facilitate improvement in computer integration in schools need to be implemented. Rural schools lack computer-integrated skills. ICT integration training, competence, equipment and appropriate software and materials are the issues that need to be addressed by the Department of Basic Education to aid in the clear adoption of information and communication technology in teaching and learning activities in general.

8. Recommendations

This study has highlighted the extent of implementation of computer integration in teaching and learning in selected schools in the OR Tambo inland district. Based on these findings, the researcher wishes to present the following recommendations: schools, in conjunction with the Department of Education, must instil a culture of computer-integrated teaching and learning in schools through workshops where both teachers and learners will acquire the necessary computer literacy skills to allow for the diverse needs and varying ability levels of students to be met. Non-governmental organisations, school governing bodies, donors, and the Department of Education must combine to raise funds to purchase and instal computers with Internet connectivity in all schools in the Mthatha Education District. The Department of Education must ensure that there is equal technology access for all schools in the country and must go beyond that to empower and assist all rural schools in furnishing their computer laboratories with the latest computer software, Internet connection, technical support and administrative support. The Department of Education must assist schools in integrating information, communication, technology and education with a global approach to enhancing learning and communication. The DOE must also assist schools in purchasing educational computer games and computer software, interactive whiteboards, LCD projectors and hand-held student devices that correlate with the curriculum to provide teachers with ongoing student assessments and reports, to create approaches to structuring instruction, and to create flexibility in presenting information to students. The Department of Education must organise workshops to train all teachers in computer literacy skills, including computer-integrated learning in the classroom. Teachers must also be encouraged to go the extra mile in learning the different computer programmes to assist in integrating the classrooms with technology. Both the Department of Education and the School Governing Bodies must include in their plans and visions the implementation of information, communication and technology in the schools. Schools must also develop strategic plans and visions for computer-integrated learning and teaching.

Appendix A: Interview schedule

Question 1a:

Could you please tell me if and how teachers in this school use computers to assist them in teaching and learning in the class?

………………………………………………………………………………………………

Question 1b:

In what forms do learners use computers to assist them in the learning process in this school?

………………………………………………………………………………………………

Question 1c:

What is the positive impact and significance of computers on the modern ways of teaching and learning in schools?

………………………………………………………………………………………………

Question 1d:

What is the state of availability of computer facilities for both teachers and learners in this school?

....

Question 2a:

Do you think that rural schools are less empowered as compared to schools in the urban areas in terms of computer integrations and availability?

....

Question 2b:

Could you please tell me if there is any assistance from the Department of Education in terms of computer integration in this school?

....

Question 3a:

What can you say about training offered to teachers and learners concerning the integration of computers in schools? Has there been any?

....

Question 3b:

What plans are in place to implement and integrate computers in the teaching and learning process in this school?

....

Question 4a:

What do you have to say concerning teachers' perceptions, resistance and reluctance to accept the implementation of computer integrations in the classroom?

....

Question 5a:

Could you please mention the challenges that teachers and learners in schools have faced in their attempt to implement computer integrations in the schools?

Appendix B: Letter to district office

No 10 Sibangweni
Mthatha
5099

To

Eastern Cape Education: Mthatha district

Informed consent

I am currently busy with research on the topic: The educational needs of the 21st century: A case study on the implementation of computer integration in teaching and learning in fulfilment of the requirements for the degree of Master of Education (M. ED) in Educational Management at the Faculty of Education in Walter Sisulu University. I therefore hereby request your consent in undertaking this research.

The following sample size has been identified for this study: The sample will comprise of 3 computer monitors or teachers and 3 principals of the Circuit 5 of Mthatha Education District||. The researcher is assuring you the strictest confidentiality and anonymity. No school or individual shall be identified in this study and at the same time school programmes shall not be disrupted by this study. The researcher will strive to be honest, objective and empathetic. The Department of Education will be informed about the outcome of this study.

Thank you, in advance for your time and co-operation.

Yours faithfully

Researcher: Z Seleke

Author details

Zikhona Selekez
Walter Sisulu University, South Africa

*Address all correspondence to: zseleke@wsu.ac.za

IntechOpen

© 2023 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

References

[1] Borthwick AC, Foulger TS, Graziano KJ. Championing Technology Infusion in Teacher Preparation: A Framework for Supporting Future Educators. United States of America: International Society for Technology in Education; 2022. eBook ISBN: 978-156484-50

[2] Klein TE, Richard P. ICT energy challenges, impact and solutions. In: 19th International ICIN Conference-Innovations in Clouds, Internet and Networks. IEEE; 2016. pp. 281-286 (Conference proceedings)

[3] Mietule I, Hushko S, Maksymova I, Sheludiakova N, Kulishov V, Lonska J. Information and communication technology: Case for tertiary education in terms of smart economics. In: Society. Integration. Education. Proceedings of the International Scientific Conference. Vol. 5. 2021. pp. 401-413. DOI: 10.17770/sie2021vol5.6396

[4] Hassan MM, Mirza T. The digital literacy in teachers of the schools of Rajouri. International Journal of Education and Management Engineering. 2021;**1**;28-40. DOI: 10.5815/ijeme.2021.01.04. Available from: http://www.mecs-press.org/. Published Online February 2021 in MECS

[5] Ahmed Z, Nathaniel SP, Shahbaz M. The criticality of information and communication technology and human capital in environmental sustainability: Evidence from Latin American and Caribbean countries. Journal of Cleaner Production. 2021;**286**:125529

[6] Masum MH, Latiff ARA, Osman MNH. Voluntary reporting, sustainable reporting and transition economy. International Business and Accounting Research Journal. 2020; **4**(2):81-88

[7] Bahrini R, Qaffas AA. Impact of information and communication technology on economic growth: Evidence from developing countries. Economies. 2019;**7**(1):21

[8] Jiboku PA, Osifo KO. Monitoring democratic governance: Modus operandi of NEPAD's African peer review mechanism. Journal of African Union Studies. 2021;**10**(2):27

[9] Padayachee K. A snapshot survey of ICT integration in south African schools. South African Computer Journal. 2017; **29**(2):36-65

[10] van der Walt JH, Oosthuizen IJ. Ubuntu in South Africa: Hopes and disappointments–a pedagogical perspective. Perspectives in Education. 2021;**39**(4):89-103

[11] Tibbitts FL, Weldon G. History curriculum and teacher training: Shaping a democratic future in post-apartheid South Africa? Comparative Education. 2017;**53**(3):442-461

[12] Amedzo EK. The Integration of Information and Communication Technology into Rural Schools of South Africa: A Case Study of Schools in Malamulele [Doctoral Dissertation]. Stellenbosch: University of Stellenbosch; 2007

[13] Stilwell C, Bell F. Information needs of learning at Emzamweni high school, Inadi, South Africa, a preliminary report of an assessment linked to the community-based learning model. In: IASL Annual Conference Proceedings. University of Alberta Libraries; 2021. ISSN 2562-8372

[14] Mbatha L. Teachers and Healthcare workers' Perceived Reproductive Health

Challenges Faced by Secondary School Adolescents in Low Resource Community of KwaZulu-Natal, South Africa (Doctoral dissertation). South Africa: University of KwaZulu Natal. Available from: https://ukzndspace.ukzn.ac.za/handle/10413/19996

[15] Wu CJ, Manne S, Ranganathan P, Bird S, Greenstein S. Socio-technological challenges and opportunities: Paths forward. Xiv preprint arXiv:2108.06738. Cornel Univesity; 2021. DOI: 10.48550/arXiv.2108.06738

[16] Heiney J, Lovrien R, Mason N, Ovacik I, Rash E, Sarkar N, et al. Intel realizes $25 billion by applying advanced analytics from product architecture design through supply chain planning. Informs Journal on Applied Analytics. 2021;**51**(1):9-25

[17] Heimbürger A, Jaakkola H, Thalheim B, Kiyoki Y, Yoshida N. Meta-level modelling of e-education ecosystem in multicultural context. Information Modelling and Knowledge Bases XXVIII. 2017;**292**:182

[18] Mampane ST. Pathways to Principalship in South Africa. The Education Systems of Africa; 22 Feb 2021. p. 327.
eBook ISBN: 978-3-030-44217-0

[19] Patrick HO, Abiolu RT, Abiolu OA. Reflections on COVID-19 and the viability of curriculum adjustment and delivery options in the south African educational space. Transformation in Higher Education. 2021;**6**:101

[20] Aljameel IH. Computer-assisted language learning in Saudi Arabia: Past, present, and future. International Education Studies. 2022;**15**(4):95-107

[21] Ran H, Kim NJ, Secada WG. A meta-analysis on the effects of technology's functions and roles on students' mathematics achievement in K-12 classrooms. Journal of Computer Assisted Learning. 2022;**38**(1):258-284

[22] Hennink M, Hutter I, Bailey A. Qualitative Research Methods. UK: Sage; 2020. eBook ISBN: 978-14739-0390-6

[23] Yin RK. Applications of Case Study Research. UK: Sage; 2011. eBook ISBN: 978-14129-8916-9

[24] Archibald MM, Ambagtsheer RC, Casey MG, Lawless M. Using zoom videoconferencing for qualitative data collection: Perceptions and experiences of researchers and participants. International Journal of Qualitative Methods. 2019;**18**:1609406919874596

[25] Hubbard DW. The Failure of Risk Management: Why it's Broken and How to Fix it. John; 2020. eBook ISBN: 978-1-11952203-4

Section 4

Metacognition in Special Education

Chapter 15

Metacognitive Strategies with Deaf and Hard of Hearing (DHH) Individuals and Ways to Assess Them

Ali Hamad Albalhareth

Abstract

This brief chapter examines the metacognitive strategies that deaf and hard of hearing (DHH) students utilize to make sense of texts. After providing an overview of the definition and history of metacognition, this chapter reviews current studies on metacognitive strategies, which can be divided into three main categories: planning or before reading; monitoring or during reading; and evaluating or after reading strategies. This chapter emphasizes the importance of linguistic knowledge and vocabulary knowledge to reading comprehension. Because metacognitive strategies are vital to reading comprehension, teachers must assess students' metacognitive strategies and use the results to design reading comprehension instruction. This chapter also discusses metacognitive assessments used to evaluate metacognitive strategies, including interviews, questionnaires, and think-aloud.

Keywords: reading comprehension, metacognitive assessments, deaf and hard of hearing (DHH), prior knowledge, vocabulary

1. Introduction

The term metacognition emerged in the 1970s and is attributed to the well-known cognitive psychologist John Flavel [1–6]. Metacognition has been recognized as one of the most crucial areas in the field of cognition. Although the term is difficult to define and assess, it refers specifically to people's ability to control their own thinking by thinking about their thinking (see [4, 7–13]).

Within the context of reading comprehension metacognition refers to individuals' ability to apply their knowledge and different cognitive strategies to maximize their comprehension (see [1, 4, 5]). One of the earliest studies on metacognition related to reading addressed memory and metamemory, which refers to individuals' knowledge and awareness of their memory's content and processes [8]; early work in reading explained that reading comprehension can be fostered through metacognitive awareness (see [14]; c.f., [15, 16]). This chapter discusses this term with respect to reading comprehension, prior knowledge, and vocabulary knowledge, specifically with individuals who are deaf and hard of hearing (DHH).

2. History of reading comprehension in relation to metacognition

Experts such as behaviorist Thorndike, and other scientists, such as Binet, Piaget, and Vygotsky have discussed metacognition using various terms. Thorndike examined metacognition's relation to reading comprehension by explaining that younger children, such as those in sixth grade may be unable to understand the text that they read automatically. Instead, they must learn to monitor their comprehension. In his work *Reading as Reasoning*, he reported that vocabulary knowledge plays a significant role in comprehending written texts [14]. Recently, Albalhereth et al. [4] argued that children without sufficient vocabulary knowledge face a great challenge in making sense of a text's meaning; they claimed that DHH children may fail to understand a text's meaning, even if they are attempting to use different metacognitive strategies, such as understanding the meaning by comprehending each individual sentence.

Alfred Binet also contributed to the field of metacognition and reading comprehension, particularly with respect to the efforts that readers make to comprehend reading materials (cited in [14]; c.f., [17]). Binet's work addressed the metacognitive strategies that are categorized as evaluating or after-reading strategies. These strategies, such as judging and critiquing texts, were discussed in Albalhareth et al.'s [4] work. The authors indicated that these strategies require a high level of skill, and they reported that DHH individuals who are poor readers use these strategies the least.

Additionally, Swiss psychologist Jean Piaget discussed the earlier scholars who also provided compelling evidence of metacognition. Piaget was among those who were interested in the schema, which refers to the cognitive process in which readers retrieve existing information and recall it to help them make sense of new texts they read [18]. Schema is the ability to integrate and add new information to the existing information they have (see [19]). Piaget explained that children may not be able to fully understand a text because they monitor their comprehension poorly. For example, Piaget [20] reported that many young children perform poorly when asked questions about a story to which they have listened. Alsamari and Albalhareth [4] explained that this is even more difficult for DHH children because when a story's content is conveyed through sign language or speech, receivers must memorize it. Yet, when the content is written out, the readers are able to reread the text and have more time to make sense of the information (see [21]; c.f., [22]).

In one of Vygotsky's studies in the 1930s, he explained that social interactions with more knowledgeable individuals increased less knowledgeable individuals' metacognitive strategies [23]. Similarly, Albalhareth et al. [4] investigated the way that peer tutoring and class discussion can increase DHH students' reading comprehension. They argued that the thinking together strategy, which is a type of reading or monitoring strategy, helps students to understand the text by sharing their ideas with others and explaining their understanding of the texts to their peers.

As previously mentioned, two areas that contribute to reading comprehension are vocabulary and prior knowledge [4, 24]. For DHH students, early acquisition of sign language is important for language, literacy, and academic outcomes [25]. Prior knowledge includes three areas: vocabulary knowledge, contextual knowledge, and structural knowledge. As stated previously, readers must have a sufficient vocabulary to comprehend the text. Furthermore, readers must possess some awareness of the particular content that they are reading; for instance, if the content is about physics, the readers must have some knowledge of this area to understand the text. Finally, readers must have some knowledge of the content's structure, which includes the text's grammar and syntax. Readers must be familiar with the grammar to be able to make sense of the passage that they read. Albalhareth et al. [4] reported an instructional practice that teachers of DHH students use in which they read the passage in English and then translate it into American Sign Language (ASL). This is referred to as "Read in English and translate into ASL". This pedagogical method helps teachers to make a complex reading passage easy to understand. Further, it increases DHH students' familiarity with the vocabulary and enhances their schema knowledge. As will be covered in the following section, previous studies have also demonstrated the importance of increasing individuals' vocabulary knowledge to enable them to use appropriate metacognitive strategies that help them to comprehend the texts (c.f., [5, 24, 26]).

3. Metacognitive knowledge

Metacognition includes two components (see **Figure 1**), the knowledge of metacognition and metacognitive regulation (e.g., [1–4]). Metacognitive knowledge refers to the awareness of what one does and does not know [28]. McCormick [29] divided metacognitive knowledge into three separate components. The first is *declarative* knowledge, or what the readers know about the texts they read [3, 30]/ second, *procedural* knowledge, involves the ability to apply their knowledge by using a particular strategy effectively and efficiently to complete a given task [31]. For instance, readers may find it useful to look at pictures or headings before they begin to read a passage, while others may prefer to re-read the previous sentence to understand the current sentence that they are reading. Finally, the third element of metacognitive knowledge is *conditional* knowledge, which refers to readers' knowledge about the what, where, when, whom, how, and why that is necessary to use a particular metacognitive strategy; it also refers to the readers'

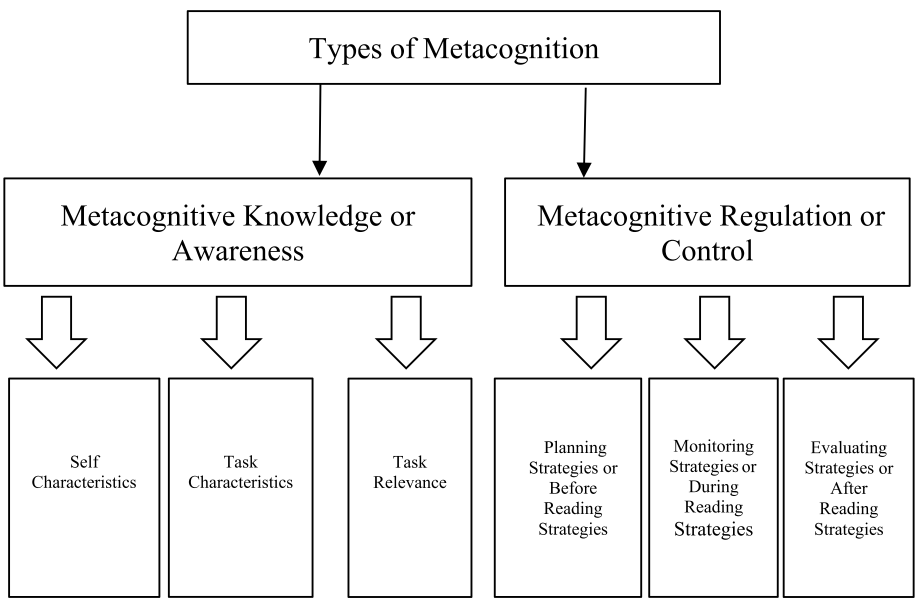

Figure 1.
Metacognitive types based upon [1–4, 27].

ability to understand the situation, which strategy would be best, why they should use this strategy, and how to apply the particular strategy to make sense of the text [3, 32].

Other scholars have divided metacognitive knowledge differently, indicating that knowledge contains three elements: self-characteristics, task characteristics, and task-relevant strategies [3, 27, 29, 31]. Self-characteristics include the ability to read and the skills required to reach the goal of learning. Task characteristics are related to reading levels and the material's difficulty, and they also involve the reader's familiarity with the reading tasks. Finally, task-relevant strategies refer to the metacognitive strategies that readers must use to comprehend the text [29].

4. Metacognitive regulation

This section explores the second component of metacognition, known as metacognitive control or regulation, which includes three types of metacognitive strategies used in the context of reading comprehension (see **Figure 1**). The field of reading comprehension received much attention from researchers and scholars 40 years ago [12]. More recent research has investigated how metacognitive regulation strategies facilitate reading comprehension, particularly for DHH students. These strategies are comprised of three categories: planning or before reading; monitoring or during reading, and evaluating or after reading strategies (see **Figure 1**) [4, 5].

4.1 Metacognitive planning strategies

Metacognitive planning strategies are those that occur before reading (Israel [1]. Largely, these strategies help readers to use their prior knowledge to think about their reading. As indicated earlier, prior knowledge consists of three elements [24], the readers' vocabulary knowledge, their knowledge of the text, and their knowledge about the text's structure and grammar; this may include morphological knowledge as well [4]. Activating students' prior knowledge by thinking about vocabulary, particularly understanding the meaning of unfamiliar words, can help readers think about the way that the vocabulary influences the text's meaning. Albalhareth et al. [4] explained that linguistics and vocabulary knowledge are the most critical components of reading comprehension [33].

In addition, before reading, readers may think about the text and enhance their understanding of it by connecting their previous knowledge to the text. During classroom discussions before reading, teachers may ask their students to think together about the reading's subject as well, so that they can share their thinking with other students, which could help students rethink the text by activating their prior knowledge (see [4, 34]).

Albalhareth et al. [4] argued that developing DHH individuals' knowledge and skills in both sign language and English is critical. It is important to cultivate their vocabulary and enhance their grammar knowledge by developing their syntax and semantic knowledge in both English and ASL (see [4]) or Arabic and Saudi Sign language (see [5]).

There are other metacognitive strategies that can fall under more than one category, such as prediction and think-together strategies, which are known also as metacognitive monitoring strategies or during-reading strategies.

4.2 Metacognitive monitoring strategies

These are known also as during-reading strategies [1]. Van Kraayenoord [35] used the terms metacognitive monitoring and metacomprehension interchangeably. These strategies are used to evaluate the passage in relation to the readers' linguistics and prior knowledge about the text. Albalhareth and Alasmari [5] argued that monitoring strategies are the most common metacognitive strategies in reading instruction, particularly for DHH readers. Previous work (e.g., [1, 2, 4]) discussed several metacognitive monitoring strategies, such as peer tutoring or class-wide peer tutoring (CWPT), which encourage students to exchange thoughts with each other to foster their reading comprehension both in the general and special education classroom settings [36]. Peer tutoring, which can be used in one-on-one learning and employed in special instruction, helps students to exchange ideas to practice thinking and repeating ideas together ([4]; c.f., [37]). The terms peer tutoring and CWPT have been used interchangeably [38] and include three monitoring strategies: predicting, self-questioning, and summarizing the passage (c.f., [39–42]). Readers can benefit from working one-on-one or in small group settings, where they are able to monitor their own learning process [38, 43]. Albalhareth et al. [4] found several actions that occur while reading and working with peers, including thinking together, and exchanging thoughts reciprocally, so they can monitor their understanding of the text [44, 45]. Other examples of monitoring strategies are encouraging readers to predict words' meaning by thinking about the definition within the context of the individual sentence's meaning or within the overall context of the passage [1, 4, 5].

Look-back strategies are the most common strategies used by DHH students during reading [18]. One such strategy includes readers re-reading the previous sentences when they encounter difficulties understanding a word or the ideas in a certain sentence. Readers also may read the entire paragraph and think about its meaning by breaking down the ideas from individual sentences to determine the overall meaning ([4]; c.f., [1, 2, 24, 26, 46]). Another look-back tactic readers may implement is to keep reading and try to comprehend the meaning later, or they may underline the words that they do not know and return to them later, determining their meaning based on the text's overall meaning. When text includes pictures reflecting ideas from the reading, readers, particularly children, can use the pictures to help them understand the text (e.g., [1, 4, 24, 26]).

In addition to thinking about the meaning based on pictures and/or context clues, looking at the text's heading or the title may help the readers clarify the passage's meaning [4]. Further, pausing their reading to look up a word's meaning in a dictionary can also help them comprehend it (see [4, 5]).

