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ADVANCED LEARNING AND TEACHING ENVIRONMENTS - INNOVATION, CONTENTS AND METHODS

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Meet the editors

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Contents

Preface

In a global world, the society has suffered many changes in all orders, and the school is not alien to these changes and paradoxes. Technology has burst into the working world, and we are unable to predict what new professions will be in the nearest future. Teachers are forced to train the citizens of the future in the current context. Their students should be equipped with the skills, abilities, and knowledge necessary to successfully face an uncertain future and live in a diverse and changing society. Teachers should also support their students in the construction of flexible and complex identities.

In a way, we could talk about the technological revolution that schools have experienced in recent years. Information and communication technology (ICT), information technology (IT), and new information and communication technology (NICT) are common words in the educational language. It might be useful to remember that ICT refers to the theories, tools, and techniques used in the treatment, processing, and transmission of information: information technology, Internet, and telecommunications.

On the other hand, learning and knowledge technologies (LKT) refer to the educational use of ICT in schools, that is, technologies are used to improve and innovate in educational processes, to facilitate the collective construction of knowledge, the creation of active learning and personalized teaching.

The educational landscape of schools has been changed by the emergence of ICT in the educational world. New digital resources and methodological strategies have emerged in teaching and learning processes, at compulsory and postcompulsory educational stages and also in higher education.

For this, permanent formation is necessary and education throughout life takes on a full meaning. Teachers need to be trained in order to acquire new knowledge, but they also need to reflect on their own practice in the classroom and exchange experiences with other teachers.

Training courses are necessary to update the knowledge and acquire new strategies, but we must not forget that teachers also learn from their practice in the classroom, from the daily work with their students; they guarantee a response to the educational, personal, and socio-emotional needs of their students.

However, the classroom is not an island or a fief of the teacher, and the twenty-first-century teachers should work collaboratively with their colleagues and share an inclusive center project. In the initial training, as shown by one of the works presented, it is important to do a training period in schools, but the completion of the practicum does not ensure by itself the achievement of the necessary skills to be a good teacher; the observation of educational situations and the reflection on their own practice could be very useful to acquire the re-

quired competences and skills; and at this point, the use of digital resources could help students to achieve their objective.

The pages of this book summarize the passion and experiences of teachers and researchers from different disciplines and contexts in different countries. This fact allows us to build a rich and global vision on the state of the art and deepen in some aspects.

This book is made up of chapters written by different authors. In a synoptic way with a rigorous process of expository and argumentative quality from various approaches, it goes through different formative perspectives in the stages of compulsory and postcompulsory education, with special emphasis on initial and continuous training of teachers; the new training demands, on the role of ICT in educational centers and on e-learning; and the use of new methodological resources based on ICT. But we would not like to neglect other methodologies no less innovative used in different disciplines such as physical education, which has its own section.

In these chapters, we emphasize the values of universality and the transversality of its contents. All of them provide suggestive nuances and interesting practices, which will undoubtedly improve teacher training and practice. Also, we would like to express our gratitude to the authors of each chapter for sharing their experiences and the results of their research. All these texts, which are exposed below, are original and actual and have been rigorously selected. Most derive from research and apply the scientific method, but others take the form of essay and provide well-founded reflections.

The readers who come from the world of teaching will find some answers to their teaching needs and new ideas to implement in the classroom. But this book will also be useful, without any doubt, to readers who come from other fields of knowledge. For all these reasons, we appreciate the opportunity to present this book that, due to the quality of the contributions and the prestige of the publisher that supports and publishes them, will undoubtedly constitute a work of reference for future research work on these topics.