The "read in English and translate into ASL" approach is another common metacognitive strategy used by DHH learners. As reported by Albalhareth et al., DHH readers can read the text in English and then they try to make sense of the reading text in their first language, ASL. There are several monitoring strategies that can be used before reading, such as prediction. Further, thinking together can be used before reading, and summarization can be used after reading, while graphic organizers can be developed to convey the text's meaning (see [4]).

4.3 Metacognitive evaluation strategies

This category is also referred to as after-reading strategies [1]. Because they require strong cognitive skills (e.g., evaluating, revising, and critiquing the text), metacognitive evaluation strategies are considered the most challenging and the least used, likely because poor readers are unable to employ them. There are other variables that can be related to these types of strategies' use, such as the text's difficulty and the readers' prior knowledge. For instance, readers must be able to evaluate and critique the reading passage and identify the text's difficulties and appropriateness by determining whether it is appropriate for the target readers. Further, they must evaluate the text's structure and grammar. More proficient readers and individuals with strong cognitive skills can use these strategies, while younger or weaker readers are rarely able to use them [1, 4, 27, 47].

Schirmer [24] explained three metacognitive evaluation strategies that strong DHH readers can use: (1) expressing skepticism; (2) evaluating the author's writing style; and (3) judging whether the reading passage was interesting and enjoyable to read. However, as claimed previously, these strategies are not used often. Accordingly, more investigations of metacognitive strategies are needed, particularly to explain DHH readers' use of after-reading or evaluation strategies. The following sections discuss metacognitive assessments.

5. Metacognitive assessment

Metacognitive assessment, defined as an individual's process of cognitive evaluation, is one of the most important strategies to discuss [48, 49]. In relation to reading, metacognitive assessment can be defined as the thinking process that readers use to assess a text and how they apply their metacognitive and self-regulation knowledge (c.f., [4, 50]). There is theoretical evidence of metacognition's application in reading comprehension, which is critical to understand students' ability behaviors related to reading practices. Metacognitive assessment outcomes allow practitioners to determine the effectiveness of instruction, intervention, and methods to meet their students' needs. It also develops practitioners' and teachers' awareness and knowledge of teaching metacognitive strategies [49]. Assessing readers' metacognition helps teachers to choose the most suitable instructions, activities, and materials before, during, and after reading that will help students to learn the metacognitive strategies that are critical in developing reading comprehension abilities [1, 4].

5.1 Reading comprehension in relation to metacognitive assessment

Comprehension integrates several skills that are difficult to assess. Similar to mental processes, in which reading comprehension occurs within the reader's brain, metacognition also can be assessed only indirectly. As indicated previously, reading comprehension and metacognitive assessments help to provide in-depth knowledge about readers' metacognitive strategies (e.g., [1, 4, 51]).

5.1.1 The use of cloze and related procedures

This assessment can assess both comprehension performance and metacognitive knowledge. The test does not evaluate the types of metacognitive strategies that readers use, but it helps to develop students' skills by using tactics such as prediction and look-back strategies [31]. LaSasso and Davey [34] used the cloze test to assess DHH readers using multiple-choice and free-response questions. The readers were assigned to one of two conditions to answer these types of questions, in which they were allowed to use lookback or no lookback. When the readers in the look-back group were allowed to go back and review the information, it helped them to answer the questions; however, those who were not able to use the look-back technique were unable to confirm the correct information. The authors used a look-back strategy to fill in the blanks in sentences and to answer multiple-choice questions. They found that the participants relied mainly on the "visual matching" strategy to answer these questions by matching the words in the question to predict the correct answer. This is referred to as the guessing strategy, which is a random method to answer questions. Further, readers could use the entire meaning or the context clues to fill in the blank, which is an effective metacognitive strategy (see [4]).

There are other assessments similar to the cloze test. For instance, the What's the Problem? test requires readers to fill in the missing information in certain words after they read the texts aloud. Block [31] stated that in the What's the Problem? test, readers need to fill in missing words rather than letters. The researcher can assess readers' visual imagery, context clues use, and prediction skills by using words with missing letters [31]. However, prediction strategies may not allow readers to fill in the missing words or letters correctly. Carroll [52] also claimed that the cloze test is used to assess readers' vocabulary and linguistics knowledge, although it gives more information about readers' syntax than their semantics knowledge. Albalhareth et al. [4] emphasized that for readers with insufficient vocabulary and linguistics knowledge, using metacognitive strategies, such as context clues strategies or prediction strategies can be effective if readers are provided with sufficient prior knowledge about the context and vocabulary in the texts, which would apply to the What's the Problem? test as well.

5.2 Metacognitive assessments instruction

There are three ways to identify metacognitive strategies [1, 4, 49]: interviews, surveys and inventories, and think-aloud assessments. These three types of assessments are valid ways to assess readers' metacognitive strategies including those with special needs, such as DHH readers (e.g., [1, 4, 53, 54]. These three assessments can be used together with other activities before, during, and after reading and can be combined to collect information on metacognitive strategies; for instance, readers can be interviewed and asked to think-aloud, or they can complete a survey during the interview, and the interviewer can clarify the questions and help them to complete the survey [1, 4].

5.2.1 Interviews

Interviews are the most common assessment used to evaluate readers' metacognitive strategies, and it is appropriate for all readers with or without disabilities; it is also suitable to use with children of all ages or adults [1]. The most important consideration is using appropriate language during the interview. When interviewing DHH children, it is important that the readers use fluent language, such as sign language. Interviews can be used before reading by asking readers about the strategies they can use; for instance, the readers can be informed about the topic and asked whether they can use specific planning strategies, such as activating prior knowledge. This is beneficial for teachers, as they may provide their students with the necessary knowledge about the text to enhance their prior knowledge. Interviews can be used during reading and after reading as well to assess readers' monitoring and evaluating strategies (see [4, 47]). Compared to other assessments, interviews are useful for two major reasons (see [1]). First, using open-ended questions to assess readers' metacognitive strategies allows researchers and practitioners to identify the metacognitive strategies that readers use and obtain more details about them. Second, it helps researchers and practitioners to identify the most effective strategies that are used depending upon the readers' age and types of texts, such as narrative or explanatory [4].

Both formal and informal interviews are useful, as they help to obtain details about readers' metacognitive strategies. Interviewers may develop open-ended questions appropriate for the participant's age and language skills; further, they may ask follow-up questions to clarify the readers' responses and obtain more knowledge during the interview that could be helpful, such as readers' behavior [4, 16, 49].

5.2.2 Surveys or questionnaires

Surveys, questionnaires, and inventory data collection tools are the most useful methods to learn about behaviors and metacognitive reading strategies readers use before, during, and after reading [1, 4]. Surveys can help researchers and practitioners collect more information in less time, and because the survey can be developed with multiple-choice questions, readers do not have to spend as much time responding compared to open-ended questions. Additionally, they can be used with one reader, smaller groups, or large populations [48]. Checklists or multiple-choice questions be used with individuals with or without disabilities. However, it is critical to develop suitable questions that are clear for the target participants. Thus, practitioners may need to develop visual cues to help readers comprehend the questions and their purpose easily. With DHH readers, pictures may be used to clarify questions for them. Moreover, surveys can help researchers collect more information if they are combined or used together with other assessment methods, such as interviews [53]. Researchers are able to clarify questions for DHH readers using sign language. Most importantly, the readers need to understand the interview's purpose and be given the directions necessary to complete the assessment, particularly for DHH children, so that they can provide accurate responses.

5.2.3 Think-aloud

The think-aloud assessment was developed as a tool to collect information about cognitive processes and abilities, such as metacognition. Interviews and think-aloud are the most common tools used to assess metacognition's dimensions [1, 55, 56]. A verbal report is a think-aloud tool that can be conducted with individuals with special needs (e.g., DHH) and individuals without disabilities (e.g., [4]). The verbal report can collect information about metacognitive strategies and provide researchers with more information about how and why readers use these strategies [31]. The think-aloud tool also provides information that identifies readers' strategies and the reason they choose them [24].

The think-aloud or verbal protocol is among the most appropriate tools with which to collect data on cognitive processes [57]. During reading, the participants think-aloud about the monitoring strategies that they are using and usually write their responses [58]. Verbal reports can be used to identify before, during, or after reading strategies, or any other strategies that are important for DHH readers' comprehension [2, 24, 26].

6. Conclusion

Although metacognition was first discussed 40 years ago, it remains one of the cognitive terms that is difficult to define and assess. This chapter provides the definition of metacognition and other terms related to reading comprehension. Metacognitive strategies are critical for reading comprehension, and planning strategies, which are also defined as before reading strategies, are the most critical. It is reported that sign language knowledge (e.g., ASL) is important for DHH prior knowledge. This chapter indicated that without sufficient prior knowledge, readers may struggle to understand a reading passage. Therefore, it is important for teachers to increase their DHH students' knowledge about the passage before they read it; further, teachers may need to ensure that readers have sufficient vocabulary knowledge.

This chapter reported that among other types of strategies, monitoring, or during-reading strategies are used most. On the other hand, evaluating strategies are used the least, particularly with poor and average readers, because they require strong reading skills. Therefore, future research should investigate this issue further. There are some strategies that can be used before reading, such as the prediction strategy; also, there are other mentoring strategies that can be used after reading, such as the summarization strategy.

Young DHH readers have different challenges when accessing ideas that are important for their prior knowledge. DHH who were born to hearing parents go through different experiences of acquiring knowledge than those who were born to deaf parents. DHH who were born to deaf parents and have early access to sign language may use different metacognitive strategies than those who were born to hearing parents who may use different modes of communication. Future research may be able to explore this idea further.

Identifying metacognitive strategies is necessary for designing appropriate reading comprehension instructions; this chapter also explained that metacognitive assessments are important and can be conducted with three tools, interviews, surveys, and think-aloud. Interviews are used most often with other types of assessments and can be used for all ages and for individuals with or without disabilities.

There are other types of assessments of metacognitive knowledge and metacognitive strategies (see [31, 59–61]; c.f., [4, 62, 63]). This chapter called for more investigations about metacognitive assessments to detect metacognitive strategies used by DHH learners before, during, and after reading.

Additional information

ORCID ID 0000-0002-8313-6864.

Author details

Ali Hamad Albalhareth
Department of Special Education, Najran University, Najran, Saudi Arabia

*Address all correspondence to: ahsbalhareth@nu.edu.sa; albalhareth.1@osu.edu

IntechOpen

© 2023 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

References

[1] Israel SE. Using Metacognitive Assessments to Create Individualized Reading Instruction. Newark, DE: International Reading Association; 2007

[2] Pressley M, Afflerbach P. Verbal Protocols of Reading: The Nature of Constructively Responsive Reading. Hillsdale, NJ: Lawrence Erlbaum Associates; 1995

[3] Schmitt MC. Measuring students' awareness and control of strategic processes. In: Israel SE, Bauserman KL, Kinnucan-Welsch K, Block CC, editors. Metacognition in Literacy Learning: Theory, Assessment, Instruction, and Professional Development. Mahwah, New Jersey: Lawrence Erlbaum Associates; 2005. pp. 123-142

[4] Albalhareth A, Paul PV, Alasmari A. Teachers' perceptions of metacognitive strategies and assessments used with d/deaf and hard of hearing students. Human Research in Rehabilitation. 2022;**12**(1):5-21

[5] Albalhareth A, Alasmari A. Metacognitive strategies implemented with d/Dhh students in upper elementary schools in Saudi Arabia. Thinking Skills and Creativity. 2023;**47**:101222

[6] Flavel JH. Metacognitive aspects of problem solving. In: Resnick LB, editor. The Nature of Intelligence. Lawrence Erlbaum Associates; 1976. pp. 231-235

[7] Flavel JH, Friedrichs AG, Hoyt JD. Developmental changes in memorization processes. Cognitive Psychology. 1970;**1**(4):324-340

[8] Flavel JH, Wellman HM. Metamemory. In: Kail R, Hagen J, editors. Perspectives on the Development of Memory and Cognition. Hillsdale, NJ: Lawrence Erlbaum Associates; 1977

[9] Flavel JH. Metacognition and cognitive monitoring: A new area of cognitive- developmental inquiry. American Psychologist. 1979;**34**(10):906-911

[10] Fleming SM, Lau HC. How to measure metacognition. Frontiers in Human Neuroscience. 2014;**8**:443

[11] Myers M, Paris SG. Children's metacognitive knowledge about reading. Journal of Educational Psychology. 1978;**70**(5):680-690

[12] Pearson PD, Cervetti GN. The roots of reading comprehension instruction. In: Israel SE, editor. Handbook of Research on Reading Comprehension. 2nd ed. New York, NY: Guilford Press; 2017. pp. 12-56

[13] Wellman HM. Knowledge of the interaction of memory variables: A developmental study of metamemory. Developmental Psychology. 1978;**14**(1):24

[14] Baker L, Carter Beall L. Metacognitive processes and reading comprehension. In: Israel SE, Duffy GG, editors. Handbook of Research on Reading Comprehension. New York: Routledge; 2009. pp. 373-388

[15] Hacker DJ, Dunloskey J, Graesser AC, editors. Metacognition in Educational Theory and Practice. Mahwah, NJ: Lawrence Erlbaum Associates; 1998

[16] Israel SE, Block CC, Kinnucan-Welsch K, Bauserman K. Metacognition in Literacy Learning: Theory, Assessment, Instruction, and

Professional Development. Mahwah, New Jersey: Lawrence Erlbaum Associates, Inc.; 2005

[17] Siegler RS. The other Alfred Binet. Developmental Psychology. 1992;**28**:179-190

[18] McAnally PL, Rose S, Quigle SP. Reading Practices with Deaf Learners. USA: Pro-Ed; 2007

[19] Rousseau DM. Schema, promise and mutuality: The building blocks of the psychological contract. Journal of Occupational and Organizational Psychology. 2001;**74**(4):511-541

[20] Piaget J. The Language and Thought of the Child (M. Gabain, Trans.). London: Routledge & Kegan Paul; 1926

[21] Morrison C, Marschark M, Sarchet T, Convertino CM, Borgna G, Dirmyer R. Deaf students' metacognitive awareness during language comprehension. European Journal of Special Needs Education. 2013;**28**(1):78-90

[22] Alasmari A, Albalhareth A. Specific challenges in the development of English literacy for deaf and hard-of-hearing students. International Journal of Literacies. 2022;**29**(2):13-26

[23] Vygotsky LS. Mind in Society. Cambridge, MA: Harvard University Press; 1978

[24] Schirmer BR. Using verbal protocols to identify the reading strategies of students who are deaf. Journal of Deaf Studies & Deaf Education. 2003;**8**(2):157-170

[25] Strong M, Prinz P. Is American sign language skill related to English literacy. Language Acquisition by Eye. 2000;**2000**:131-141

[26] Schirmer BR, Bailey J, Lockman AS. What verbal protocols reveal about the reading strategies of deaf students: A replication study. American Annals of the Deaf. 2004;**149**(1):5-16

[27] Baker L, Brown A. Metacognitive skills and reading. In: Pearson PD, Barr R, Kamil ML, Mosenthal P, editors. Handbook of Reading Research. New York: Longman; 1984. pp. 353-394

[28] Meichenbaum D. Teaching thinking: A cognitive-behavioral perspective. In: Thinking and Learning Skills. Routledge; 2013. pp. 407-426

[29] McCormick CB. Metacognition and learning. In: Reynolds WM, Miller GE, editors. Handbook of Psychology: Educational Psychology. New Jersey: John Wiley & Sons; 2003. pp. 79-102

[30] Paris SG, Lipson MY, Wixson K. Becoming a strategic reader. Contemporary Educational Psychology. 1983;**8**(3):293-316

[31] Block CC. What are metacognitive assessments? In: Israel SE, Block CC, Bauserman KL, Kinnucan-Welsch K, editors. Metacognition in Literacy Learning: Theory, Assessment, Instruction, and Professional Development. Mahwah, New Jersey: Lawrence Erlbaum Associates, Inc.; 2005. pp. 83-100

[32] Pressley M, Harris KR. Cognitive strategies instruction: From basic research to classroom instruction. In: Alexander PA, Winne PH, editors. Handbook of Educational Psychology. Mahwah, NJ: Lawrence Erlbaum Associates; 2006. pp. 265-286

[33] National Reading Panel. Report of the National Reading Panel: Teaching Children to Read – An Evidence-Based Assessment of the Scientific

Research Literature on Reading and its Implications for Reading Instruction. National Institute for Literacy at EDPubs. Rockville, MD: National Institute of Child Health and Human Development; 2000

[34] LaSasso C, Davey B. The relationship between lexical knowledge and reading comprehension for prelingually, profoundly hearing-impaired students. Volta Review. 1987;**89**(4):211-220

[35] Van Kraayenoord CE. The role of metacognition in reading comprehension. Focal Points of the Research and Development of Pedagogically-psychological Perspectives. 2010;**2010**:277-302

[36] Mahdavi JN, Tensfeldt L. Untangling reading comprehension strategy instruction: Assisting struggling readers in the primary grades. Preventing School Failure: Alternative Education for Children and Youth. 2013;**57**(2):77-92

[37] Utley CA, Mortweet Van Scoyoc S, Greenwood CR. Peer-mediated instruction and interventions. Focus on Exceptional Children. 1997;**29**(5):1-24

[38] Alzahrani T, Leko M. The effects of peer tutoring on the reading comprehension performance of secondary students with disabilities: A systematic review. Reading & Writing Quarterly. 2017;**34**(1):1-17

[39] Fuchs D, Fuchs LS. Peer-assisted learning strategies: Promoting word recognition, fluency, and reading comprehension in young children. The Journal of Special Education. 2005;**39**(1):34-44

[40] Fuchs D, Fuchs LS. Increasing strategic reading comprehension with peer-assisted learning activities. In: McNamara DS, editor. Reading Comprehension Strategies: Theories, Interventions, and Technologies. New York: Lawrence Erlbaum Associates; 2007. pp. 175-197

[41] Maheady L, Mallette B, Harper GF. Four classwide peer tutoring models: Similarities, differences, and implications for research and practice. Reading & Writing Quarterly. 2006;**22**(1):65-89

[42] Palincsar A, Brown AL. Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. Cognition and Instruction. 1984;**1**(2):117-175

[43] Mastropieri MA, Scruggs TE, Graetz JE. Reading comprehension instruction for secondary students: Challenges for struggling students and teachers. Learning Disability Quarterly. 2003;**26**(2):103-116

[44] Greenwood CR, Delquadri JC, Hall RV. Longitudinal effects of classwide peer tutoring. Journal of Educational Psychology. 1989;**81**(3):371-383

[45] Greenwood CR. Longitudinal analysis of time, engagement, and achievement in at-risk versus non-risk students. Exceptional Children. 1991;**57**(6):521-532

[46] Snow CE, Burns MS, Griffin P, editors. Preventing Reading Difficulties in Young Children. Washington, DC: National Academy Press; 1998

[47] Silvestri JA, Wang Y. A grounded theory of effective reading by profoundly deaf adults. American Annals of the Deaf. 2018;**162**(5):419-444

[48] Harris TL, Hodges RE. The Literacy Dictionary: The Vocabulary of Reading and Writing. Newark, DE: International Reading Association; 1995

[49] Paris SG, Flukes J. Assessing children's metacognition about strategic reading. In: Israel SE, Block CC, Bauserman KL, Kinnucan-Welsh K, editors. Metacognition Literacy Learning: Theory, Assessment, Instruction, and Professional Development. Mahwah, NJ: Lawrence Erlbaum Associates; 2005. pp. 121-139

[50] Zimmerman BJ. Self-regulated learning and academic achievement: An overview. Educational Psychologist. 1990;**25**(1):3-17

[51] Block CC, Israel SE. The ABCs of performing highly effective think-alouds. The Reading Teacher. 2004;**58**(2):154-167

[52] Carroll JB. Defining language comprehension: Some speculation. In: Carroll JB, Freedle RO, editors. Language Comprehension and the Acquisition of Knowledge. Washington DC: V.H. Winston and Sons; 1972

[53] Strassman BK. Deaf adolescents' metacognitive knowledge about school-related reading. American Annals of the Deaf. 1992;**137**(4):326-330

[54] Banner A, Wang Y. An analysis of the reading strategies used by adult and student deaf readers. Journal of Deaf Studies and Deaf Education. 2011;**16**(1):2-23

[55] Ericsson KA, Simon H. Protocol analysis: Verbal reports as data. Cambridge, MA: MIT Press; 1984

[56] Ericsson KA, Simon H. Protocol analysis: Verbal reports as data. Cambridge, MA: MIT Press; 1993

[57] Krahmer E, Ummelen N. Thinking about thinking aloud: A comparison of two verbal protocols for usability testing. IEEE Transactions on Professional Communication. 2004;**47**(2):105-117

[58] Krockow EM, Colman AM, Pulford BD. Exploring cooperation and competition in the centipede game through verbal protocol analysis. European Journal of Social Psychology. 2016;**46**(6):746-761

[59] Perfetti CA, Lesco R. Sentences, individual differences, and multiple texts: Three issues in text comprehension. Discourse Processes. 1979;**23**(3):337-355

[60] Stanovich KE. The Matthew effects in reading: Some consequences for individual differences in the acquisition of literacy. Reading Research Quarterly. 1986;**21**(4):360-407

[61] Tergeson JK, Wagner J. What it means to learn to read. Child Development. 1987;**56**(5):1134-1144

[62] Oakhill J, Yuill N. Higher order factors in comprehension disability: Processes and remediation. In: Cornoldi L, Oakhill J, editors. Models of Effective Educational Assessment. Mahwah, New Jersey: Lawrence Erlbaum Associates, Inc.; 1999. pp. 111-135

[63] LaSasso C. The effect of WH question format versus incomplete statement format on deaf students' demonstration of comprehension of text-explicit information. American Annals of the Deaf. Washington, D.C: Gallaudet University Press; 1979;**124**(7):833-837

Section 5

Metacognition and Cognition in Science

Chapter 16

Enhance Learning among Natural Science Learners in a South African Rural District Using Case-Based Learning

Nomxolisi Mtsi, Shakespear M. Chiphambo and Nomaroma Kumanda

Abstract

Case-based learning has become a teaching method that is commonly used by science teachers. The objective of the study is to explore how teachers implement case study as the teaching method that promotes critical thinking in science learning. The study was informed by Vygotsky's social constructivism and Shulman's pedagogical content knowledge. Both theories constructively align with the study since they emphasise that knowledge is produced through active engagement and the subject matter needs to be driven by using the relevant pedagogy. A mixed-method approach was employed in the study. Thirty out of sixty-seven schools were purposefully sampled to respond to the questionnaire and 10 out of 30 (one teacher from each of the schools) volunteered to participate in the semi-structured interviews. Data were analysed using both qualitative and quantitative approaches. Themes were used to analyse qualitative data, and descriptive statistics were used to analyse quantitative data. The findings revealed that most teachers use a case-based learning approach. However, some teachers indicated that the method consumes relatively more time and requires specific skills on the part of the teacher. Therefore, the study recommends that teachers need to collaborate with other science teachers as well as their science cluster leaders for information sharing.