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Section 1

Learning to Be a Good Teacher - Connectivity, Digitization, Innovation

Chapter 1

Pedagogical and E-Learning Techniques for Quality Improvement of ICT Education

Mgnas Fernando

Additional information is available at the end of the chapter

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Abstract

This chapter elaborates how the pedagogical and e-learning techniques are useful in enhancing the quality of Information and Communication Technology (ICT) education in developing countries. From the literature review and outcomes of other surveys, it was proven that the pedagogical techniques are one major missing component of an ICT education system in developing countries, including Sri Lanka. To raise the quality of ICT education, this study has developed a prototype model to increase the usage of pedagogical techniques and digital learning environment in the ICT education activities. The proposed model is designed with six activity levels. Each level in the model is aligned with the levels of Bloom's taxonomy and other pedagogical techniques, which is embedded in the levels of Bloom's taxonomy. The model was validated by a panel of teachers and was tested in the school environment too. The validity of performance was proved using six hypothesis tests and other methodologies. The analysis shows that the students' performance in problem solving has increased by 19.5% due to the different treatment levels used. It was also proved that the embedded techniques (mixture of traditional and modern pedagogical methods) are more effective in skill development of students compared with the existing context.

Keywords: pedagogies, Bloom's taxonomy, e-learning, quality, ICT education

1. Introduction

Information and Communication Technology (ICT) applications, in particular with the education system, might change the future of the underdeveloped world, eliminating the digital divide from the education system both locally and in the international arena [1]. However, there are some challenges that the developing world faces in trying to adopt ICT to the education

sector. These challenges relate to: limitation of funds, Internet access, lack of trained staff, hesitation to change to new technologies and policy inadequacy. Several researchers and educationists have suggested that ICT would be an important part of education for the next generation.

Modern technology offers many means of improving the teaching and learning process in the classroom. In comparison to developed countries like UK, USA, Singapore, etc., ICT skills of students in developing and developed countries, including Sri Lanka, show no comparative improvement as evident in the school system. Based on experiences gained in developed counties as well as with instructions and guidelines of local and international experts, responsible implementers have carried out several activities to enhance ICT education. Yet, no combative significant improvement has been reported regarding ICT education.

ICT is a major ingredient for rapid development and should be implemented through the school platform. As such, researchers are keen to explore how this could be done. Considering the abovementioned facts, investigating the quality improvement and exploration of research possibilities of ICT education in the Sri Lankan educational system is considered appropriate because Sri Lanka is a rapidly developing country in Asia. This study elaborates on a researchable framework toward improvement of quality ICT education. It utilizes existing resources while improving the methodologies along with pedagogical techniques and e-learning approaches used in the secondary schools of Sri Lanka.

2. Importance of ICT for the teaching, learning and evaluation (TLE) process

The strategic role played by Information and Communication Technology (ICT), nowadays, is undisputed as ICT has merged with almost all of our day-to-day activities. ICT has paved the way to be informed, keep abreast and contribute toward evolving technology as well. ICT has made inroads to almost every sphere resulting in a heavier burden on education as both the current and future workforce need to be well-equipped to meet the demands of the communication age. It is education that has to play a major role toward the supply of high quality and skillful professionals capable of handling both present and future needs. Current trends make it imperative for higher education in the country to seriously think about and if necessary, completely overhaul, if the country aspires to make revolutionary changes in development. The message seems to have gained ground and ICT education has received prominence with the education process.

The quality of higher education or improvements of a school depends on dimensions such as quality learners, quality learning environments, quality content, quality processes and quality outcomes [2]. The effectiveness of the teaching and learning (TL) process consists of five subprocesses such as curriculum design, pedagogical design, implementation quality, outcomes assessment and resource provision [3]. Pedagogical design is an important component in these subprocesses, and it is an independent factor regardless of the standard design of higher education or school education where pedagogical techniques are easily adopted by the educational communities [3]. Contemporary definitions describe pedagogy as the art, profession or science of teaching. Accordingly, pedagogy can be defined as an effective way of

describing the relationships between teaching, learning and assessment in classrooms [4, 5]. There is also a belief that to talk of pedagogy is to talk of the appropriate ways teachers interact with learners.

2.1. Pedagogy

There is no accepted universal ultimate model for effective pedagogy or quality teaching, learning and evaluation (TLE). The ultimate outcome expected from a quality TLE process is to enrich students with an expected level of skills regarding cognitive, affective and psychomotor quantifiers against the expected skill levels of the course unit or educational program. Traditional definitions describe pedagogy as either science/theory or art/practice of the TLE process that makes a difference related to the cognitive, affective and psychomotor levels of students. New pedagogies can be defined concisely as new models of TLE partnerships between and among students and teachers. The aim is to achieve deep learning skills. The goals require making use of prevalent digital access through various technologically innovative digital tools.

Studies on pedagogy reveals that pedagogical talents will provide much support toward actuation of TLE skills required to face the changes in TLE process in the twenty-first century. Educational experts also recognize that the majority of transmission or knowledge delivering processes is highly ineffective for the twenty-first century as against the expected competencies and skills of learners [4]. However, it is experimentally and practically provided that learners need skills such as critical thinking, innovation capabilities, ability to communicate efficiently and effectively, problem solving abilities through negotiation and collaboration, and so on. Therefore, pedagogical involvement of the TLE process is a vital component of a skills development process of learners. Accordingly, TLE process should be embedded in the new pedagogical techniques toward achieving student outcomes with expected skills. This can be done through digital accesses with new tools and technologies related to ICT [4].

2.2. Importance of pedagogy

Many countries in the world still remain economically poor. This affects their technological status. It can be argued that various reasons contribute toward poverty and economies. As such, there is an imbalance between the economic situation and technological aspects. This imbalance, in turn, will directly affect the quality of an education system leading to a digital included [5]. Among countries and within a country, there are disparities, province-wise, district-wise and rural and urban situations too. Whereas in some parts of the world, ICTs are contributing to revolutionary changes in the development process, in other parts of the world, the lives of people have hardly been touched by these innovations. Therefore, by providing such facilities at a reasonable level, the development process of developing countries or poor, can be enhanced and isolation from new inventions can be minimized up to some extent.

As discussed earlier, most ICT experts and educationists recommend that ICT technology can be used to minimize the digital divide in different situations. It is an undisputed fact that future economies and even potential for innovations with technology of any country would depend on the quality of education provided [6]. When one discusses quality education, one

of the key ingredients toward quality education is pedagogy. To achieve quality education, pedagogical techniques need to be incorporated with the TLE process, in addition to other factors such as human resources (teachers and other resource persons, etc.) and physical resources (classroom facilities, labs, computers and multimedia devices, etc.).

Toward providing deep learning skills to the student community, first, the teachers should have skills with deep learning activities [7]. To equip teachers for this purpose, this chapter provides an experimental model for teachers to accrue deep learning skills and means to transmit the gained knowledge to the student community. This is to be done through an activity-based learning environment incorporated with ICTs. The process for the proposed model is based on a pedagogical innovation platform. It is arranged in the following ways: (1) through classroom training and practices with innovative pedagogical techniques using interactive ICT techniques and e-facilities (both teacher-directed and self-regulated learning), (2) participating in and practicing with pedagogical innovation techniques through professional learning communities and (3) implementing stages (1) and (2) with students in the school environment.

2.3. ICT education and pedagogy

Subject matter and pedagogical training are important concepts in the design of teacher training programs [8]. It is apparent that most ICT teacher training programs in developing countries lack a robust theoretical framework [9]. It is imperative for ICT teaching and learning methods and methods of teacher training to blend meaningfully toward maintaining quality with ICT education. Therefore, pedagogical techniques have to be embedded in ICT training programs to obtain expected outcomes [10]. Quality methods related to teaching and teacher