Keywords: case-based learning, case study, teaching method, science learning, natural science

1. Introduction

Case-based learning (CBL) is one of the teaching methods that assists teachers when implementing the curriculum in class. Hence, teachers need to be aware of the approaches to be used in learning and teaching. Case-based learning is an approach that encourages students to apply deep learning so that they can solve the scenarios given in science lessons. Literature defines a case study as an approach that permits active interaction to solve real-life challenges [1, 2]. Case-based learning is also called case study instructional strategy, and it is a method that encourages interactive learning in the classroom. Literature acknowledges that case study encourages students to learn more and apply the learned content knowledge in different situations, and critical thinking becomes significantly enhanced [3, 4]. Moreover, literature notes that teachers should design authentic learning activities that will assist aspiring prospective educators to be ready to use their knowledge and abilities in the 21st-century classrooms [5]. The present researchers believe that once students acquire the skills of solving problems, they can also apply them in the field of work and in their communities.

When implementing a curriculum, it is wise to select the relevant approaches that will allow students to use their critical thinking. As experienced teachers, we believe that the curriculum needs to be responsive to the needs of the students and society. Winn et al. [6], avers the use of cognitive learning techniques to enhance students' ability to have a deeper understanding of the content and be able to transfer it to different context. Thus, Lovat [7] highlights the viewpoint that curriculum is concerned with knowledge, how we know and how we can prove that we know. Therefore, it is significant to engage the students and give tasks that require them to demonstrate their understanding. For example, when training student teachers, the content knowledge learned should be demonstrated during the school-based experience (SBE). SBE is work-integrated learning (WIL). Du Plessis [8] defines WIL as an approach that advocates the formal integration of structured real-life experiences. Keller [1] and Sunbul [2] share the same understanding that case study permits active interaction thus facilitating the search for solutions to problems encountered in real-life situations.

2. Literature review

2.1 The significance of case-based learning as a teaching methodology

Case-based learning is highly recognised because of the positive impact it has on learning and teaching, and it promotes interactive learning [1]. It is a method that focuses on solving problems in the classroom and in real-life situations [1, 2]. Literature highlights that case study is the method that allows interdisciplinary learning and deals with solving societal issues [9, 10]. The method encourages creativity and prepares a well-rounded student who can also make decisions in the future. Furthermore, it enhances presentation skills when giving feedback to the audience; hence, students need to work very hard to provide constructive feedback. Teachers also need to quickly give positive feedback about the tasks to motivate students to work harder.

2.2 Case-based learning promotes deep learning

Case-based learning promotes deep learning unlike surface learning since students can take control of their learning and gain new knowledge in the process. Deep learning is described as the understanding of content knowledge by students [11, 12]. Brookhart [13] explains that when students acquire knowledge, they need to apply it in and outside the school. Consequently, Shulman [14] proposes that teachers need to be well-equipped in content knowledge and to deliver it using the relevant pedagogies. Literature indicates that when using a case study, higher-order thinking develops, and students are able to operate at higher levels of Bloom's taxonomy of cognitive learning [10, 15]. Moreover, the same authors state that Bloom's taxonomy [16] came with a framework that emphasises the following aspects: recalling knowledge, analysing and evaluating, rather than just teaching students to remember facts (rote learning). To us, it means the scenarios given in class need to promote higher levels on Bloom's taxonomy of cognitive learning.

Bloom [16] states that learning is divided into three domains: (a) cognitive: mental skills (knowledge), (b) affective: growth in feelings or emotional areas (attitude or self) and (c) psychomotor: manual or physical skills (skills). The three domains are very important, and teachers need to apply them in the lesson. One of the three domains, the affective domain, encourages teachers to use relevant instructional methodologies that would allow educational activities, for instance, paying attention when the teacher starts the lesson as well as during the lesson. In the affective domain, five characteristics are very important [5], and they relate to each other for a lesson to be successful. Receiving, responding, valuing, organisation and classification by value or value complex are among these traits. The domain urged teachers to implement effective instructional techniques that would enable learning activities, addressing the following: Paying attention both when the teacher begins the lesson and when it is being taught.

If students receive the newly learned knowledge positively [6], then the learning and teaching becomes effective. When learners receive the lesson enthusiastically, they will respond constructively by participating in the lesson actively either working as individuals or working as groups. Hence, it is important for teachers to constructively align the learning outcomes with the assessment criteria, moreover, to use the relevant method that will encourage the students to be actively engaged. Participating in the lesson means the value of the lesson is treasured by learners, and they demonstrate their appreciation by asking questions, discussing, and seeking clarity when necessary.

2.3 Case-based learning enhances problem-solving skills

Problem-solving is referred to as a problem-based learning strategy (PBLS; [17]). There is a connection between case-based learning and problem-based learning. When students are conducting case study tasks, they need to apply problem-solving skills of which they need to critically engage in research on the topic and give positive feedback. Five stages need to be performed when solving a problem, and these are investigating, developing, presenting work, analysing and evaluating the problem-solving process [17]. The stages will assist the teachers to guide the students before they can follow.

2.4 Challenges and benefits of case-based learning

The literature recognises that case study is one of the top methods that can be used in the classroom as it prepares students in applying higher-order thinking [1]. Sunbul [2] and Cakmak [18] state that when the case study is used correctly, teamwork is promoted, communication becomes significantly enhanced and students are able to find real solutions to problems. Moreover, the author also highlights that the scenarios given to students can be examined by all students in class or as groups before teachers can do their evaluation. Bilen [19], Nas [20] and Gozutok [21] state that critical thinking becomes more advanced when students are involved in case discussions.

Preparing case studies takes a long time and can be difficult to conduct in overcrowded classrooms [2, 22, 23]. Therefore, teachers need to be mentored and guided in using the case-study method. Moreover, the above authors also mentioned that good preparation before the application is needed to avoid disappointments when conducting the session [2, 22, 23]. Thus, teachers need to get enough learner materials and training from the school management committee and the department officials. Current studies claim that support is the key to implementing curriculum effectively [24]. Furthermore, Phasha, et al. [25] highlights that the quality of education can be upgraded only if challenges encountered by teachers are positively addressed and all the stakeholders play an instrumental role in supporting the teachers.

2.5 Problem statement

The study was triggered by challenges faced by teachers in the science field. Some of the teachers confirmed that science is not an easy subject, they struggle immensely when implementing the curriculum in class. They follow CAPS documents, which they struggle to analyse. In addition, they complained about being allocated a subject to teach without having a background in science or due to a shortage of teachers in that field. The study was conducted in one rural education district in South Africa's Eastern Cape Province. Findings revealed that educators in South Africa encounter challenges in terms of science resources, content knowledge and infrastructure [26]. The three aspects mentioned above are the focus areas that need to be prioritised before implementing the science curriculum. Thus, it is the researchers' responsibility to go deep and find out if teachers use the case-based learning method to enhance science learning.

2.6 Theoretical and conceptual background

The study is underpinned by two theories, Vygotsky's [27] (1896–1934) social constructivism and Shulman's [14] pedagogical content knowledge. The two theories align with the study as they emphasise that the students need to be engaged and guided by a knowledgeable person to reach the academic level that is expected. The second theory posits that the knowledgeable person needs to master the content first before involving the student and using the relevant approach to drive the lesson. Since the two theories complement each other, the implication is that, before teachers make use of the case study approach, they should be familiar and knowledgeable with the content, understand the type of student and their environment before they can assign tasks. This implies that teachers must understand individual learners' needs so that they can prepare relevant tasks for them.

2.7 Research objective

The paper sought to explore teachers' acknowledgement of the case study as a teaching method that promotes critical thinking in science learning.

2.8 Research question

How do teachers use case-based learning as a teaching method that promotes natural science learning?

2.9 Research and methodology

A mixed-method approach was employed in the study. The data were analysed using both qualitative and quantitative approaches. Descriptive statistics were used for quantitative data and themes were used to analyse qualitative data. To examine case-based learning used by teachers when teaching Natural Sciences (NS), this study employed a descriptive and survey design. A questionnaire was used to collect data. The study used purposeful sampling to select schools based on proximity to the researchers. Thirty out of sixty-seven schools are in six out of the eight circuits in the selected education district. The population was made up of 15 female and 15 male teachers.

2.10 Ethical considerations

Ethical considerations such as informed consent, voluntary participation and withdrawal, confidentiality and for anonymity codes like Teacher 1 (T1), Teacher 2 (T2)...up to Teacher 9 (T9). The researchers also guaranteed that no participant would be put exposed or subjected to risk or harm as a result of their participation in the study.

3. Results

Educators identified 44 responses on the strengths of the case study method. The responses are presented in descending order: simplifying otherwise complex activities/scenarios (13, 30%), promoting research skills/integrating and synthesising basic knowledge in real-life cases (10, 23%), exposing learners to real-life scenarios (9, 21%), fostering critical thinking and enhancing communication (7, 16%) and allowing discussions and cooperative learning (5, 11%).

The shortcomings of the case study method amassed 27 responses with the most commonly identified weakness being that the method was relatively more time-consuming compared to other teaching strategies (15, 56%). The second common disadvantage identified was that case studies were difficult to utilise if learners were disinterested (8, 30%). The less common disadvantages were stated as promoting little in-depth learning and requiring specific skills on the part of the teacher (3, 11%) and learners (1, 4%) respectively.

3.1 Discussion

3.1.1 Strengths

Case study as a strategy that simplifies otherwise complex activities and scenarios was among the strengths identified by educators. Cakmak et al. [18] caution that the language used should not be too complicated to allow students to understand the scenario and be able to unpack it. Exposing learners to real-life scenarios is very important, Keller [1] explains that a case study is the best method to use in the classroom as it prepares students for post-secondary achievement. Sunbul [2] indicates that the case study method assists students to find operative solutions to problems that they encounter in similar real-life situations in a shorter time. Benefits identified by educators were promoting critical and analytical thinking, improving communication, contributing positively to the development of critical thinking, problem-solving and decision-making skills. Previous studies [19–21] report that critical thinking is developed when students are engaged in case discussions. Moreover, for discussions and cooperative learning, students could learn through engaging in discussions, therefore, they enjoy the method [22]. Teamwork is significantly important and cooperative learning is the key for this method as students work in groups to find solutions.

Promotion of research skills, as well as integration and synthesis of basic knowledge in real-life cases, are other strengths mentioned by respondents. Respondents also mentioned that research skills are sharpened when using case-based learning. Hence, it is important for teachers to guide the student during the process.

3.1.2 Weaknesses

Weaknesses mentioned by respondents included the consumption of relatively more time compared to other methods. Literature highlights that case studies consume large stretches of time and can be difficult to implement in congested classrooms [2, 22, 23]. Another weakness mentioned was that little in-depth learning was achieved and that specific skills on the part of the educator might be needed. Other studies have also demonstrated that case studies require educators to make good preparations before application [2, 22, 23]. Regarding the difficulty to implement the case study method if learners are disinterested due to the need for deep and critical thinking to solve the problem, several researchers have faced similar challenges. For example, Sunbul [2] reports that due to different challenges, it is often hard to implement the method.

Themes were drawn from the participants' responses on exploring case-based learning as a teaching method that enhances natural science learning. Themes were organised to connect with research questions to cater to NS teachers. The themes are as follows:

- Higher-order thinking
- Group work
- Support

3.1.3 Qualitative findings

Teachers agreed that there are methods that promote higher-order thinking concerning the case study. Their verbatim quotes are as follows:

> *The case study involves investigations, and they promote higher-order thinking. An example, when giving learners a question, it needs a conclusion at the end. So the learner will critically think about what happened up to the last stage. It is not easy, sometimes since it requires specific skills on the part of the teacher, I still need support (T1) (T2).*

> *Case study promotes higher thinking, e.g., When I give them questions like "What are stem cells? How do you get them? How are they harvested?" Then learners will do*

a lot of thinking (T3). Problem-solving and investigation are part of the case study, they encourage higher order thinking and learners can voice out whatever they know and also ask questions (T9).

Working as groups assists the students to brainstorm and come up with facts. Activities need to be aligned with the content specified in the CAPS policy document and allow students to think outside the box, however, consume relatively more time as compared to other methods and students delay with the feedback (T4). The following approaches that will increase thinking skills are investigations, problem-solving (T7).

A case study is not easy for me, I need support. I am used in the lecture and textbook method. Lack of support is a challenge. When I attend the workshop, it does not work for me because they are too theoretical than practical, we need the practical part of NS (T6) (T8).

4. Discussion

To promote higher-order thinking, the participants revealed that investigations enhanced higher-order thinking. Previous studies such as Keller [1], Grassberger, Wilder [3] and Nkhoma [4] indicate that case study encourages students to learn more and apply critical thinking. Moreover, Winn et al. [6] encourages the use of cognitive learning strategies so that students can apply deep learning and actively participate in the lesson. The present researcher concurs with the authors above, teachers with the teaching and lecturing background profess the practicality of the method. It gives students the freedom to look for different learning materials that will assist them in compiling or demonstrating the task given.

Some of the science teachers confirmed that case study requires specific skills. Literature revealed that, to master the required skills concerning the case study, one needs to have good problem-solving skills and be able to understand the investigation skills [17]. Subsequently, Akbulut and Hill [5] notes that authentic learning activities motivates student teachers to be prepared for the 21st century classrooms. The participants mentioned that group work promotes learning and teaching when implementing a curriculum using a case study. Cakmak [18] and Sunbul [2] state that case study promotes teamwork, good communication skills among the group and students find constructive solutions to problems. Teamwork is immensely important; students divide the tasks and allocate duties to everyone in the group. However, group work can disadvantage shy students by further alienating them while those who are significantly confident seize the opportunity to dominate in the group.

Some of the participants complained that case study consumes relatively more time, and literature avers that case-based learning takes a long time and can be difficult to conduct [2, 22, 23]. The present researchers are of the view that exposing students to real-life scenarios or projects that demand critical thinking is particularly crucial. Therefore, it is important to prepare students to be able to apply their minds, evaluate the problem and emerge with good decisions.

There is an existing need for support, as revealed by some of the science teachers. Getting support in the core business of the school is very significant, so the school managers need to monitor and implement positive interventions that will support teachers. Literature notes that support is the key to the successful implementation of the curriculum [24]. While Phasha et al. [25] mentions that challenges encountered by teachers need to be addressed immediately to avoid unnecessary delays in the curriculum implementation.

4.1 Summary of findings

The findings revealed that case-based learning exposes learners to real-life scenarios and promotes critical and analytical thinking; however, the challenges are compounded in congested classrooms and lessons take a long time when implemented in overcrowded classrooms. Case-based learning prepares students to apply problem-solving, investigation and decision-making skills. However, there are some metacognition challenges experienced such as time-constraints and need for thorough preparation before conducting science sessions as lack of preparation negatively affects learners with learning barriers.

5. Conclusions

The study was conducted in one district of the Eastern Cape Province of South Africa. Findings indicate that science teachers are using the case-based learning method, and it is a particularly interesting method as it promotes learning and teaching. Most participants raised the issue of higher-order thinking that enhances the method in terms of scenarios given to learners for problem-solving purposes. Science teachers also mentioned that case study is good for science learning, and it becomes more successful when cooperative learning is applied. The study also revealed that support is needed to strengthen learning and teaching of natural science and motivate teachers to implement the curriculum confidently.

5.1 Recommendations

Science teachers need to work with their colleagues at school and share information with other teachers in their respective districts. They also need to invite science teachers from other provinces to exchange pedagogical content knowledge using online platforms, conducting webinars and sharing views on the effectiveness of applying case-based learning online and apply the following steps when conducting case-based learning:

- Understanding of the content knowledge
- Identify the problem
- Give a case-based scenario
- Allocate tasks according to groups
- Draft clear guidelines
- Provide clear rubric

Acknowledgements

Our deepest gratitude goes to the education district office and schools that participated in the study.

All authors have read and agreed to the published version of the manuscript.

Author contributions

Conceptualization, Mtsi N. and Kumanda N.; methodology, Mtsi N. and Chiphambo, S.M.; validation, Mtsi N. and Kumanda, N.; formal analysis, Chiphambo S.M.; investigation, Mtsi N; resources, Mtsi, N.; writing—original draft preparation: Mtsi N..; writing—review and editing, Chiphambo S.M. and Kumanda N.

Funding

None.

Conflict of interest

None of the researchers has any conflict of interest, and no gain is expected from this study.

Informed consent statement

Informed consent was obtained from all subjects involved in the study.

Data availability statement

The data presented in this study are available on request from the corresponding author. The data are publicly available.

Author details

Nomxolisi Mtsi[1], Shakespear M. Chiphambo[2]* and Nomaroma Kumanda[2]

1 Faculty of Education and School Development, Queenstown Campus, Walter Sisulu University, South Africa

2 Department of Curriculum Studies, Queenstown Campus, Walter Sisulu University, South Africa

*Address all correspondence to: schiphambo@wsu.ac.za

IntechOpen

© 2024 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

References

[1] Keller C. Using STEM Case Studies to Prepare Today's Students for Tomorrow's Jobs an Evaluation of Spark 101 Interactive STEM Videos. 2016. Available from: http://www.spark101.org/media/user_files/2016-03-07_SparkEvaluation-Final.pdf [Accessed: June 23, 2017]

[2] Sünbül AM. Öğretim İlke ve Yöntemleri (4. Baskı). Konya, Türkiye: Eğitim Kitabevi; 2010

[3] Grassberger R, Wilder S. Impacting student learning using a living case study Higher Education, Skills and Work-based Learning. 2015;**5**(4):338-369

[4] Nkhoma M. Examining the Mediating Role of Learning Engagement, Learning Process and Learning Experience on the Learning Outcomes through Localized Real Case Studies. 2013. Available from: http://www.emeraldinsight.com/doi/abs/10.1108/ET-01-2013-000 [Accessed: November 23, 2016]

[5] Kbulut M, Hill JR. Case based pedagogy for teacher education: An instructional model. Contemporary Education Technology. 2020;**12**(2):4-7, ep287, DOI: 10.30935/cedech/8937

[6] Winn AS, DelSignore L, Marcus C, Chiel L, Freiman E, Stafford D, et al. Applying cognitive learning strategies to enhance learning and retention in clinical teaching setting. MedEdPORTAL. 2019;**15**:10850

[7] Lovat T, Smith D. The Origins and Nature of Curriculum: Curriculum Action and Reflection Revisited. 3rd ed. Wentworthfalls, NSW: Social Science Press; 1995. pp. 8-21

[8] Du Plessis E. Students' Experiences of work Integrated Learning in Teacher Education. 2010. Available from: http://www.researchgate.net/publication/319879067

[9] Bonney KM. An argument and plan for promoting the teaching and learning of neglected tropical diseases. Journal of Microbiology and Biology Education. 2013;**14**(2):183-188

[10] Herreid CF. Case studies in science—A novel method of science education. Journal of College Science Teaching. 1994;**23**(4):221-229

[11] Loyens SMM, Gijbels D, Coertjens L, Cote´ D. Students' approaches to learning in problem-based learning: Taking into account students' behavior in the tutorial groups, self-study time, and different assessment aspects. Studies in Educational Evaluation. 2013a;**39**(1):23-32. DOI: 10.1016/j. stueduc.2012.10.004

[12] Biggs JB, Kember D, Leung DYP. The revised two-factor study process questionnaire: R-SPQ-2F. British Journal of Educational Psychology. 2001;**71**(1):133-149

[13] Brookhart S. Educational assessment knowledge and skills for educators. Educational Measurement, Issues and Practice. 2011a;**30**(1):3-12

[14] Shulman LS. Those who understand: Knowledge growth in teaching. Educational Researcher. 1986;**15**(2):4-14

[15] Anderson LW, Krathwohl DR, Airasian PW, Cruikshank KA, Mayer RE, Pintrich PR, et al., editors. A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives. New York: Pearson, Allyn & Bacon; 2000

[16] Bloom BS, Engelhart MD, Furst EJ, Hill WH, Krathwohl DR, editors. Taxonomy of educational objectives,

Handbook I: The Cognitive Domain. New York: David McKay Co Inc; 1956

[17] Aji WN, Budiyono S. The teaching strategy of Bahasa Indonesia in curriculum 2013. International Journal of Active Learning. 2018;**3**(2):58-64

[18] Çakmak Z, Akgün IH. A theoretical perspective on the case study method. Journal of Education and Learning. 2017;*7*(1):96-102

[19] Bilen M. Plandan Uygulamaya Ogretim (7. Baskı). Ankara, Turkiye: Ani Yayıncılık; 2006

[20] Nas R. Hayat Bilgisi ve Sosyal Bilgiler Ogretimi (3. Baskı). Bursa, Turkiye: Ezgi Kitabevi; 2006

[21] Gozutok D. Ogretim İlke ve Yontemleri (3. Basking). Ankara, Turkiye: Ekinoks Yayınevi; 2011

[22] Kucukahmet L. Ogretim İlke ve yontemleri (23. Baskı). Ankara, Turkiye: Nobel Yayın Dagıtım; 2009

[23] Alacapınar GF. Ornek olay yontemi ve egitim icin ornek olaylar. Ankara, Turkiye: Anı Yayıncılık; 2008

[24] Nkambule G, Amsterdam C. The realities of educator support in a south African school district. South African Journal of Education. 2018;**38**(1):1-11. DOI: doi.org/10.15700/saje.v38n1a1433

[25] Phasha T, Bipath K, Beckmann J. Educators' experiences regarding continuous professional development and the curriculum assessment policy statement. International Journal of Educational Science. 2016;**14**(1, 2):69-78

[26] Mtsi N, Maphosa C, Moyo G. Exploring educators' preparedness to teach natural sciences at the senior phase of south African secondary schools. Journal of Educational Studies. 2016;**15**(2):108-135

[27] Vygotsky L. Mind in Society. The Development of Higher Psychological Processes. Cambridge, Massachusetts: Harvard University Press; 1978

Chapter 17

Perspective Chapter: Metacognitive Approaches for Teaching Scientific Communication to Chemistry Students

Sabrina G. Sobel and Lisa DeTora

Abstract

Learning to communicate clearly in STEM fields requires mastery of discipline specific vocabulary and norms of writing style and citations, along with following general rules for quality writing. For many students, this is too much to grasp all at once. A consciously metacognitive approach in teaching oral and written communication can improve student learning, retention, and performance in scientific communication. However, the role and application of metacognitive approaches may differ in the sciences and writing studies. We discuss different communication settings in which metacognitive approaches drawn from chemistry education and from writing studies may both be applied: the laboratory report, the seminar presentation, literature reviews, and oral examinations. In each of these settings, students benefit from metacognitive activities, such as reflections, co-creating the curricular environment, oral exams, and course discussion. Our observations in the context of undergraduate chemistry courses are broadly applicable to all STEM education.

Keywords: metacognition, pedagogy, chemistry, writing studies, scientific communication, oral exams, laboratory reports, literature reviews

1. Introduction

In this chapter, we review information about metacognition and writing studies and then describe several course design elements that employ metacognitive approaches to STEM education, specifically in the setting of written and oral communication. The approaches described derive in large part from experience in the chemistry classroom; however, similar approaches may be adapted to other disciplines.

1.1 Learning to communicate about science: the example of chemistry

Obtaining an undergraduate education requires students to master many skills and multiple forms of knowledge. Accreditation guidelines also indicate that students should be able to convey this knowledge, and other information, effectively.

For instance, the Middle States accreditation guidelines, Standard III.5.b. indicates that an institution should offer "a curriculum designed so that students acquire and demonstrate essential skills including at least oral and written communication, scientific and quantitative reasoning, critical analysis and reasoning, technological competency, and information literacy" [1]. The American Chemical Society undergraduate accreditation requirements (ACS-CPT Guidelines) include, "... writing and speaking opportunities that allow students to learn how to communicate technical information: (1) clearly and concisely, (2) in a scientifically appropriate style for the intended audience including non-technical audiences, (3) ethically and accurately, and (4) utilizing relevant technology" [2]. Of course, the specifics of these general categories will differ from discipline to discipline, necessitating specialized knowledge that should be imparted by experts.

In *Write like a Chemist,* [3] Robinson and colleagues describe some basic genres of writing in chemistry, such as posters and journal articles, as well as how to identify their basic characteristics. This practice, known as genre analysis, requires the reader and writer to identify certain elements that will be important to a final written product, such as:

- Audience
- Purpose
- Organization
- Grammar and other writing conventions
- Scientific content.

Many manuals for scientific writing lay out specifics of these genre conventions; however, Robinson and colleagues, by suggesting that genre analysis is necessary to learn writing for a specific scientific discipline also indirectly suggest a need for metacognitive approaches to such learning. In other words, they ask readers and writers to think about the reasons for communication, the accepted formats that are legible to target audiences, and whether, or not, certain texts meet their intended goals.

Vanderbilt University's guide to metacognition, by Nancy Chick, defines this term as "the processes used to plan, monitor, and assess one's understanding and performance," and as such requires "a critical awareness of a) one's thinking and learning and b) oneself as a thinker and learner" [4]. Without these critical skills, it is impossible to communicate effectively. Chick also quotes experts who indicate the necessity for learners to "know about" rather than merely "practice" metacognitive skills [5]. In other words, it is not enough to train students to engage in specific practices; one must also raise an awareness that learning is an active process and promote the idea of personal agency in that learning. We have applied these basic ideas in various contexts of scientific communication, specifically in the context of chemistry education.

1.2 The need for metacognitive approaches to scientific communication

The ability to effectively communicate scientific information, whether in writing or speaking, requires metacognitive skills in different areas. These areas include knowledge of the scientific subject matter to be communicated and an understanding of the conventions of spoken and written forms used in the sciences as well as facility with the uses of language more generally. The need for this type of multilayered metacognitive knowledge may explain some of the inherent difficulties in the teaching of scientific communication to students who are still in the process of learning basic scientific information and skills, as opposed to practicing scientists, the target audience for many guides to scientific writing. Most guides merely lay out the main requirements for specific genres, attending to the various elements Robinson and colleagues specify. Robinson and coauthors took on a different approach when they explicitly encourage the idea of genre analysis as a means of learning how to follow such guidelines [3]. While specialized help in writing itself may also provide additional benefits, Zerbe, for example, points out a fundamental disjunction between the usual modes of teaching writing to college students and the nature of scientific thought [6]. The first relies on an ability to self-reflect and the role of revision in improving communication while the latter is more concerned with hypothesis generation, accuracy, quantitative reasoning, and data management.

Another point to consider when working with college students is that these students may or may not be successful in acquiring the knowledge and skills they will need to pursue further education or careers in the sciences. The coursework itself is a barrier to scientific communication insofar as it is necessary to understand scientific content in order to communicate it. Students who are unwilling or unable to master the many skills and knowledge types needed to understand and engage in scientific inquiry will, of necessity, be ineffective communicators of this content. Thus, science educators may attempt to leverage metacognition in science classrooms in an effort to improve outcomes for mid- and low-performing students and better enable high performing students to progress in acquiring knowledge and skills preferentially to (or instead of) writing about them [7]. In other words, many metacognitive approaches to science education focus on the content and the acquisition of specific analytical and quantitative skills, instead of explicit discussion of how to communicate well.

In this chapter, we discuss metacognition in relation to scientific information, writing and oral communication, and then outline some course design elements we have developed in the context of undergraduate chemistry education to promote metacognition, specifically in and through student ownership of their learning. Further, we detail some steps we have taken to raise our own awareness not only of student learning but about how our specific teaching strategies promote metacognition for our students and ourselves. It is appropriate to note in this context that studies centered on imparting writing skills and knowledge to students are often viewed as inherently metacognitive [8] and hence may provide a generalized series of approaches of use to science educators.

Written and oral communication in chemistry courses arise in several different contexts including written projects such as laboratory reports or review papers, oral presentations or seminars, and oral exams. The last of these is a novel approach to chemistry education and therefore deserving of more extensive comment outside of this chapter. We have commented on seminar presentations and literature reviews in a prior publication [9].

2. Metacognition in chemistry education and writing instruction

2.1 Defining metacognition

Metacognition, or the act of applying cognitive activities to themselves, became a burgeoning area of study during the 1990s. Yzerbyt and coeditors collected a series of contributions that examined this phenomenon in various contexts, and provided insights into modes of interpreting differences among socially prescribed behaviors, feelings, and cognitive understanding [10]. These coauthors define metacognition in contrast to social cognition, linking the former to the role of language in human understanding, social cohesion, and problem-solving. In effect, these authors viewed metacognitive functions as self-correction and a way of managing information in contrast to feelings, and therefore as a potential protection against bias. While these distinctions have become increasingly important for all students in the light of recent political polarization, science students must learn to put aside feelings-based reasoning as part of entering the discipline.

The need for metacognitive skills and knowledge extends beyond educational contexts and into all areas of lived experience. Metcalf and Shimamura [11] collected a series of essays that consider metacognition as related to an understanding of memory (or metamemory), and as essential to problem solving in both educational contexts and day-to-day existence. Metacognition, in other words, is necessary for people to navigate the world in which they live and to solve various sorts of real-world problems. Three main components of problems in this context are defined as: the goal to be solved; the facts, assumptions, or resources available for solving this problem, or givens; and the barriers or obstacles that exist to reaching the goal within the set of givens [11]. This basic format may be seen in academic problem solving and also in the problems that arise in everyday situations, as well as in experimental scientific inquiry. Chemistry education requires attention to each of these domains, with a focus on encouraging students to differentiate between feelings-based and cognitively based problem solving.

In this chapter, we consider the role of metacognition in teaching communication skills to chemistry students. As such, we recognize the necessity for understanding the connections among metacognition, scientific content, and language use. However, the uses of language are not a primary focus in undergraduate scientific education, even though students must learn to communicate like scientists. Learning to communicate in any scientific discipline or subfield requires the acquisition of language, such as specialized vocabulary, as well as an understanding of the way that language is generally used by professional researchers. Such considerations are commonly considered in language-based disciplines, and not an explicit focus in chemistry education.

In a recent volume on metacognition and language acquisition [12], for instance, the preface notes several important concepts:

"It is quite indisputable, for instance, that good language learners should possess a high level of awareness of the intricacies of the target language they are trying to master, how it compares to their mother tongue and other known languages, the challenges involved in the process, their own deep-seated beliefs about learning and teaching of additional languages, and the strategies that can be employed for this purpose. The same holds true for language teachers who, in order to teach more effectively, should clearly be not only aware of their instructional practices and their beliefs about those practices but also cognizant of the extent to which different instructional options fit in with learners' individual profiles or contextual considerations. It should also be kept in mind that teachers never cease to be learners themselves, either in regard to the language they teach, the additional languages they themselves might be learning or the various techniques and procedures that they can fall back on to make their lessons more engaging and beneficial to their student."

We agree with these propositions and view the ability to communicate scientific information effectively as multifaceted—involving elements of language, science, and other types of cognition. In fact, learning to communicate science requires specialized language acquisition, or knowledge of the vocabulary of the field, as well as other types of learning, such as quantitative reasoning. Further, we believe that science educators are themselves lifelong learners, not merely of scientific content, but also of the evolving nature of communication in science.

2.2 Metacognition in chemistry education

We commented earlier, following Chick [4] that metacognition involves planning, monitoring, and assessing personal performance as well as encouraging personal agency. However, many different methods and modalities may be used to encourage or assess metacognition in the chemistry—or any STEM—classroom, and these approaches may be applied to content as opposed to communication. Given the looseness of definitions of metacognition in many working and educational settings, it is worth reviewing a few recent studies of metacognitive approaches to pedagogy in the chemistry classroom. This short review is not comprehensive, nor is it intended to be, but it does provide an overview of some important concepts.

The recent literature in chemistry education outlines certain benefits of metacognitive approaches in various populations. For instance, metacognitive approaches were effective in augmenting active learning in a General Chemistry I class, thereby enhancing the acquisition of chemistry concepts [13]. Mutambuki and colleagues sought to investigate the potential additive benefits of active learning and metacognition, each of which had been shown independently to improve student outcomes in the chemistry classroom [7]. However, Mutambuki and colleagues also observed that prior studies tended to employ metacognitive strategies implicitly, that is, without directly explaining the aims of metacognition or asking students to perform a specific evaluation. In contrast to these earlier studies, Mutambuki et al. used a more explicit mode of such learning, explaining their aims more directly to students. They found that their metacognitive interventions led to increases on test scores that were significant, both statistically and in terms of boosting students' overall course grades. Furthermore, this explicit instruction in metacognition was beneficial for students seeking to learn more challenging chemistry concepts.

A more implicit, therefore a more typical, method of assessing metacognition was used by Bunce et al. across multiple sections of a general chemistry course at the United States Naval Academy [14]. These instructors encouraged reflection on learning through the use of clickers in classroom situations to help students understand when their answers to problems were correct or incorrect, thus providing an opportunity for thought in a lower stakes setting than during the examination itself. Bunce and coauthors found a correlation between student confidence in their answers and correctness—in other words, students with correct answers were more likely to feel confident in their answers. Unlike Mutambuki and colleagues, Bunce et al. found only nascent and partial evidence of metacognition in their students, however.

Heidbrink and Weinrich [15] observed that more implicit modes of metacognitive instruction in the chemistry classroom might be necessary, given the lack of instruction most professors receive in such practices. In other words, and in contrast to the work quoted earlier in language instruction, instructional staff in the sciences tend to receive more focused education centering on content mastery and knowledge rather than pedagogy. In their study, Heidbrink and Weinrich found that a majority of students (20 of 25) in an upper-level biochemistry course were able to use a specific, indirect metacognitive prompt to improve their problem solving within a particular context. Heidbrink and Weinrich used a think-aloud protocol to assess how students would tease out the answers to buffer problems with and without the benefit of answering questions designed to encourage reflection. These researchers found that asking advanced students to reflect on what might not work well for another student, following research by Talanquer [16], enhanced metacognition. They found changes in metacognitive activities for high- mid- and low-performing students, which they described as transferable but not generalizable due to sample size concerns.

A few major concepts are important when considering this prior work. First, a general pattern of imparting metacognitive skills indirectly or implicitly encouraging metacognition through reflective prompts can have positive benefits for students at all skill levels. It is worthy of note that each of these studies was conducted under very different classroom conditions and at institutions with varying acceptance criteria. Second, the nature of education and opportunities for professional development among faculty in chemistry curricula should be considered when suggesting modes of encouraging metacognition. Unlike the general culture in language studies, where pedagogy, practice and an atmosphere of continual self-reflection are essential elements of all research, scientific fields tend to demand more specific focus on experimentation and skills acquisition independent of the more nuanced aspects of communication. In fact, as Heidbrink and Weinrich [15] observe, the lack of opportunity for formal education in metacognitive content and approaches is a potential obstacle to this kind of teaching for many chemistry instructors, who must focus on subject matter expertise and keep abreast of developments in the field. In contrast, the ACS-CPT Guidelines now explicitly state, "Additionally, a program should provide opportunities for faculty to maintain their knowledge of effective practices in chemistry education and modern theories of learning and cognition in science" [2]. However, and thirdly, more explicit approaches to metacognition in the chemistry classroom are also possible, and beneficial, for those who have the appropriate time, inclination, and resources, as Mutambuki and colleagues demonstrate [7]. Finally, the preceding work tends to focus on the role of metacognitive processes and pedagogy in the acquisition of scientific knowledge and concepts. This is not surprising, given that imparting scientific knowledge is the core aim of most chemistry courses.

2.3 Metacognition in writing and communication studies

Writing studies developed as a subfield of English, and therefore strongly related to language study. Bazerman [17] described the need for a consolidated study of writing, given the fundamental importance of literacy in modern society as well as the often piecemeal attention to various aspects of literacy, such as language acquisition, linguistics, or writing instruction in the academy. Bazerman also argued that writing studies was uniquely situated to build a consolidated picture of writing given the tendency in the professional field of writing studies to focus on pedagogy and practice as well as assessing the means of evaluating the effects of such pedagogy and practice. As a major discipline and field of academic endeavor, writing studies has tended to pursue its work metadiscursively and metacognitively, seeing the various functions of writing, student writing, pedagogy, anecdote, and professional development as intrinsically and inextricably linked. In other words, the aims and approaches of writing studies are essentially metacognitive.

Subsequent work in writing studies comments on various "threshold concepts" [8] with the intention of encouraging faculty members and students to reflect on their own belief systems in the context of writing and thinking about writing.

Adler-Kassner and Wardle identify several threshold concepts about writing, each of which is metacognitive. Individual chapters, for instance, explain the social and rhetorical character of writing, how words get meaning, the ethics of writing, and the forms and genres used in writing. These specific concepts might be seen to exist in conversation with the work collected by Yzerbyt and coeditors [10], who emphasized the social and language-based elements of metacognition as well as the necessity for metacognitive activity to reduce or eliminate bias.

Writing studies scholarship also seeks to address multiple audiences simultaneously. The authors who contributed to Adler-Kassner and Wardle's book about threshold concepts in writing studies, for instance, explain these concepts for the benefit of students, faculty members, and writing program administrators. Each essay is intended to make explicit the often implicit knowledge and understanding that traditionally informed writing studies, but more importantly is intended to lay out a belief the reader shares but has not yet articulated. In effect, Adler-Kassner and Wardle collected a series of essays that illuminate the kinds of knowledge that Bazerman described as common in writing studies, yet in need of consolidation [8].

Open access sources such as *Bad Ideas About Writing,* (available at: https://textbooks.lib.wvu.edu/badideas/badideasaboutwriting-book.pdf) (see also [18]), similarly, take on a metacognitive approach that encourages readers to reflect on various aspects of writing, writing instruction, and the assessment of such instruction. Ball and Loewe curated a collection of essays that describe bad ideas about topics such as good writing, good writers, grammar, how to write, writing instruction, and the assessment of such instruction. Each of the individual concepts collected is intended to encourage readers to think about why the base idea is bad. Such work parallels the kind of approach Heidbrink and Weinrich took when working with advanced biochemistry students; however, the inherent reflexivity and metacognitive approach of writing studies enables these authors and editors to automatically expand the spheres of influence of these works. Writing studies colleagues understand the basic wisdom of considering metacognitive questions and omit reflections on whether any precise concept is generalizable, opting instead to offer many perspectives to foster greater critical engagement and to offer readers choices for their own work.

Although it may seem from these specific observations that writing studies is the ultimate answer to the ultimate question about metacognition in teaching scientific writing and communication to science students, this is not entirely the case. For one thing, Harris [19] suggests that writing studies is not ideally situated to address all concerns about writing in all disciplines. Importantly, Hesse [20] distinguished scientific writing from the subset of writing modalities that fall naturally within the remit Bazerman describes. In fact, the ACS-CPT 2015 guidelines Section 7.4 stated, "Effective communication is vital to all professional chemists. Speech and English composition courses alone rarely give students sufficient experience in oral and written communication of technical information. The chemistry curriculum should include critically evaluated writing and speaking" [21]. As mentioned before, this emphasis continues, and is expanded, in the 2023 ACS-CPT Guidelines [2]. This call for specific attention to chemistry communication beyond the composition classroom is important for the work we describe.

As a last comment on writing studies approaches, we consider a model of teaching commonly used in technical communication. Cargile Cook's well-accepted model of layered literacies in technical communication [22], as critiqued by Lawrence and Hutter [23] provides a metacognitive approach to complex information by asking teachers and students to account for different types, or layers, of literacy. However, as Lawrence and Hutter note, these layers are not sufficient to account for all the modalities and literacies valued within the technical communication literature. The endeavor to add more layers into Cargile-Cook's framework can ironically create further barriers to success for students and faculty. Thus, although scholars and teachers, like Zerbe [6] and Hanganu-Bresch and colleagues [24] have pursued work on scientific writing, certain barriers continue to exist, specifically what DeTora has termed 'competing mentalities' between scientific and more rhetorically based disciplines [25]. A key omission in most of these studies is scientific content itself, which is a primary aim of chemistry education and communication. Next, we discuss how we have managed to negotiate between the competing mentalities.

3. Using metacognitive methods in teaching chemistry communication

3.1 Disciplinary approaches

The authors of this book chapter have come together to teach communication to chemistry students from very different vantage points. SS, a PhD in chemistry who has taught undergraduates and supervised undergraduate research for some decades, has approached the teaching of chemistry communication from a disciplinary perspective, consistent with the accreditation requirements specified by the American Chemical Society [2]. This approach is similar to that recommended by Robinson and colleagues in *Write Like a Chemist* [3] insofar as the intention of such teaching is twofold:

1. To ensure that students are able to communicate effectively as chemists within the community of practicing and teaching chemists.

2. To ensure that students meet the minimum competency requirements for chemistry communication in writing and speaking, including learning the general accepted formats for such communication.

Such skills are necessary in order to enculturate students to chemistry as a discipline, certainly, but more importantly, effective communication helps transform students into members of a professional scientific community.

In contrast, LDT, a PhD in English with an MS in bioethics and decades of experience in biomedical writing practice, came to the teaching of communication in chemistry from a much less focused perspective. LDT's background included exposure to writing studies education as well as training in professional aspects of biomedical writing for expert audiences [26]. Unlike the type of training suggested in work like the *ACS Style Guide* [27] or *Write Like a Chemist* [3], this perspective is multidisciplinary and therefore necessarily more flexible because chemistry is only one of the sciences represented. Furthermore, biomedical writing is also intended to reach various audiences outside the sciences, such as patients and caregivers. Thus, LDT viewed the aims of teaching writing in chemistry as layered:

1. To fulfill the expectations and accreditation requirements needed to allow students to become practicing chemists.

2. To understand how these set of skills and knowledge can also enable effective chemistry communicators to interact with broader groups in the culture of science and beyond.

In laying out these disciplinary perspectives, it becomes obvious how and why metacognitive approaches might be necessary to help students. First, the project of becoming a chemist requires specific reflection on and assessment of success in acclimating to the professional culture of chemistry. The authors consider three different settings for teaching written and oral chemistry communication to undergraduate students: laboratory reports, literature reviews, and oral exams. In each of these situations, metacognitive approaches that bridged prior knowledge from both chemistry and writing studies were used.

3.2 Laboratory reports

A simple expedient that can help students to improve their performance both generally and in writing is to provide an opportunity for reflection and revision on the various parts of a laboratory report based on specific comments. Such an approach is metacognitive in that it requires that students respond to feedback and reflect on what they could have done better. It is consistent with wisdom in writing studies, which emphasizes that opportunities for revision generally help students improve not only a specific product but also future writing [24]. However, there are drawbacks to this approach in day-to-day teaching.

First, many courses require multiple laboratory reports, which could create logistical issues for students and faculty. The project of responding to faculty comments means that students must wait for feedback before finishing a laboratory report. Even if faculty are able to respond to writing within the space of a given week, students may be tasked with writing up a draft of a second experiment at the same time as a revision for the first experiment. This overlapping of assignments within a single laboratory course might also interfere with students' ability to handle their work in additional courses.

Second, providing specific written comments on individual laboratory reports can be burdensome for faculty members. As Heidbrink and Weinrich [15] have observed, faculty members in the sciences often lack specific training in pedagogy, which tends to extend to specific training in writing instruction. Furthermore, the increasing reliance of institutions of higher learning on part time faculty members and graduate students also raises questions about fair labor practices. Hence, although we do recommend specific written feedback for individual students and opportunities for revision, we question the logistical feasibility of this idea for very large classes, course designs that require many laboratory reports, and teaching situations in which faculty members carry a heavy burden of coursework. Certainly, advanced majors in upper-level courses should receive this type of feedback.

In larger classes, particularly lower-level classes heavily populated by non-majors, providing scaffolded frameworks for lab reports where students only have to fill in certain details, explanations, and calculations may refocus student attention on chemistry content and vocabulary. Such an approach may also reduce grading burdens by limiting the volume of text students produce. Faculty may then organize these scaffolded forms around specific metacognitive questions designed to help students master difficult content.

For example, in the General Chemistry 1 lab class taught by SS, only one formal lab report is required [28]. All other reports are pre-formatted data pages and thought questions. All faculty who teach this course share a general format for the lab report specifying organization of sections, data and calculations. This ensures uniformity in presentation of information in the lab report, freeing up the student to concentrate on analysis and interpretation. Students are prompted to follow the four C's, a concept developed by a scientist in consultation with writing studies colleagues: every Concluding sentence should refer to an observation, data, or calculation (relational phrase that discusses values/numerical results), Context, Comparison, and Clarity [29]. Students are also prompted to construct Claim, Evidence and Reasoning statements, which is a solidly scientific perspective [30]. Through these well-accepted constructs, students can implicitly apply metacognition. A suitable grading rubric was developed that emphasizes understanding along with accuracy of results, again asking students to reflect upon their experience and data. These measures assure a balance between writing concerns and scientific knowledge and thinking.

3.3 Oral exams

Oral exams bear a direct relationship to the rhetorical and linguistic traditions Bazerman associates with writing studies. They are a common feature of graduate qualifiers in chemistry programs, especially in larger programs. According to the American Chemical Society, at least 50% of doctoral programs require an oral preliminary exam and/or a comprehensive oral exam, with larger programs requiring oral exams more often than smaller ones [31]. Oral seminars are also common features of graduate programs and professional meetings; furthermore, the metacognitive skills necessary for success in these practices are also important for any career path or program of study and therefore might be beneficial for undergraduates. Oral exams in undergraduate education gained popularity during the Covid-19 pandemic as instructors sought to assess student learning in environments that made it difficult to detect academic dishonesty or lucky guessing [32].

The published literature shows that oral exams can be successful in many kinds of chemistry courses. Dicks et al. found superior performance on oral exams in a large undergraduate Organic Chemistry course as compared with final course grades based on oral exams plus written exams [33]. Giordano and Christopher used oral final exams in Physical Chemistry and General Chemistry to assess student performance and maintain a personal connection with students learning remotely [34]. Kamber presented implementation of a final oral exam in an undergraduate Biochemistry class while teaching remotely [35]. In these studies, faculty noted that cheating opportunities were reduced. More importantly, oral exams allowed faculty to identify areas of confusion for students and to maintain personal contact during distance learning. Students found the exams themselves to be effective vehicles for learning and felt benefitted by personal contact with the instructors.

SS has used oral exams in various chemistry courses and incorporating different metacognitive elements, providing both scaffolding and feedback to students. By fostering student learning and connection during oral exams, SS observed benefits similar to those described in the studies cited [33–35]. Some examples of scaffolding might include presenting an example problem in class and explaining the thought process of problem solving, including possible false starts and rethinking. In-class small groups might also work together to solve problems and develop questions for the professor. A Socratic method can be helpful in prompting students to analyze how they thought through the problem solving process. Practice exams are another type of opportunity to practice. By using multiple forms of practice, students can be well-prepared for oral exams.

As with personalized feedback on individual laboratory reports, oral exams present logistical challenges, primarily for faculty members. Rather than preparing an exam and administering it in a 1- to 2-hour block, faculty members must set aside 10–15 minutes per student. So much time investment is impracticable for very large classes, although online meeting platforms such as Zoom make this easier. Further, faculty must consider student performance in different areas such as presentation skills, content mastery, and ability to answer questions about their thinking. The time commitment of oral exams can be more feasible if an automatically graded online exam is used in conjunction with a brief oral exam. Since students may discuss their experiences with each other, it is necessary to randomize questions or calculations to prevent cheating.

Most studies of oral exams solicit student opinions via formats such as a follow-up anonymized survey. As noted by Kamber, [35] many students have not experienced an oral exam before starting college. Placing the only oral exam at the end of a semester may cause greater anxiety than breaking up the oral exam experience into multiple smaller exams throughout the semester.

Additional options for oral input and feedback might include asking students to make short videos explaining a specific problem or concept—this option also could apply to small groups, for instance, which would foster connection not only with faculty but also with other students in distance-learning settings.

3.4 Literature review and seminar

As discussed in a prior publication, [9] the authors coteach a course for advanced chemistry undergraduates in which students must complete a literature review following an American Chemical Society journal format as well as delivering a 10 minute oral presentation on their research. The course was originally designed by SS as a structured experience in which students heard sample seminars and read example papers to reproduce and provided feedback via a written form and were required to ask a set number of questions following a peer's seminar [36]. The benefits of such a structure were clearly tied to the American Chemical Society accreditation guidelines [21] and were intended to impart specific skills in chemistry communication as well as provide an opportunity to engage in peer review. After LDT joined the course as a co-teacher, the experience evolved to address changing accreditation guidelines, to meet the changing needs of students as the major diversified, and to focus more strongly on metacognitive approaches to the work. This metacognitive focus became more important as the course expanded to serve an increasing number of students interested in forensic science and STEM education. It is worthy of note that forensic science, as an applied discipline, requires metacognitive approaches to problem-solving, while STEM education requires students to consider communication as an essential part of their work as opposed to an activity that takes place after the real work is done.

The current configuration of this course is inherently metacognitive in that it requires students to collaborate with peers and faculty to choose an overarching theme, such as climate change or food science. Students then each develop a literature review and seminar presentation within the overarching theme, which is shared incrementally as a work in progress with the group for informal discussion. The students also complete a common project centered around the overarching theme. Readings draw from work about writing by and for scientists as well as texts from writing studies are brought in as preparatory work. Students discuss these texts with each other and with faculty in connection with the course theme and their own projects. During each class meeting and each assignment, faculty and students work together to identify their goals, assess their own progress, and evaluate the relative success of various works. They also share experiences to help foster a sense of community collaboration which is unique in the students' experiences because collaboration is usually limited in STEM lecture classes.

Since this is a specialized course open only to certain students, it is easy to foster a sense of shared community and purpose. The inherently metacognitive nature of this work is made possible by the prior preparation of students—who are generally advanced in their course of study—as well as the ongoing engagement between the two faculty members. It is worthy of note that this kind of open-ended discussion-based workshop is fairly common as an approach in writing studies, but not in undergraduate STEM education, so faculty focused on scientific study and teaching may not be comfortable with what might appear to be a lack of structure.

4. Discussion, conclusion, and recommendations

Above, we described some course design elements that employ metacognitive approaches that can be used in various settings in STEM education such as examinations, writing laboratory reports or literature reviews, and oral communication. We conclude that although the shared experiences that led us to create these design elements overlap in the teaching of chemistry, similar approaches may be used in various settings in STEM education, the social sciences, and writing studies.

A consciously metacognitive approach in teaching oral and written communication can improve student learning, retention, and performance in scientific communication. However, the role and application of metacognitive approaches may differ in the sciences and writing studies. We discussed different communication settings in which metacognitive approaches drawn from chemistry education and from writing studies may both be applied: the laboratory report, the seminar presentation, literature reviews, and oral examinations. In each of these settings, students may benefit from metacognitive activities, such as reflections, co-creating the curricular environment, oral exams, and course discussion. Our observations in the context of undergraduate chemistry courses are broadly applicable to all STEM education.

In each of the settings just described, metacognitive approaches can incorporate similar elements for students. First, students should be asked to reflect generally on their ability to understand and convey concepts and calculations in a specific course setting. Second, students should be asked to explain specific concepts and calculations and why their approach is appropriate. Finally, students should be asked to explain how and why their answers apply to the specific tasks at hand. These elements correspond to the ideas of planning, monitoring, and assessment that Chick [4] mentions.

In each of the settings described above, one or more faculty members considered the possible connections between metacognitive approaches to scientific content—in this case, chemistry—as well as writing and then planned, monitored, and continually assessed their own work, making adjustments to meet student needs. A side benefit of this ongoing engagement has been publication of information about the seminar course. More significantly, SS has published more papers with student researchers. This was unanticipated, but it has also benefitted students enrolled in these various classes because such engagement necessarily enriches subsequent teaching. We recommend considering metacognitive elements when teaching any type of scientific communication.

Acknowledgements

No funding was received to support the current work.

The authors would like to acknowledge Dr. Vandana Bindra for helpful conversations regarding each of the courses described above.

Conflict of interest

The authors declare no conflict of interest.

Notes/thanks/other declarations

We thank all the students of CHEM 80 past and present.

Author details

Sabrina G. Sobel[1]* and Lisa DeTora[2]

1 Department of Chemistry, Hofstra University, Hempstead, NY, USA

2 Department of Writing Studies, Hofstra University, Hempstead, NY, USA

*Address all correspondence to: sabrina.sobel@hofstra.edu

IntechOpen

© 2024 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

References

[1] "Standards" Middle States Commission on Higher Education. Available from: https://www.msche.org/standards/ [Accessed: June 15, 2021]

[2] "ACS Guidelines for Bachelor's Degree Programs" Committee for Professional Education. Washington, DC, USA: American Chemical Society; 2023. Available from: https://www.acs.org/education/policies/acs-approval-program/guidelines.html [Accessed: September 2, 2023]

[3] Robinson MS et al. Write like a Chemist: A Guide and Resource. New York: Oxford University Press; 2008. ISBN 9780195305074. Available from: https://global.oup.com/us/companion.websites/9780195305074/ [Accessed: August 31, 2023]; https://search-ebscohost-com.ezproxy.hofstra.edu/login.aspx?direct=true&db=nlebk&AN=1204691&site=ehost-live

[4] Chick N. Metacognition. Vanderbilt University Center for Teaching. 2013. Available from: https://cft.vanderbilt.edu/guides-sub-pages/metacognition/ [Accessed: August 31, 2023]

[5] Zohar A, David AB. Paving a clear path in a thick forest: A conceptual analysis of a metacognitive component. Metacognition Learning. 2009;**4**:177-195. DOI: 10.1007/s11409-009-9044-6

[6] Zerbe MJ. Composition and the Rhetoric of Science: Engaging the Dominant Discourse. Carbondale: Southern Illinois University Press; 2007. Available from: http://www.siupress.com/books/978-0-8093-2740-9

[7] Mutambuki JM, Mwavita M, Muteti CZ, Jacob BI, Mohanty S. Metacognition and active learning combination reveals better performance on cognitively demanding general chemistry concepts than active learning alone. Journal of Chemical Education. 2020;**97**(7):1832-1832. DOI: 10.1021/acs.jchemed.0c00254

[8] Adler-Kassner L, Wardle E, editors. Naming What We Know, Classroom Edition: Threshold Concepts of Writing Studies. Logan: Utah State University Press; 2016. ISBN: 978-1-60732-577-2. Available from: https://upcolorado.com/utah-state-university-press/item/2965-naming-what-we-know-classroom-edition

[9] DeTora L, Sobel S. Chapter 13: Collaborative Models of Scientific Writing. 1st ed. The Routledge Handbook of Scientific Communication: Routledge Press; 2021. ISBN: 9781003043782. Available from: https://www.taylorfrancis.com/chapters/edit/10.4324/9781003043782-13/collaborative-models-scientific-writing-lisa-detora-sabrina-sobel

[10] Yzerbyt VY, Lories G, Dardenne B. Metacognition: Cognitive and Social Dimensions. London: SAGE Publications Ltd.; 1998. DOI: 10.4135/9781446279212

[11] Metcalfe J, Shimamura AP, editors. Metacognition: Knowing about Knowing. A Bradford Book Serial. Cambridge, Mass: MIT Press; 1994. ISBN-10: 0262631695. Available from: https://mitpress.mit.edu/9780262631693/metacognition/

[12] Åsta H, Bjørke C, Dypedahl M, editors. Metacognition in Language Learning and Teaching. Routledge Studies in Applied Linguistics.

New York: Routledge; 2018. DOI: 10.4324/9781351049146

[13] O'Carroll IP, Buck MR, Durkin DP, Farrell WS. With anchors aweigh, synchronous instruction preferred by naval academy instructors in small undergraduate chemistry classes. Journal of Chemical Education. 2020;**97**(9):2383-2388. DOI: 10.1021/acs.jchemed.0c00710

[14] Bunce DM, Flens EA, Neiles KY. How long can students pay attention in class? A study of student attention decline using clickers. Journal of Chemical Education. 2010;**87**(12):1438-1443. DOI: 10.1021/ed100409p

[15] Heidbrink A, Weinrich M. Encouraging biochemistry Students' metacognition: Reflecting on how another student might not carefully reflect. Journal of Chemical Education. 2021;**98**(9):2765-2765. DOI: 10.1021/acs.jchemed.1c00311

[16] Talanquer V. Concept inventories: Predicting the wrong answer may boost performance. Journal of Chemical Education. 2017;**94**(12):1805-1810. DOI: 10.1021/acs.jchemed.7b00427

[17] Bazerman C. The case for writing studies as a major discipline. In: Olson GA, editor. Rhetoric and Composition as Intellectual Work. Illinois, USA: Southern Illinois UP; 2002. ISBN 9780809324330

[18] Fishman J. Bad ideas about writing. Composition Studies. 2019;**47**(1):191-197. Available from: https://open.umn.edu/opentextbooks/textbooks/794

[19] Harris J. Déjà vu all over again. College Composition and Communication. 2006;**57**(3):535-542. Available from: http://www.jstor.org/stable/20456902

[20] Hesse DD. Who Owns Writing? 2005 CCCC Chair's Address in College Composition and Communication 57, No. 22005. pp. 335-357. Available from: http://www.jstor.org/stable/30037918

[21] Committee for Professional Training. ACS Guidelines and Evaluation Procedures for Bachelor's Degree Programs [Internet]. Washington, DC, USA: American Chemical Society; 2015. Available from: https://www.acs.org/content/dam/acsorg/about/governance/committees/training/2015-acs-guidelines-for-bachelors-degree-programs.pdf [Accessed: June 15, 2021]

[22] Cargile Cook K. Layered literacies: A theoretical frame for technical communication pedagogy. Technical Communication Quarterly. 2002;**11**(1):5-29. DOI: 10.1207/s15427625tcq1101_1

[23] Lawrence HM, Hutter L. Confronting methodological stasis: Re-examining approaches to technical communication pedagogical frameworks. In: Klein MJ, editor. Effective Teaching of Technical Communication: Theory, Practice and Application in the Workplace. Boulder: WAC Clearinghouse/University of Colorado Press; 2021. DOI: 10.37514/TPC-B.2021.1121.2.05

[24] Hanganu-Bresch C, Zerbe MJ, Gabriel Cutrufello G, Maci SM. The Routledge Handbook of Scientific Communication. Milton: Taylor & Francis Group; 2022. Available from: http://public.eblib.com/choice/PublicFullRecord.aspx?p=6809725

[25] DeTora L. In: Klein MJ, editor. Competing Mentalities: Situating Scientific Writing Pedagogy and Practice in Technical Communication. Effective Teaching of Technical Communication: Theory, Practice and Application in the Workplace. Boulder: WAC Clearinghouse/University of Colorado

Press; 2021. pp. 271-285. DOI: 10.37514/TPC-B.2021.1121.2.14

[26] DeTora L. Regulatory Writing : An Overview. Rockville, MD: Regulatory Affairs Professionals Society; 2020. ISBN: 978-1-947493-55-1

[27] Coghill AM et al. The ACS Style Guide: Effective Communication of Scientific Information. 3rd ed. Washington, DC: American Chemical Society; 2006. ISBN: 978-0841239999

[28] Experiment #26 fromWagner, Strothkamp, Ryan. Ideas, Investigation and Thought. 3rd ed. Island Park, NY, USA: Whittier Publications, Inc; 2000. ISBN 978-1576041017

[29] Ruscetti T, Krueger K, Sabatier C. Improving quantitative writing one sentence at a time. PLoS One. 2018;**13**(9):e0203109. DOI: 10.1371/journal.pone.0203109

[30] Model Teaching. Claim-Evidence-Reasoning (CER) [Internet]. 2019. Available from: https://www.modelteaching.com/education-articles/writing-instruction/claim-evidence-reasoning-cer [Accessed: September 04, 2023]

[31] Shulman J. Survey of Ph.D. Programs in Chemistry [Internet]. Washington, DC, USA: American Chemical Society: Chemistry for Life; Available from: https://www.acs.org/content/acs/en/education/students/graduate/survey-of-phd-programs-in-chemistry.html; [Accessed: June 15, 2021]

[32] Holme TA, editor. Insights gained while teaching chemistry in the time of COVID-19. Journal of Chemical Education. 2020;**97**(9):2375-3470. DOI: 10.1021/acs.jchemed.0c01087

[33] Dicks AP, Lautens M, Koroluk KJ, Skonieczny S. Undergraduate oral examinations in a university organic chemistry curriculum. Journal of Chemical Education. 2012;**89**:1506-1510

[34] Giordano AN, Christopher CR. Repurposing best teaching practices for remote learning environments: Chemistry in the news and oral examinations during COVID-19. Journal of Chemical Education. 2020;**97**(9):2815-2818

[35] Kamber DN. Personalized distance-learning experience through virtual oral examinations in an undergraduate biochemistry course. Journal of Chemical Education. 2021;**98**(1):395-399

[36] Novick SG, (now Sobel). Elements of and in the chemical literature: An undergraduate course. Journal of Chemical Education. 1995;**72**(4):297-301

Chapter 18

Teachers' Role in Chemistry Metacognition

Awelani V. Mudau and Tavonga Tawanda

Abstract

Teachers' role in chemistry metacognition describes what metacognition and chemistry metacognition are, their importance in chemistry education and how they can be taught or improved in science or chemistry learners that might be finding the subject difficult or demanding. This chapter educates science and chemistry teachers with the requisite metacognition and chemistry metacognition skills, knowledge and attitudes using chemistry relevant prior knowledge. The science and chemistry teachers in this chapter are also educated through a selected difficult chemistry topic on how to utilize the acquired metacognition and chemistry metacognition skills, knowledge and attitudes in the classroom. The metacognition and chemistry metacognition skills, knowledge and attitudes are utilized through modeling and scaffolding by the science and chemistry teachers for the learners to observe and learn metacognition and chemistry metacognition in practice. Replace the entirety of this text with your abstract.

Keywords: metacognition, chemistry metacognition, prior knowledge, modeling, scaffolding

1. Introduction

Chemistry as a science subject is perceived as a very difficult or challenging subject in terms of learning and teaching by both learners and teachers [1]. This perception of chemistry being a very difficult or challenging subject has led to many science learners performing poorly and losing interest in the subject [2, 3]. Therefore, there is need to attract more learners to study chemistry and improve the performance in this subject that is perceived as very difficult. Chemistry metacognition can improve the performance of learners and attract more learners to chemistry education.

2. Metacognition

Metacognition is part of self-regulation in the learning process with cognition and motivation [4]. Cognition are the processes involved mentally in understanding, knowing, and learning. Metacognition is the changes in learning behavior by which learners themselves go through when they plan, monitor and evaluate mentally during the learning process [5]. Motivation is the willingness by learners to actively engage in metacognitive and cognitive skills [4].

Metacognition is an individuals' skill to utilize prior knowledge to plan a tactic for an upcoming learning task, take required steps to problem solve, reflect on results and evaluate results as well as modifying the approach when it is necessary to do so [5].

Metacognition is the ingenious intentional control of cognitive and affective outcomes of thinking and insight aimed at the acquisition of knowledge, skills, and attitude during the learning process [6]. Metacognition is when a person can monitor their own understanding and awareness of their cognitive processes as well as having the ability to control them [7]. Metacognition is recognizing the value of prior knowledge with an accurate assessment of the demands of a challenging learning activity or goal and what understanding, and skills are needed as well as the intelligence required to make the right deduction on how to use one's elaborate and systematic knowledge in a specific situation reliably and efficiently [8]. Chemistry metacognition is the recognition of the value of chemistry prior knowledge with an accurate assessment of the demands of a chemistry challenging learning activity and what understanding, and skills are needed as well as the intelligence required to make the right deduction on how to use one's elaborate and systematic relevant prior chemistry knowledge in a specific situation reliably and efficiently.

Metacognition knowledge consists of what a person knows, about their cognitive processing power, about several approaches that are useful in learning and solving a problem as well as the requirements to effectively accomplish the learning task [9]. The definition of metacognition and its components depend on the researchers' context and theoretical tradition such as educational psychology, cognitive science, cognitive behavioral, cognitive developmental, socio-cultural, and social learning, asserts [10]. The socio-cultural theoretical definition and context of metacognition is employed in this chapter. Socio-cultural theory focuses on the impact of culture (beliefs, attitudes etc.) on teaching and learning as well as how peers and adults influence the learning (development) of an individual, making human learning largely a social process [11].

The several different definitions of metacognition have the following in common; knowledge of one's knowledge, the monitoring and regulation of one's knowledge consciously as well as the cognitive and affective states of being [11, 12]. John H. Flavell's model and Anne Brown's model are the most common models of metacognition [13]. These are theoretically distinct but compatible theories of metacognition, presenting a problem in terms of the agreed metacognition terminology and metacognitive processes. There are two major components of metacognition which are further divided into other subcomponents. Metacognitive knowledge (cognitive knowledge) and metacognitive regulation (cognitive regulation) make up metacognition [14–16].

There are three aspects of knowledge which comprise metacognition, there is procedural knowledge and conditional knowledge which are closely related as well as declarative knowledge, which refers to knowing in terms of knowledge, strategies and skills which are important for completing a learning task successfully under different conditions [13, 17]. This is knowledge about the task at hand in terms of prior knowledge, which is useful in the given scenario. Declarative knowledge is divided into person, task and strategies (actions) variables [18]. Person variables involve recognition of one's strengths and weaknesses in the learning process, including information processing. Task variables refer to what an individual knows or might find out in terms of the nature and mental (intellectual) requirements (demands) to accomplish the learning task [19].

Strategy variables refer to the plans in ones' mind which can be applied flexibly to positively accomplish the learning task [20]. Procedural knowledge is the knowledge of how to put into use procedures such as learning strategies or actions using declarative knowledge to achieve goals and conditional knowledge as knowledge about why and when to make use of various skills, procedures and strategies or cognitive actions [17]. One has knowledge about when and why to make use of declarative and procedural knowledge. Metacognitive knowledge can be changed through adding, removing or revising metacognitive experiences and metacognitive knowledge can be inaccurate, fail in terms of being activated, or may fail to have much or any influence [17].

Metacognitive control/regulation of cognition or executive control are sequences of activities that assist learners to control their own learning or thinking [21]. Metacognitive control is having three components or skills which are planning, monitoring and evaluation [22]. Planning includes the choosing of befitting strategies and provisions that are effective in terms of performance or goal attainment [21]. Monitoring is the judgment of the progress of one's current thinking and task performance. Evaluation refers to assessing or examining the completed task or goal which can demand more planning, monitoring and evaluating depending on the outcome [22].

Planning, monitoring and evaluation as self-regulating processes in most learning situations are not explicit or conscious, as they are automated to a large extent and might develop with reflection being unconscious as well as not having a language for communication between teachers/instructors and learners in this area [23]. Metacognition can be taught to any individual irrespective of age, grade (level) or subject specialization [24–26]. Adult learners usually have more knowledge of cognition and are better able to describe it in a coherent fashion way when compared to adolescents and children [22].

The learners' knowledge of cognition is explicit and develops late in terms of age [22]. Metacognitive skills and their use without assistance develop over time and the experiences of the learner out of the classroom should be taken into consideration because they are significant in the development of metacognitive skills [27]. Knowledge of cognition and regulation of cognition are related to each other as an improvement in declarative knowledge of cognition makes regulation of cognition easier [28].

3. Benefits of metacognition in chemistry education

Metacognition has a positive impact in general on learner outcomes in terms of thinking and learning, particularly for learners with disabilities [29–31]. Independent learning leads to self-monitoring of the progress in terms of learning. When learners can monitor the progress they are making, they take control their own learning in the and out of the classroom [5].

Abilities of metacognition assist learners to transfer acquired knowledge, skills and affective states to another context or learning task. Learners with inadequate access to educational resources benefit from metacognition as educational outcomes improve [32]. An increase of metacognition leads to increased motivation states [33]. Metacognitive regulation increases academic performance in various ways such as the application of attentional resources in a better way, application of existing strategies in a better way and a higher awareness of breakdowns in comprehension [28]. Learning is improved significantly when an understanding of how and when to apply the metacognitive skills by learners is achieved [4].

Metacognitive learners have achievement levels that are high and also compensates for those learners who might have cognitive limitations [6]. Independent learning ability of learners is increased as leaners become in control of their own learning in and outside the school through being able to plan, monitor and evaluate their own progress during the learning process [5]. The metacognitive ability of a learner to identify learning strategies that work and those which do not work as well as the ability to identify ones' ones' failures and successes increases the learners' resilience and perseverance [34]. There is no need of specialized teaching and learning equipment in metacognitive teaching making it cost-effective as metacognition trained teachers are required only. Metacognition assist learners in transferring knowledge (metacognitive strategies) across other contexts and tasks in different subjects. Learners of all age groups can effectively learn metacognitive skills and benefit from them.

Lack of relevant prior knowledge or low academic ability might be compensated for by metacognitive knowledge [28]. Resilience is improved by metacognition as learners can identify their own successes and failures, strategies that best work for them or which failed them thereby increasing the learners' perseverance in improving in their work [5]. Metacognition is important to learning that is successful as it allows learners to determine their weaknesses which can be corrected through the construction of new cognitive skills, resulting in learners better managing their cognitive skills [28]. There is social and emotional growth by learners as they get aware of their mental states which allows learners to think of how to be confident, respected, and happy. Metacognition also allows learners to understand other learners or individuals' perspectives better [5].

4. Prior knowledge in chemistry learning

One of the major contributors to learning challenges in chemistry is the learners' prior knowledge (pre-learning conceptions) [35]. Prior knowledge is the foundation on which new knowledge is built on by learners during learning [35]. According to the constructivist learning theory, each learner comes to the classroom possessing a unique experience (prior knowledge, skills and attitudes) [36]. The ability to learn is affected by the learners' background and prior knowledge. Learners construct their own meanings based on prior knowledge when it comes to chemistry explanations from the teacher or textbook and observations from chemistry experiments (chemistry theory and practical) [36]. Relevant prior knowledge gives learners the relevant context for the learning and integration of metacognitive knowledge, skills and attitudes [37]. Metacognition is the capability to apply relevant prior knowledge to plan, monitor and evaluate ones' mental processes during a learning process [9].

5. Modeling as a teaching strategy

Modeling is a very efficient way of teaching and learning any new knowledge, skill and attitude [38, 39]. In human beings from the age of childhood to the age of adulthood, modeling has a very important part in acquiring and developing cognitive and metacognitive skills, interpersonal skills, fine motor skills and later in life professional skills [38]. Observation is the primary process through which cognitive and metacognitive skills, interpersonal skills, fine motor skills and later in life professional skills are acquired. The acquisition and development of motor skills by children happen through observing the interactions of their parents, peers and siblings with their environments (worlds) [38, 39].

Parents, siblings and peers are the children's models whom they observe in terms of learning from the simplest form of knowledge, skill and attitude to the complex [40, 41]. The knowledge, skills and attitudes that are learnt and repeated by the learner depends ultimately on the reinforcement provided and the level of the learner to repeat what was observed. The learning of cognitive skills that are simple such as reading or basic arithmetic skills to problem solving and critical thinking which are more complex are facilitated through thought process verbalization by models when they perform such activities [40, 41]. The models' thoughts become observable, and can potentially be modeled, by conspicuous verbal characterization of the actions of the model.

Modeling both actions and thoughts has a lot of features that are helpful in the terms of contribution to the effectiveness of producing improvements in cognitive skills that are lasting [38]. Attention is gained and held through nonverbal modeling which is normally quite challenging to sustain through talking on its own. This also gives a didactic semantic environment inside which the verbalized rules are embedded [38, 41]. Cognitive abstractions are given meaning by behavioral referents. Furthermore, verbalized rules and approaches can be performed again in different forms as and when they are needed in imparting cognitive skills without the observers' interest being taxed by applying dissimilar exemplars [41].

Additionally, increased, and varied application of modeling deepens an understanding of the generative rules. According to the social cognitive learning theory, the acquisition of self-regulatory and metacognitive skills as well as competence develop first through observational learning which is also called social interaction [42]. There is advocacy for the development of self-regulatory competence by learners, in which learners are given a lot of opportunities to practice the different types of strategies that are associated with self-regulated learning so that they fully develop and become proficient in these set of skills [42]. Proficiency in these metacognitive and self-regulatory skills becomes easy when guidance, social reinforcement and feedback are provided during practice by models [42].

6. Metacognitive modeling

The modeling of metacognition exhibit how one should think during lessons which focuses on deciphering data and information, analyzing and conclusion drawing on what was learned [38, 40]. Metacognitive modeling is very useful especially in a science class where teachers make use of multiple steps in problem-solving. In metacognitive modeling, teachers verbalize metacognition through their own thought processes whilst they are solving the problem on the overhead, board any learning media being used [38, 40]. In the thinking-out-loud approach, the focus of the teachers' talk is to plan and articulate explicitly the thought processes associated with metacognitive learning. Metacognitive modeling can be done also when learners read the chemistry text whilst the teacher is asking questions that are rhetorical or comments about what is to anticipated in the chemistry text or subtopic that is coming [38, 40].

7. Modeling scaffolding technique

Teachers should consider the learners' position in the teaching and learning process when applying modeling as a technique of scaffolding [38–40]. First the teachers model the chemistry task for learners and then learners begin the task assigned and work through the chemistry task at a pace of their own [39, 40]. The teacher gives learners more demanding tasks which they can now do on their after learning from the less demanding chemistry tasks. The teacher models the chemistry task several times so as to create an environment that is supportive to learners who might have language challenges or learning disabilities [38].

8. Teachers' metacognitive knowledge and skills as a learner

The teacher must be able to motivate them-self and be aware of their strengths and weaknesses as a self-regulating learner [39]. This enables the teacher to motivate them-self when it comes to learning as a metacognitive learner [43]. The metacognitive learner must be fully engaged in learning metacognitively to improve their learning. Teaching learners how to learn metacognitively needs a teacher who is aware of the types of metacognitive learners which are tacit, aware, strategic, and reflective metacognitive learners [44, 45]. Learners who are not aware of their metacognitive knowledge and never think of any learning strategies are called tacit learners. Learners who are aware of some kind of metacognitive knowledge that they do such as generating ideas and finding evidence are called aware learners. However, thinking is not necessarily deliberate or planned [43].

Strategic learners can; do problem-solving, do organized thinking, classify, group, make decision, and seek evidence. They know learning strategies which apply the that assist them in learning [44]. Reflective learners reflect on learning during the learning process whilst taking into consideration of the success or failures of the learning strategy that is being uses as well as revising them the learning strategy when appropriate [45–48].

Developing learners' metacognitive knowledge, that is knowledge by learners of themselves in terms of a learner, the strategies to use in dealing with tasks is a very effective method of improving learning outcomes. Teachers must support learners to plan, monitor, and evaluate their own learning.

9. The teaching of metacognition strategies

Precise, clear, and readily observable teaching on the metacognitive strategies of planning, monitoring and evaluation is done to improve learners' metacognitive learning through a chemistry concept such as concentration. A number of steps that start by the activating relevant prior knowledge of the learner so as to begin the lesson from the known (simple knowledge) (prior knowledge) to the unknown (complex knowledge) new concept [6, 49]. This leads to independent practice by learners as they monitor their progress in the set goals on the topic concentration which leads to evaluation where learners reflect on their learning of the topic [4].

10. Metacognitive modeling by the teacher

Effective metacognitive skills teaching is done through modeling as the expert learner (teacher) shows the thought processes [4, 9]. Modeling by the teacher is a cornerstone of effective teaching. The metacognitive thinking processes are verbalized by the teacher who is the expert learner in terms of metacognitive learning [4]. A question on the topic concentration is presented to the learners to solve: What is the concentration in mol dm^{-3} of a solution made from 7.31 g sodium chloride in 250 cm^3 of distilled water? The teacher models metacognitive thinking by thinking out loudly (verbalization) in the three phases of metacognitive learning (planning phase, monitoring phase and evaluation phase). This done through the expert metacognitive learner asking himself/herself questions loudly for the learners to observe metacognitive thinking processes [9].

10.1 Planning phase

Teacher as expert metacognitive learner verbalizing thinking process: What is it that l am expected to learn? [4, 9].

Definition of concentration. Convert a given mass into mol and a given volume into dm^3. Calculate concentration.

Teacher as expert metacognitive learner verbalizing thinking process: What is the relevant prior knowledge that can assist me with this learning task? [4, 9]. At home, we add various amount of table salt to soup, the saltiness changes, increasing with the amount of salt added. When we add teaspoons of sugar into tea/coffee the sweetness depends on the number of teaspoons added per fixed volume of tea. Also dried fruits such as mango or sweet reeds or sugar cane are sweeter than fresh mango, sweet reeds/sugar.

Teacher as expert metacognitive learner verbalizing thinking process: What is it that l should do first? [4, 9]. From my relevant prior knowledge of sugar dissolving in tea/coffee and the changes of sweetness from dried and fresh mango/sweet reeds/ sugarcane, l know that concentration is the mass of a substance per unit volume. That means l have an idea from my relevant prior knowledge and know what concentration is though l did not know the chemistry technical term "concentration"?

Teacher as expert metacognitive learner verbalizing thinking process: What direction should I be thinking? [4, 9]. The mass and volume are given but not in the required units, so l should first convert the given mass and volume into the required units before doing anything.

Teacher as expert metacognitive learner verbalizing thinking process: How long should take to complete this? [4, 9]. The thinking, definition and calculation should take me 6 minutes at most.

10.2 Monitoring phase

Teacher as expert metacognitive learner verbalizing thinking process: In terms of the learning task, what is my progress? [4, 9].

I am doing well at the moment as it clear what l should do next.

Teacher as expert metacognitive learner verbalizing thinking process: Am I in the right direction? [4, 9] Yes, l am in the right direction as the conversion of the given mass and volume into mol and dm^3 units will give me the appropriate units in mol dm^{-3}.

Teacher as expert metacognitive learner verbalizing thinking process: How should I go on from here? [4, 9]. I should know the relative atomic masses of Na and Cl for me to convert the mass of NaCl into mol. I should also know how to convert of cm^3 into dm^3.

$$\text{Molar mass}\,(\text{NaCl}) = 23\,\text{g}\,/\,mol + 35.5\,\text{g}\,/\,mol = 58.5\,\text{g}\,/\,mol$$

$$\text{Number of } mol \text{ of NaCl in } 7.31\,\text{g of NaCl} = \frac{7.31\,\text{g}}{58.5\,\text{g}\,/\,mol} = 0.125\,mol$$

$$\text{Volume of } 250\,cm^3 \text{ in } dm^3 = \frac{250\,dm^3}{1000} = 0.25\ dm^3$$

Teacher as expert metacognitive learner verbalizing thinking process: What is the important information l should remember?

$$\text{The concentration of the NaCl solution is} = \frac{0.125\,mol}{0.25\ dm^3} = 0.5\ mol\,/\,dm^3$$

Teacher as expert metacognitive learner verbalizing thinking process: Must I do things in a different direction? [4, 9]. No, I think l am in the right direction so far.

Teacher as expert metacognitive learner verbalizing thinking process: Must I do some adjustment to my pace due to some minor challenges? [4, 9]. Yes, l need to slow down a bit to make sure l do not end up having serious.

Teacher as expert metacognitive learner verbalizing thinking process: What should if I am not understanding what l am doing? [4, 9]. I have to go back to my relevant prior knowledge that will assist me with coming up with the definition of concentration from which l can proceed.

10.3 Evaluation phase

Teacher as expert metacognitive learner verbalizing thinking process: How did I perform? [4, 9]. I think l did well.

Teacher as expert metacognitive learner verbalizing thinking process: What is it that l learned? [4, 9]. I learned how to arrive at the definition of concentration and how to use the definition to calculate the concentration of a solution without having to cram a formula demonstrating a deep understanding of the concept of concentration of solutions.

Teacher as expert metacognitive learner verbalizing thinking process: Where the results l got the expected results? [4, 9].

Yes, l got the expected results as l proved it by working backwards.

Teacher as expert metacognitive learner verbalizing thinking process: What is it that should have been done in different way by me? [4, 9]. I could have used the formula:

$$C = \frac{n}{V}$$

where C—concentration, n—number of moles and V—the volume to calculate the contraction of the NaCl solution, however changes of getting a deeper understanding are very slim as it is just substitution mechanically into the formula to calculate the concentration.

Teacher as expert metacognitive learner verbalizing thinking process: Is it possible for me to use this type of thinking in other situations or problems as well as in other subjects? [4, 9]. Yes, this type of thing can be used in other situations or problems as well as in other subjects.

Teacher as expert metacognitive learner verbalizing thinking process: Might there be something I do not understand, any knowledge gaps in my understanding? [4, 9]. As far as the definition of concentration and calculation of concentration task is concerned, there is no knowledge gap. The only knowledge gap could be on the calculation a of a new concentration after adding a certain amount of distilled water (dilution) the 0.5 mol/dm^3 NaCl solution.

Teacher as expert metacognitive learner verbalizing thinking process: Is there any need for me to fill the gap in knowledge by going back from the beginning to the end of the definition and calculation of concentration task? Yes, l needed to back to the original task, and use my understanding of the definition and calculation of concentration and which l got from my relevant prior knowledge to come up with some sort of equation. This is because the number of moles of NaCl remains constant in the original solution and the diluted solution.

Teacher as expert metacognitive learner verbalizing thinking process: How can l use this type of thinking in other learning situations or problems as well as subjects? This type of thinking can be used in other learning situations or problems as well as subjects by first identifying the relevant prior knowledge to use in that new learning situation or problem as well as subjects [4, 9].

As the teacher model's metacognition through verbalization of metacognitive thinking by asking these types of questions, there is an increase in the metacognitive knowledge, skills, and attitudes of learners. It happens by moving those learners who were tacit and aware learners to learners who are strategic and reflective. This gives learners the metacognitive tools they require to manage and benefit a lot from their learning. In turn, this will have a huge impact on the success and achievement beyond the school-based learning environment.

Worked examples are type of scaffold-ed tasks which enable learners to develop their cognitive and metacognitive skills by avoiding having a lot of demands on learners' mental resources.

11. Appropriate metacognitive challenge level

Setting the appropriate metacognitive challenge levels for learners enables learners to progress and develop the knowledge of themselves as learners (metacognitive knowledge, tasks, and strategies). The metacognitive challenge level motivates learners in accepting doing the required chemistry learning task. Learners should be motivated for them to accept a chemistry challenge. The chemistry tasks given to learners should not be above the level of the learners' cognitive level especially when they are expected to use the new learning strategies [4, 9].

12. Metacognitive development and promotion

Metacognitive skills in the teaching and learning environment can be developed through dialog in the classroom, explicit teaching and modeling. Cognitive and metacognitive strategies knowledge and understanding can be acquired through learner-teacher or learner-to-learner talk. Purposeful dialog is required, with teachers supporting and guiding the conversation to make sure it builds on relevant prior knowledge, and it will be challenging.

13. Encourage independent learning

For learners to develop independent skills of learning, explicit support by teachers is required. Scaffolding is used to design a practice that is guided, with support being withdrawn gradually as learners get more proficient. This enables learners to develop strategies and skills before they the learners can practice the learning strategies and skills independently. For learners to accurately judge how they are learning effectively, they require effective feedback on time and learning strategies [4, 9]

14. Teacher metacognitive support by school

Metacognitive professional development courses and resources of high quality as well as a conducive environment must be provided by the school to ensure all teachers have an opportunity to learn metacognitive knowledge, skills, and attitudes as expert learners. This will make it easy for teachers to teach and model metacognitive self-regulated learning to learners. Metacognitive knowledge, skills and attitudes are well learned when there is support and time given to teachers by senior leaders for consistent implementation of metacognitive teaching and learning approaches [4]. The metacognitive self-regulated learning skills of learners can be assessed by a variety of ways which include scaffolding, think aloud and observations. Teachers must build metacognitive teaching as part of their normal teaching activities and not take metacognitive teaching and learning as extra duties or activities [9].

15. Research questions

1. What is the effect of the teachers' chemistry metacognitive modeling on leaners' chemistry metacognitive learning?

2. How does the teachers' chemistry metacognitive modeling impact learners' chemistry academic performance?

16. Methods

The social constructivist learning theory guided this embedded mixed methods research designed study over 8 weeks. This research design includes the collection and analysis of qualitative and quantitative data within an approach that is primary qualitative that leads an integration of the results and conclusions from these data into a whole that is cohesive [50, 51]. From a population of 150 leaners, 29 learners were purposively sampled for the research who consisted of 14 females and 15 males. Focus groups and document analysis were used to collect the data. The Metacognition Awareness Inventory (MAI) by Scraw and Dennison [22] was adapted for use in this study.

17. Results

Comparing the metacognition awareness mean scores of the learners from focus group mean scores before and after the teachers' chemistry metacognition modeling

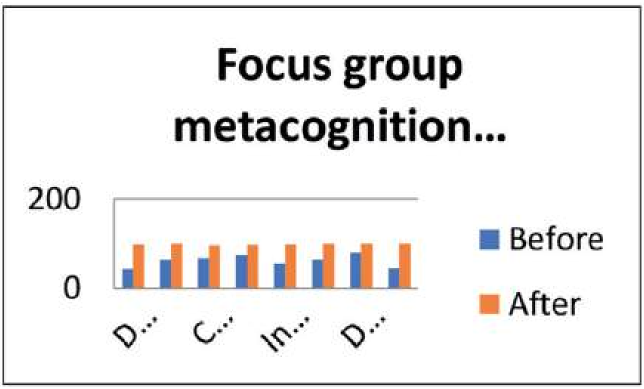

Figure 1.
Metacognition awareness mean score before and after teacher metacognitive modeling intervention. From "The influence of indigenous knowledge on chemistry metacognition" [52].

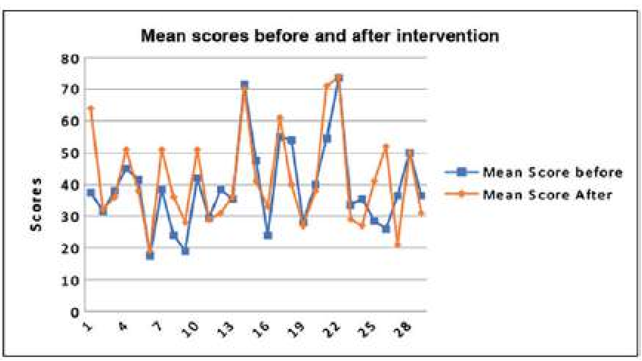

Figure 2.
Comparison of assignment 2 and chemistry test 2 and 3 post-intervention. From "The influence of indigenous knowledge on chemistry metacognition" [52].

intervention, there was a significant improvement in the metacognition awareness of the learners after the metacognition modeling intervention. **Figure 1** shows a comparison of the metacognition awareness mean scores before and after teachers' chemistry metacognitive modeling.

There was a positive change in mean scores in chemistry assignments and chemistry test scores of the learners after the metacognition modeling intervention. These outcomes imply an positive impact on metacognitive learning by learners as a result of metacognitive modeling by the teacher as well as academic improvement by the learners after the metacognition modeling intervention by the teacher. **Figure 2** shows the learner mean chemistry assignments and tests before and after the intervention.

18. Discussion

The findings suggest that the teachers' chemistry metacognitive modeling improved learners' chemistry metacognitive learning. This correlates with the findings of a previous study which showed that modeling enhances metacognitive development in learners through the sharing of common thinking strategies that are visible which assists learners to be aware more of their own thinking [47]. These findings are also correlates with a study in which the metacognitive modeling technique were found to be very effective in teaching learners metacognitive learning skills [48]. The findings of this study also suggests that teacher metacognitive modeling improve the academic performance of learners. There is a correlation with these findings with a study which showed that modeling of cognitive and metacognitive skills improves the academic performance of learners [53].

19. Conclusion

This study examined the effect of the teachers' chemistry metacognitive modeling on learners' metacognitive learning and learners' academic performance. From these findings, the following conclusions can be drawn teachers' chemistry modeling improves learners' chemistry metacognitive learning and learners' chemistry academic performance.

20. Recommendations

It is recommended that chemistry teachers be capacitated with metacognition knowledge skills and attitudes including metacognitive modeling skills for application in everyday chemistry teaching to empower learners with metacognitive skills and improved academic performance in chemistry by learners.

21. Summary

This chapter discussed one of the major challenges of learning chemistry and a way of dealing with this major challenge in chemistry education. The definition, importance, and application of chemistry metacognition by teachers were explained in order to improve chemistry learning outcomes and motivation of learners in chemistry education.

Author details

Awelani V. Mudau[1]* and Tavonga Tawanda[2]

1 University of South Africa, Pretoria, South Africa

2 Department of Science and Technology Education, University of South Africa, Pretoria, South Africa

*Address all correspondence to: mudauav@unisa.ac.za

IntechOpen

© 2023 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

References

[1] Mustafaoglu FM, Yucel AS. Context-based teaching experiences of chemistry teachers: Expectations, gains and applicability conditions. Journal of Turkish Science Education. 2022;**19**(3):958-978

[2] Fitriyana N, Pratomo H, Wiyarsi A, Marfuatun M. In-service high school chemistry teachers' view towards chemistry: Is it a difficult subject? AIP Conference Proceedings. 2023;**2556**(1):1-12. DOI: 10.1063/5.0109916

[3] Oladejo IA, Ademola IA, Ayanwale MA, Tobih D. Concept difficulty in secondary school chemistry – An intra-play of gender, school location and school type. Journal of Technology and Science Education. 2023;**13, 255**(1):275

[4] Howell R. Metacognition and high potential. Potential Plus UK. 2020. Available from: https://potentialplusuk.org/index.php/2020/09/16/metacognition-and-high-potential-lea

[5] Sword R. Metacognition in the classroom: Benefits & strategies. 2021. Available from: https://www.highspeedtraining.co.uk/hub/metacognition-in-the-classroom

[6] Jia X, Li W, Cao L. The role of metacognitive componets in creative thinking. Frontiers in Psychology. 2019;**10**:1-11

[7] Flavell JH. Metacognition and cognitive monitoring. A new area of cognitive-development inquiry. American Psychologist. 1979;**34**(10):906-911

[8] Taylor S. Better learning through better thinking: Developing student's metacognitive abilities. Journal of College Reading and Learning. 1999;**30**:34-45

[9] The Teaching Excellence in Adult Literacy. Metacognitive processes TEAL Centre Fact Sheet No. 4. 2010. pp. 1-4. Available from: https://lincs.ed.gov/sites/default/files/4_TEAL_Metacognitive.pdf

[10] Mccormick CB, Dimmitt C, Sullivan FR. Metacognition, learning and instruction. Educational Psychology. 2012;**7**:69-97

[11] Mcload S. Vygotsky's socialcultural theory of cognitive development. Child Psychology and Development. 2023. Available from: https://www.simplypsychology.org/vygotsky.html

[12] Stebner F, Schuster C, Weber X, Greiff S, Leutner D, Wirth J. Transfer of metacognitive skills in self-regulated learning: Effects on strategy application and content knowledge acquisition. Metacognition and Learning. 2022;**17**:715-744. DOI: 10.1007/s11409-022-09322-X

[13] Schraw G. Assessing metacognition: Implications of the Buros Symposium. Issues in the Measurement of Metacognition. 2000. Available from: https://digital.commons.unl.edu/burosmetacognition

[14] Denis JL, Somerville MP. Supporting thinking about thinking: Examining the metacognition theory-practice gap in higher education Higher Education. 2023. pp. 99-117. DOI: 10.1007/s10734-022-00904-x

[15] Terneusen A, Quaedflieg C, Heugten C, Ponds R, Winkens I. Metacognition and Learning. 2023. DOI: 10.1007/s11409-023-09350-1

[16] Chacon-Diaz LB. A framework for meta-learning in science education for a time of crisis and beyond. Cultural Studies of Science Education. 2023;**18**:589-599. DOI: 10.1007/s11422-023-10150-x

[17] Mahdavi M. An overview: Metacognition in education. International Journal of Multidisciplinary and Current Research. 2014;**2**:529-535

[18] Flavell JH. Speculations about the nature and development of metacognition. In: Weiner FE, Kluwe FH, editors. Metacogntion, Motivation and Understanding. New Jersey: Lawrence Erlbaum; 1987

[19] Papaleontiou-Louca E. The concept and instruction of metacognition. Teacher Development. 2003;**7**(1):9-30

[20] Isaacson RM, Fujita F. Metacognitive knowledge, monitoring and self-regulated learning: Academic success and reflections on learning. Journal of the Scholarship of Teaching and Teaching. 2003;**6**(1):61-64

[21] Nazarieth M. A brief history of metacognition and principles of metacognitive instruction in learning. BEST: Journals of Humanities, Arts, Medicine and Sciences. 2016;**2**(2):61-64

[22] Schraw G, Dennison RS. Assessing metacognitive awareness. Contemporary Educational Psychology. 1994;**19**(4):460-475. DOI: 10.1006/ceps.1994.1033

[23] Schraw G, Hartley C, Hartley K. Promoting self-regulation in science education: Metacognition as part of a broader perspective on learning. Research in Science Education. 2006;**36**:111-139

[24] Dawson TL. Metacognition and learning in adulthood. Developmental Testing Service. 2016. DOI: 10.13140/RG.2.1.2231.0649. Available from: https://www.researchgate.net/publication/305755437

[25] Tuononen T, Hyytinen H, Raisanen M, Hailikari T, Parpala A. Metacognitive awareness in relation to university students' learning profiles. Metacognition and Learning. 2023. DOI: 10.1007/s11409-022-09314-x

[26] Flavell JH. Cognitive Development. Englewood Cliffs, NJ: Prentice Hall; 1985

[27] Noushad PP. Cognitions about cognitions. The Theory of Metacognition. 2008. Available from: https://files.eric.ed.gov/fulltext/ED502151.pdf

[28] Schraw G. Promoting general metacognitive awareness. Instructional Science. 1998;**26**:113-125

[29] Georghiades P. From the general to the situated: Three decades of metacognition. International Journal of Science Education. 2004;**26**(3):365-383

[30] Sethuraman M, Radhakrish G. Integrated practice of metacognitive strategies and second language writing. MIER Integrated Practice of Metacognitive Strategies and Second Language Writing. 2021;**11**(1):118-136

[31] Muijs D, Bokhove C. Metacognition and Self-Regulation: Evidence Review. London: Education Endowment Foundation; 2020. Available from: https://educationendowmentfoundation.org.uk/evidence-summaries/evidence/metacognition-andself-regulation-review/

[32] Uppal N, Kumar A. Promoting metacognitive learning strategies: A necessity during pandemic. Dogo

Ransang Research Journal: UGC Care Group 1 Journal. 2020;**10**(11):30-35

[33] Pintrich PR. The role of metacognitive knowledge in learning, teaching and assessing. Theory Into Practice. 2010;**41**(4):219-225

[34] Lebuda I, Benedek M. Asystematic framework of creative metacognition. Physics for Life Reviews. 2023;**46**:161-181

[35] Shofwa A, Endang S, Budi H, Sri Y. Prospective chemistry teachers' pedagogical content knowledge in chemical application planning. Journal of Physics Conference Series. 2021;**1842**:1-7. DOI: 10.1088/1742-6596/1842/1/012076

[36] Chen P, Hon J, Ye J, Ho Y. The role of teachers' constructivist beliefs in classroom observation: A social cognitive theory perspective. Frontiers in Psychology. 2022;**13**:1-10. DOI: 10.3389/fpsg.2022.904181

[37] Witherby AE, Carpenter SK, Smith AM. Exploring the relationship between prior knowledge and metacognitive monitoring accuracy. Metacognition and Learning. 2023;**18**(2):1-31. DOI: 10.1007/s11409-022-09344-z

[38] Salisu A, Ransom EN. The role of modeling towards impacting quality education. International Letters of Social and Humanistic Sciences. 2014;**32**:54-61. DOI: 10.18052/www.scipress.com/ILSHS.32.54

[39] Bandura A. Social Foundations of Thought and Action: A Social Cognitive Theory. Englewood Cliffs, NJ: Prentice-Hall; 1986

[40] Sulasmi E. Effectiveness of modeling learning strategies to improve student learning outcomes. Budapest International Research and Critics Institute Journal (BIRCI-Journal). 2021;**4**(1):926-936

[41] Torres M, Orleans A. Modelling metacognition in science teaching: A Philippine context. Researchgate. 2021. DOI: 10.13140/R6.2.2.15742.31049. Available from: https://www.researchgate.net/publication/351936337

[42] Schunk DH, Zimmerman BJ. Modeling and self-efficacy influences on children's development of self-regulation. In: Juvonen J, Wentzel KR, editors. Social Motivation: Understanding children's School Adjusment. Cambridge: Cambridge University Press; 1996. pp. 154-180. DOI: 10.1017/CBO9780511571190.009

[43] Quigley A, Muijs D, Stringer EC. Metacognition and self-regulation learning. London Education Endowment Foundation. 2021. Available from: https://educationendowmentfoundation.org.uk/education-evidence/guidance-reports/metacognition

[44] Sudadi S, Lolang E, Ariawan J, Kusnadi IH, Munir M. The effectiveness analysis of computational thinking patterns and levels of students metacognitive awareness in solving learning problems. Journal on Education. 2023;**6**(1):2166-2177

[45] Perkins D. Smart Schools: Better Thinking and Learning for every Child. New York: Free Press; 1992

[46] Buck-Pavlick H. Empowering metacognition through dance writing and collaborative dance making. Journal of Dance Education. 2022. DOI: 10.1080/15290824.2022.2051041

[47] Conrady K. Modelling metacognition: Making thinking visible in a constant course for teachers. Journal of Research in Mathematics

Education(REDMAT). 2015;**4**(2):132-160. DOI: 10.17583/redimat.2015.1422

[48] Schofield L. Why didn't l think of that? Teachers' influence on students metacognitive knowledge of how to help students acquiremetacognitive abilities. Kairaranga. 2012;**13**(1):56-62

[49] Teng MF. Metacognition. In: Weng Z, Sparks R, Biedron A, Teng F, editors. Cognitive Individual Differences in Second Language Acquisition: Theories, Assessment and Pedagogy. Berlin: De Gruyter; 2023. pp. 175-199

[50] Creswell JW, Plano Clark VL. Designing and Conducting Mixed Methods Research. 3rd ed. Thousand Oaks, CA: SAGE; 2018

[51] Leedy PD, Ormrod JE. Practical Research Planning and Design. 12th ed. London: Pearson Education; 2021

[52] Tawanda T, Mudau AV. The influence of indigenous knowledge on chemistry metacognition [version 1; peer review: 2 approved with reservations]. F1000Research. 2023;**12**:589. DOI: 10.12688

[53] Medina-Martínez M, Pagán-Maldonado N. Teaching cognitive and metacognitive SRL strategies in the science class: An experimental design to determine effect on academic achievement. International Journal of Educational Excellence. 2016;**2**(2):77-105. DOI: 10.18562/IJEE.020

Chapter 19

Implementation of Conceptual Change Approach to Improve Learners' Understanding of Quantitative Chemistry Aspects

Zanele Ginyigazi, Lungiswa Nqoma, Bulelwa Makena and Pretty Thandiswa Mpiti

Abstract

Implementing a conceptual change approach helps students correct misconceptions and gain a deeper understanding of key quantitative Chemistry concepts, including stoichiometry, chemical equations and substance quantity calculations. For improvement of how learners understood quantitative aspects as measured with chemical change, a conceptual change approach became the centre of inquiry. A case study and qualitative approach were used to collect data from 50 learners and 12 learners. The findings indicate an improvement in learners' scientific understanding after the administration of a pre-test and a post-test. Concurrently, provided by this study is evidence denting that misconceptions of learners can be facilitated with great conceptual understanding through the application of a conceptual change framework. The study recommends a well-designed conceptual change instructional approach that leads to significantly better acquisition of scientific concepts.

Keywords: conceptual change, quantitative aspects, chemical change, chemistry, scientific

1. Introduction

Upon the analysis of matric results in South Africa (more so those of the Eastern Cape Province), the results of Physical Science were observed to be trailing behind. The trend from 2016 to 2019 reveals that the subject trails behind in comparison to others (National Diagnostic Report (NDR)) [1].

An attempt has been made to counteract the dilemma of poor performance in Physical Science by launching several initiatives and programmes nationally and in respective provinces at the level of higher education institutions. An example of the government's attempt to improve the Physical Science results was the establishment of Dinaledi schools, which were to be increased to roughly 400 [2]. The Dinaledi Focus Schools Project was included in the National Strategy to raise the number of quality passes by learners in Grades 10–12. The focus was on Mathematics and Physical

IntechOpen

Science, more so on previously disadvantaged learners. There are studies that have argued that underperformance in Physical Sciences is caused by the unavailability of infrastructure and quality of teaching [3]. However, attention has been on improving Physical Science performance overall, but no attention was paid on the actual strategies to be used. Therefore, this study focuses on identifying and characterising learners' misconceptions and difficulties with quantitative aspects of chemical change and how to remove these misconceptions to enhance learning and teaching using the conceptual change approach. Conceptual change is the process of change from the learner's prior conception to scientific conception [4]. This study employed a qualitative research methodology to gather data. In-depth interviews and a rigorous qualitative technique were used to study participants' opinions of the conceptual change model and how it affects conceptual change. Qualitatively designed research would enhance participants' conceptual change experience during classroom teaching, thus imparting greater knowledge regarding the roles of the different conceptual change model phases [5].

Against the above background, the researchers wished to find answers to the following research question: To what extent can the implementation of the conceptual change approach be used as a teaching and learning strategy in Physical Sciences, in one rural school?

2. Literature review

An instructional strategy wherein the teacher serves as an implementor and facilitator by guiding learners towards scientifically constructing valid ideas is termed as the conceptual change instructional strategy. This approach permits the instructor to pose thought-provoking questions, which then become a leeway for learners to conduct experiments under the mentorship of guided discussions.

Syuhendri [6] explored the effect of conceptual change-based instruction accompanied by demonstrations on 11th-grade learners' attitudes towards Chemistry. Ebru, Fulya, Hakan, Vuslat, Necdet, Nuray and Filiz [7] examined conceptual change and the effect analogy has in bringing about conceptual change in Physics learners. Chinyere and Madu [8] found that the experimental analogy model improved the understanding of the concept of light refraction compared to regular lecture methods. However, learners frequently have misconceptions that prevent them from developing meaningful comprehension of complicated ideas. The researchers posit that simply giving learners the logical justifications for scientific ideas during instruction of quantitative aspects of chemical change does not promote conceptual understanding to the point where such justifications make little sense considering the learners' own beliefs. The most influential model of conceptual change was proposed by Posner et al. [9]. Baidoo et al. [10] articulate as they concur that one of the best approaches to address misconceptions by learners about real-life situations and the manner they perceive physical world operations is through using the Piagetian concept of accommodation and the Khunian concept of 'scientific revolution'. Conceptual shift is the idea that pupils learn in a new way while building on a variety of existing information. As a means to enhance learning by categorising science concepts misconceptions, the suggested vital strategy then becomes the conceptual change text-oriented instruction. Designing learning environments that allow learners to become aware of their current internal justifications and beliefs is essential for promoting conceptual change and improving problem-solving abilities.

3. Methodology

This study looked at the use of the conceptual change approach as a teaching and learning strategy for Physical Sciences at a rural school. With the help of the qualitative research approach, a thorough analysis and explanation of the events under consideration were provided [11]. The Chemistry Achievement Test (CAT) was used to create lessons for the intervention programme and to determine the learners' alternate conceptions [12]. The CAT examinations were piloted on a small sample of Grade 11 Physical Sciences teachers from neighbouring schools to confirm topic validity. The information gathered by the CAT was examined using quantitative description. To guarantee the validity of the observation schedule for the intervention lessons and the interview schedule, colleagues in the same field were asked to review them.

Table 1 represents a summary of the sample.

Purposive sampling was chosen for this study. The sample included 50 learners from a Grade 11 Physical Sciences class. Semi-structured interviews also used purposeful sampling. Twelve of the 50 learners who were sampled were chosen for interviews. They were sampled based on their performance, with four learners, each receiving low, average and high marks in the pre-test. Each group had four randomly selected learners (**Table 2**).

Activity	Sample size	Sampling technique	Criteria
Pre-test and post-test	50 Grade 11 Physical Sciences learners	Purposive	The entire Physical Sciences class
Conceptual change lessons	50 Grade 11 Physical Sciences learners	Purposive	Entire Physical Sciences class
Interviews	12 of the 50 Physical Sciences learners	Selected from each defined group	4 low, 4 middle, 4 high performing Learners

Table 1.
Sample size.

Research Question	Method	Instrument	Respondents	Analysis
	Test	**Marking memo**	**50 learners**	**Test scores**
How can conceptual change pedagogy be administered towards enhancing learner understanding on quantitative aspects of chemical change?	Intervention lesson that was videotaped for observation purposes	Lesson plan: addressed in this part are the stages of conceptual change inclusive of fruitfulness, dissatisfaction, plausibility, intelligibility and observation schedule	50 learners	Observation and thick descriptions
	Post-test	Marking memo	50 learners	Test scores
	Interviews	Interview schedule	12 learners	Coding for themes

Table 2.
Research data collection plan.

3.1 Data collection plan

The data collection process was designed around the research question, and the lessons were prepared to meet the four conditions of conceptual change (dissatisfaction, intelligibility, plausibility and fruitfulness) [13]. Learners were required to work in groups and were given the opportunity to interact verbally. The goal was to allow learners to question concepts and recognise the limitations of their knowledge. For two weeks, learners were taught about chemical change four times a week during 50-minute class periods. Following the post-test, semi-structured interviews were conducted in the researchers' school. The 12 learners were divided into three focus groups of four.

3.2 Procedure

A pre-test was assigned to learners prior to their exposure to the intervention programme to assess their conceptual knowledge. The pre-test results are illustrated in the form of a table and graph in **Table 3** and **Figure 1**, respectively. The terms on quantitative aspects of chemical change were reviewed with Grade 11 Physical Sciences learners. The learners were then assigned a pre-test to assess their understanding of the quantitative aspects of chemical change from previous grades.

The pre-test results are shown in **Table 3** and **Figure 1**.

As indicated in the diagram, 90% of the learners scored less than 40% and none scored 60% or higher. According to the pre-test results, the majority of Grade 11 Physical Sciences learners were unable to answer questions about the quantitative aspects of chemical change. If this issue is not addressed, it may lead to additional difficulties in this section of Grade 12. As a result, the study proposed a conceptual change approach to solving the problem.

%	0–9	10-19	20-29	30-39	40-49	50–59	60–69	70–79	80–89	90–100
Freq	5	22	11	7	3	2	0	0	0	0

Table 3.
Pre-test scores in the form of percentages.

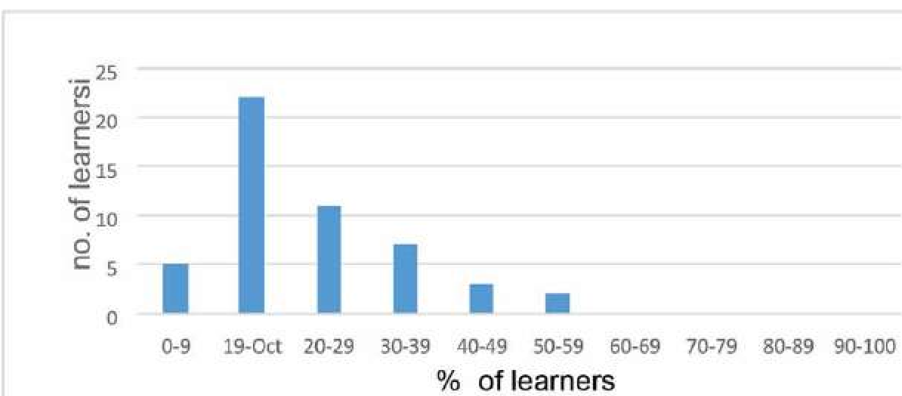

Figure 1.
Pre-test scores graph.

4. Intervention

Instruction on using the conceptual change approach was imparted on learners, which included the application of various tactics such as appropriate comprehension addressing demonstrations and misconceptions. Teaching and learning processes focused on enlightenments to maximise the plausibility and intelligibility of scientific concepts. The researchers prepared conceptual change texts in the quantitative aspects of chemical change.

Instruction was aimed to cover the mole concept, molar mass and stoichiometry, all of which are aspects of quantitative chemical change. When developing the three lessons, the conceptual change stages were holistically considered.

5. Conceptual change approach

Learners were taught through the conceptual change approach, which had the main focus on considering the extent to which scientific conceptions' plausibility and intelligibility could be maximised as alluded to by the four conditions put forward by Posner et al. [9] were used to implement conceptual change, namely dissatisfaction, intelligibility, plausibility and fruitfulness. These four conditions suggest that there are several important conditions that must be fulfilled before the conceptual change is likely to occur.

6. Dissatisfaction

Swafiyah et al. [4] declare that it is a necessary juncture for learners to be efficient at defining and relating terms for a particular concept. By so doing, they would be regarded to have mastered the concept of quantitative aspects of chemical change. The pre-test results revealed that the concept was poorly understood. As a result, the teacher felt it imperative to impose learners in a video lesson before engaging in discussion. The teacher entered the Grade 11 Physical Sciences class. On the chalkboard, the topic for discussion was posed by the teacher, with indications of quantitative aspects versus chemical change. The approach used by the teacher to familiarise learners with the emerging topic was through the review of Grade 10 work. It began with a revision of the mole concept, wherein a mole was defined as equivalent to the volume of a substance.

Following video viewing, the teacher posed a series of questions to the learners. As an example: What is a substance? Learners responded as follows:

What is the scientific name for anything that takes up space?

Learners began to recall work from Grades 8–10.

It is a single atom. [Learner No. 3].

A proton is what it is. [Learner No. 5].

It is a single electron. [Learner No. 6].

Material. [Learner No. 7].

I believe it is matter. [learner].

They were giving various answers, both correct and incorrect and their responses were written on the board. Bloom's taxonomy denotes that the point of departure when teaching is by introducing learners to what they are already familiar with before embarking on imposing abstract or unfamiliar aspects. This type of discussion assisted the teacher in getting closer to the concept from what they knew. Although some of the answers were incorrect, they were throwing related terms together.

The teacher divided the learners into five groups of ten and used the learners' responses to generate activity. Substances, material, matter, atoms, protons and electrons were the terms used. During the presentations, the teacher dispatched learning resources like Prestik and Koki pens to learners grouped according to learner abilities. Thereafter, learners were expected to design personal concept maps, which were later pasted for visibility and accessibility to all. During presentations, learners directed questions to the group that was presented at that particular time.

In the end, learners who had a different understanding of the scientific viewpoint concurred with the outcomes emanating from class engagements. As a result, they retracted how they initially perceived things. Upon further probing, the mole concept was introduced (as this concept had been previously unpacked) and defined as an amount of a substance. Learners understood the word substance but struggled with the word 'amount'? The teacher instructed the learners to look up the word 'amount' in their dictionaries. They came up with various answers that all had the same meaning. They came up with various answers that all had the same meaning as 'many' or 'quantity'.

As engagements were ongoing, learners provided examples of substances for which they were familiar with the quantities. Responses included items like 10 kg of sugar, 12.5 kg of mealie meal and dozens of eggs.

What is the number of eggs in a dozen? [Teacher].

One dozen eggs contain 12 eggs. [B Group].

How many sugar grains are there in 10 kg of sugar? MH! [Teacher] They are too numerous to count. [D Group].

In your opinion, how are granular substances packed?

Learners responded with eagerness, indicating that weighting of objects is used for packaging. [A Group].

The mole was defined by the teacher as a scientific quantity of substances. Periodic tables were circulated to learners to interact with and asked to examine the elements on the table. Explanations were uttered with indications that sometimes it is necessary to know how many particles (atoms or molecules) are in a sample of a substance or how much of a substance is required for a chemical reaction to occur in a single mole of any substance or how much of a substance is required for a chemical reaction to occur. There are 6.023 × 1023 particles in one mole of any substance. It denotes the presence of numerous particles. This is referred to as Avogadro's number. The teacher attempted to persuade the learners about scientific concepts by referring to their discussions, such as how sugar grains could be weighed 1 kg, 5 kg or 10 kg but had many particles inside each pocket.

Learners indicated that they now understood what the term 'mole' meant. Learners indicated that they initially misunderstood the term. After establishing dissatisfaction with learners' the teacher felt implied to further clarify the scientific viewpoint by using worksheets and explanations. Exercises were used to present discussion questions. The teacher went on to explain that if you weighed out samples of several elements, the mass of the sample would be the same as the relative atomic mass of that element.

7. Intelligibility

People need to comprehend the structuring of emergent concepts adequately to investigate the likelihood of inheriting [9]. The teacher introduced the apparatus into the classroom for learners to accommodate factors that promote new ideas that appeared abstract. The balance scale and filter paper were distributed by the teacher to each group and chemical. Iron fillings were given to Group A, magnesium powder to Group B, sulphur powder to Group C, zinc powder to Group D and copper fillings to Group E. When learners use their senses, they learn more effectively. The teacher gave the learners a worksheet to fill out and a periodic table as support material.

All group members were given equal opportunities to partake in the experiment. During this investigation, the teacher was also hands-on in mentoring and supporting all activities pioneered by each group. When learners experience challenges, they easily interact with the teacher as the classroom environment caters to learner diversity and learner-centred collaborations [E Group].

The teacher explained to the entire class that the number at the top of the periodic table represents the element's atomic number, and the number at the bottom represents the element's atomic mass. Until this point, the teacher had been attempting to share experiences and, at the same time, imparting knowledge by filling in the gaps in what learners already know. Learners felt very proud of the scientific knowledge attained.

8. Plausibility

Plausibility is stage number 3 of conceptual change theory. Posner [9] asserts that emerging knowledge needs to be revealed by learners. At this point, learners are supposed to mentally picture the new concepts they have learned. At this point, the new hypothesis appears plausible.

The learners were exposed to new scientific knowledge, and the teacher was responsible for directing the learning towards cognitive reformation. As the teacher diversified teaching-learning strategies, conceptual change theory was adopted to introduce chemical concepts by engaging in problem-solving tactics.

The teacher provided analogous problem-solving examples. The examples assisted learners in developing problem-solving skills that would allow them to solve higher-order cognitive level questions such as quantitative or conceptual problems. The examples were created using the steps outlined above. The learners were able to conceptualise the problems that need to be solved. The teacher began to delve deeper into calculations involving chemical equations, which had already been introduced in Grade 10. The teacher reminded learners of the chemical change that occurs during the chemical reactions that result in the formation of a new substance. The teacher made an example by sharing that mixing ingredients that have undergone measuring is an important strategy when preparing for baking, explaining that flour has to be in its maximum quantities. As a result, the product was dependent on ingredients that were lesser than others. That is known as a limiting reactant or limiting reagent in a chemical reaction.

Learners responded to the following questions:

Question No. 1.

From the tabled example above, what is the number of tentative sandwiches to be produced?

It is likely possible that one can produce approximately 10 slices of bread and cheese, meaning each slice of cheese is catered for two slices of bread [C Group].

Question 2:

Classify the limiting ingredient in the scenario above.

The group's limiting ingredient is slices of bread. [A Group].

Question 3: Which of the following ingredients is in excess?

There is an excess of cheese because some slices of cheese remain. [D Group].

For students to have a clearer understanding, the teacher felt it imperative to use figures and diagrams to explain the chemical equation, beginning with the reactants, which can be molecules or atoms. To functionally use diagrams together with balanced equations when chemical reactions are being modelled, it is important to note that when equations are balanced, it is then ensured that each element applied on the reactant side produces an equal amount when equated to the product side. The figure demonstrated therefore was intended to indicate that in a case where three carbon molecules were on the reactant side, automatically so the product side correspondingly contains three carbon molecules. As the law of conservation of matter stipulates, reactants can either be solid or liquid and can be described in terms of mass or volume.

9. Fruitfulness

Fruitfulness is the final stage of conceptual change theory. Any new concept designed needs to benefit learners as this would allow them opportunities and exposure to real-life circumstances, thus leading to future-content learners, as argued by Posner et al. [9]. Following the demonstration, learners continued to discuss the events associated with chemical reactions and energy concepts. The main goal of these discussions was to demonstrate how functional and effective the newly learned concepts were. Learners seemed to have accomplished these experiments as they shared their real-life experiences extracted from occurrences from their immediate and diverse environments.

10. Industrial reaction to produce fertiliser

Question: According to the following equation, sulphuric acid (H_2SO_4) reacts with ammonia (NH_3) to produce the fertiliser ammonium sulphate ($(NH_4)_2SO_4$):

$(NH_4)_2SO_4 = H_2SO_4(aq) + 2NH3(g)\ (aq)$

How much ammonium sulphate can be made from 2.0 kg of sulphuric acid and 1.0 kg of ammonia?

Answer

Step 1: Convert the sulphuric acid and ammonia masses into moles

$n(H_2SO_4) = m/M$

$=2000$ g/98.078 g/mol = 20.39 mol $n(NH_3) = 1000$ g/17.03 g/mol = 58.72 mol

$=1000$ g/17.03 g/mol = 58.72 mol

Step 2: Determine which of the reactants is limiting using the balanced equation.

According to the balanced chemical equation, one mole of H_2SO_4 reacts with two moles of NH_3 to produce one mole of $(NH_4)_2SO_4$. As a result, 20.39 moles of H_2SO_4 must react with 40.78 moles of NH_3. In this case, NH_3 is in excess, and H_2SO_4 is the limiting factor.

In the following equation, sulphuric acid (H_2SO_4) reacts with ammonia (NH_3) to produce the fertiliser ammonium sulphate ($(NH_4)_2SO_4$):

$H_2SO_4(aq) + 2NH_3(g) = (NH_4)2SO_4\ (aq)$

What is the maximum mass of ammonium sulphate that can be obtained from 2.0 kg of sulphuric acid and 1.0 kg of ammonia?

Answer

Step 1: Convert the mass of sulphuric acid and ammonia into moles n.

Step 3: Determine the maximum amount of ammonium sulphate that can be produced.

Answer

According to the equation, the mole ratio of H_2SO_4 in the reactants to $(NH_4)_2SO_4$ in the product is 1:1. As a result, 20.39 moles of H_2SO_4 will produce 20.39 moles of $(NH_4)_2SO_4$.

The maximum mass of ammonium sulphate that can be produced is calculated as follows:

m = n M = 20.41 mol 132 g/mol = 2694 g

The maximum amount.

The teacher further asked a question referring to example 9,

Why is it necessary to produce fertilisers? [Teacher].

For the production of good quality food. [G3L2].

How the necessary concepts of quantitative aspects of chemical change were clearly explained by the teacher with clarifications that industry productivity also depends on these critical aspects of change.

After the intervention post-test was administered, the post-test was identical to the pre-test. The results show that learners' performance in a post-test improved significantly when compared to the pre-test. The results are analysed and interpreted using a table and graph.

A close examination of the post-test reveals that the intervention process had a positive influence on the results. 60% of the learners achieved more than 50%, indicating that more learners understood the concept. Only 20% got less than 30%.

10% got between 30% and 40%.

11. Interviews

Focus group interviews were conducted with 12 Grade 11 Physical Sciences learners for this study. Three groups of learners were formed. The category of these three formed by four learners in each were coded as (FL). The interviews were conducted to determine how well learners have gained new knowledge through collaborating with others when experiments were conducted. In the group of 50 learners, there was a mix of varying learner abilities from low to high achievers.

At the conclusion of the intervention, all learners took part in focus group interviews. The goal was to get their thoughts on how to implement the lesson. During interviews, learners were asked how they performed in the pre-test versus the post-test, as well as what motivated their responses. According to the responses, all of them scored higher on the post-test because of how the lesson was presented. They compared the lesson presentation to how it is usually taught. The following codes were obtained based on the responses of the learners: activities, experiments, learner participation, group activities, writing activities and approach preference (**Table 4**).

Learners reported that the experiments and demonstrations done in class were the main difference, as they had never done science experiments before. One learner stated that the way the teacher presented the lesson made them grasp all the

Codes	Learners quantity & percentage
Activities and experiments	50 (100%)
Learner participation and group activities	50 (100%)
Writing activities and preference approach	50 (100%)

Table 4.
Learners distribution in percentages indicating codes identified from data gathered.

information, while the other stated that it was their first time doing experiments in class. All learners stated that they usually made notes, but this time, they wrote laboratory reports, which increased their knowledge retention. In terms of teacher-learner engagements, it was reported by learners that it was their norm to listen and form self-compiled notes, concurrently; for this lesson, there was maximum learner participation. Learners also shared that all learners engaged themselves in discussions as they were eager to see the experiment outcomes. This is supported by one learner who uttered: 'there was exchange of ideas throughout the discussions'.

As indicated by some learners, there were improved collaborations as learners were exposed to working with class members who never belonged to their groups. This has led to the formation of new friends and the extension of social skills. Another achieved skill, as perceived by learners, was compiling reports of what they observed, which was seen to have improved their writing capabilities.

Another learner indicated that they enjoyed writing by themselves. All of them preferred the way the researchers presented the lesson, citing reasons such as learning better, being motivated, enjoying the lesson, participation and involvement, and retention of new knowledge.

12. Discussion

In this investigation, a conceptual change approach was administered to have a better understanding of quantitative aspects versus chemical change.

The study found that there was an improvement in learners' scientific understanding after pre-test and post-test. The study recommends a well-designed conceptual change instructional approach that leads to significantly better acquisition of scientific concepts. The study is significant because it addresses the issue of poor performance in Physical Sciences, particularly in the Eastern Cape Province of South Africa. The study suggests that a conceptual change instructional strategy is an effective teaching strategy that can be used to improve learners' understanding of science concepts. The study also highlights the importance of designing learning environments that allow learners to become aware of their current internal justifications and beliefs, which is essential for promoting conceptual change and improving problem-solving abilities. The study employed a qualitative research methodology, which is appropriate for exploring learners' misconceptions and difficulties on quantitative aspects of chemical change. The study used a case study approach and collected data from 50 learners and 12 teachers. The study used the Chemistry Achievement Test (CAT) to create lessons for the intervention programme and to determine the learners' alternate conceptions. The CAT examinations were piloted on a small sample of Grade 11 Physical Sciences teachers from neighbouring schools to confirm topic validity. The study's findings suggest that the conceptual change approach is an effective teaching strategy that can be used to improve learners' understanding of science concepts. The study recommends a well-designed conceptual change instructional approach that leads to significantly better acquisition of scientific concepts. The study also highlights the importance of designing learning environments that allow learners to become aware of their current internal justifications and beliefs, which is essential for promoting conceptual change and improving problem-solving abilities. Overall, this study provides valuable insights into the use of conceptual change instructional strategy to improve learners' understanding of science concepts [14]. The study's findings have important implications for science education in South Africa and other countries facing similar challenges. The study suggests that science educators should consider using conceptual change instructional strategy to improve learners' understanding of science concepts and promote problem-solving abilities.

13. Findings

The conceptual change approach was effective: The study found that the conceptual change approach was an effective teaching strategy that led to a significant improvement in learners' scientific understanding after pre-test and post-test. This means that learners who participated in the conceptual change instructional programme had a better understanding of the quantitative aspects of chemical change than those who did not participate in the programme.

Importance of designing learning environments: The study highlighted the importance of designing learning environments that allow learners to become aware of their current internal justifications and beliefs, which is essential for promoting conceptual change and improving problem-solving abilities. This means that teachers should create a classroom environment that encourages learners to reflect on their existing ideas and beliefs about a topic so that they can challenge and change them when necessary.

Qualitative research methodology: The study employed a qualitative research methodology, which is appropriate for exploring learners' misconceptions and difficulties on quantitative aspects of chemical change. This means that the study used open-ended questions and interviews to collect data on learners' understanding of the topic, rather than relying on standardised tests or surveys.

Case study approach: The study used a case study approach, which involved studying a particular group of learners or a specific classroom setting in depth. This allowed the researchers to get a detailed understanding of the learners' existing ideas and beliefs, as well as the effectiveness of the conceptual change instructional programme.

Use of Chemistry Achievement Test (CAT): The study used the Chemistry Achievement Test (CAT) to create lessons for the intervention programme and to determine the learners' alternate conceptions. The CAT examinations were piloted on a small sample of Grade 11 Physical Sciences teachers from neighbouring schools to confirm topic validity. This means that the study used a standardised test to assess learners' understanding of the topic and to create lessons that addressed their specific misconceptions.

Implications for science education: The study's findings have important implications for science education in South Africa and other countries facing similar challenges. The study suggests that science educators should consider using the conceptual change instructional strategy to improve learners' understanding of science concepts and promote problem-solving abilities. This means that science teachers should incorporate a conceptual change approach into their teaching practice to help learners overcome their existing misconceptions and develop a deeper understanding of scientific concepts.

14. Conclusion

In conclusion, this study provides valuable insights into the use of a conceptual change instructional strategy to improve learners' understanding of the quantitative aspects of chemical change. The study found that the conceptual change approach was an effective teaching strategy that led to a significant improvement in learners' scientific understanding after pre-test and post-test. The study also highlighted the importance of designing learning environments that allow learners to become aware of their current internal justifications and beliefs, which is essential for promoting conceptual change and improving problem-solving abilities.

The findings of the study have important implications for science education in South Africa and other countries facing similar challenges. Science educators should consider incorporating a conceptual change approach into their teaching practice to help learners overcome their existing misconceptions and develop a deeper understanding of scientific concepts. This approach has the potential to improve learners' academic performance and promote problem-solving abilities, which are critical skills for success in science and beyond. Overall, this study highlights the importance of adopting innovative teaching strategies that are grounded in educational research to promote effective learning and improve educational outcomes.

15. Recommendation

Based on the findings of this study, there are several recommendations that can be made for science educators and policymakers. Firstly, science educators should consider incorporating a conceptual change approach into their teaching practice to help learners overcome their existing misconceptions and develop a deeper understanding of scientific concepts. This approach should be implemented in a well-designed learning environment that allows learners to reflect on their existing ideas and beliefs, which is essential for promoting conceptual change and improving problem-solving abilities. Secondly, policymakers should consider investing in teacher training and professional development programmes that focus on innovative teaching strategies that are grounded in educational research. These programmes can help to equip science teachers with the skills and knowledge they need to implement effective teaching strategies that promote conceptual change and improve educational outcomes. Lastly, further research should be conducted to explore the effectiveness of the conceptual change approach in other areas of science education and in other contexts. This can help to provide more evidence on the effectiveness of this approach and inform the development of more effective teaching strategies in science education.

Author details

Zanele Ginyigazi*, Lungiswa Nqoma, Bulelwa Makena and Pretty Thandiswa Mpiti
Faculty of Education, Walter Sisulu University, South Africa

*Address all correspondence to: zginyigazi@wsu.ac.za

IntechOpen

© 2024 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

References

[1] Chirau T, Less L, Mapitsa CB, Smith L, Thabane M. Diagnostic Report. Pretoria: Department of Basic Education; 2018

[2] Department of Education. National Diagnostic Report. Pretoria; 2016

[3] Omeodu MD, Adolphus T, Alabi DA. Implementation of physics education curriculum for skill development among students in tertiary institutions in rivers state. Advance Journal of Education and Social Sciences. 2023;**8**(2):1-14

[4] Swafiyah B, Muhammad BA, Yamusa AZ. Effect of conceptual change instructional strategy on chemistry Students' performance in acids and bases concepts. ASEAN Journal for Science Education. 2023;**2**(1):47-54

[5] Addido J, Burrows A, Slater T. The effect of the conceptual change model on conceptual understanding of electrostatics. Education Sciences. 2022;**12**(10):696

[6] Syuhendri S. Teaching for conceptual change on Newton's first law. In: Journal of Physics: Conference Series. Vol. 2165, No. 1. Philadelphia: IOP Publishing; 2022. p. 012036

[7] Ebru T, Fulya OP, Hakan A, Vuslat YC, Necdet S, Nuray C, et al. Analysis of various potential prognostic markers and survival data in clear cell renal cell carcinoma. International Braz J Urol. 2017;**43**:440-454

[8] Chinyere NM, Madu B. Effect of analogy teaching approach on students' conceptual change in physics. Greener Journal of Educational Research. 2014;**4**(4):119-125. DOI: 10.15580/GJER.2014.4.032414160

[9] Posner GJ, Strike KA, Hewson PW, Gertzog WA. Toward a theory of conceptual change. Science Education. 1982;**66**(2):211-227

[10] Baidoo J, Adane M, Luneta K. Solving algebraic fractions in high schools: An error analysis. Journal of Educational Studies. 2020;**19**(2):96-118

[11] Ivey G. Interpreting hidden meaning in qualitative research interview data: Opportunities and challenges. Qualitative Research in Psychology. 2023;**20**(1):21-51

[12] Magwilang EB. Teaching chemistry in context: Its effects on students' motivation, attitudes and achievement in chemistry. International Journal of Learning, Teaching and Educational Research. 2016;**15**(4):60-68

[13] Djudin T. Transferring of mathematics knowledge into the physics learning to promote students' problem-solving skills. International Journal of Instruction. 2023;**16**(4):231-246

[14] Djudin T et al. Writing reflective journal and corrective feedback: The endeavors to increase students' physics achievement of dynamic fluids. Jurnal Ilmu Pendidikan Fisika. 2020;**5**(3):141-150

Edited by Murat Tezer

This book takes the reader on a journey of metacognitive learning. You are invited to explore mental processes to understand and learn key concepts. The authors help readers discover their learning potential by informing them about how thought processes work, while also offering practical strategies and techniques. This book not only offers a deep understanding of the learning process but also offers readers practical steps to improve their cognitive abilities. If you want to discover and develop your learning potential, this book will be an indispensable guide for you.

Katherine K.M. Stavropoulos,
Education and Human Development Series Editor

ISSN 2755-9513
ISBN 978-0-85014-164-1

Published in London, UK
© 2024 IntechOpen
© NeoLeo / iStock

IntechOpen