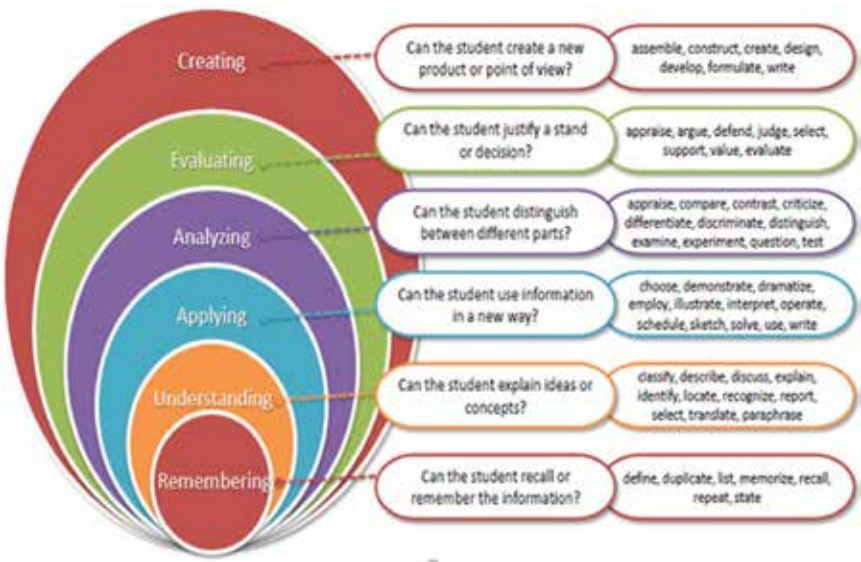

Figure 1. Revised Bloom's taxonomy (source: http://pcs2ndgrade.pbworks.com/w/page/46897760/Revised%20Bloom's%20Taxonomy (last accessed on 02/03/2017)).

training are essential to achieve the learning outcomes maintained in international quality standards. One of the internationally accepted quality educational methodologies of teaching and learning is Bloom's taxonomy. However, other pedagogical techniques can also be used for the development of quality ICT education.

2.4. Quality enhancement with Bloom's taxonomy

Bloom's taxonomy is considered an internationally accepted quality educational pedagogy for teaching and learning. An exploration of the theoretical foundation of the revised Bloom's taxonomy reveals that the levels of learning and similar useful and appropriate verbs (as shown in **Figure 1**) of the revised Bloom's taxonomy can be used to implement quality teaching and learning processes.

Developed countries use pedagogical methodologies [4] like Bloom's taxonomy to enhance the quality of their teaching and learning processes.

3. Digital learning environment (e-learning)

The digital learning environment is a successful technique to acquire required skills and knowledge with teacher training programs [11] as well as in the students' learning paradigm [12, 13] in the modern world. In this era, ICT education and general education are equipped with a digital learning environment [13, 14]. An examination of the literature on ICT for education reveals that the quality of one's education tends to improve particularly through continuing existing face-to-face learning and distance education which is also called blended learning [2, 15]. Blended learning refers to the design and delivery of right content in the right format using the right mix of media. It combines online digital media with traditional classroom methods requiring the physical presence of both teacher and student, with some element of student control over time, place, path or pace.

In the last three decades, there have been great changes in the education landscape of economically advanced countries. For example, increasing access to education has resulted in the diversification of student populations that have a wide range of learning styles and learning needs which are quite different from the traditional and elitist student populations. At the same time, education institutions are asked to respond to the demands of globalization and the knowledge economy, to prepare students with twenty-first century skills and competencies for the labor markets, which require changes in the curriculum and teaching practices. There are demands for increased efficiency, more transparent accountability and better performance in both research and teaching. Some policy makers see digital technology as a tool to help manage some of these changes, and in particular, to use it as a transformative tool in teaching and learning [16]. Further, developed economies use the blended approach, whereas in developing countries, its usage is minimal [1]. Therefore, by introducing blended learning approaches to the teaching and learning paradigm, quality education and ICT education can be achieved [16]. Accordingly, blended learning techniques [e-Books, Learning Management Systems (LMS) activities, e-discussion forum, etc.] are highly useful techniques for the achievement of quality with education.

4. Important learning methodologies and other pedagogies

Literature reviews reveal that activity-based learning and problem-solving activities are greatly contributing toward the enhancement of ICT education in schools [10, 17]. Further, other pedagogical techniques like Kolb's excremental reflective learning model [18, 19], facial expression and emotional models also contribute highly toward the quality of education in the teaching, learning and evaluation process [18].

4.1. Activity-based and problem-based learning

Activity-based learning is a comprehensive approach for classroom teaching and learning that is designed to engage students in investigation of authentic problems [8]. Activity-based learning provides goals mastery versus ability, learning versus performance and task versus ego involvement [8]. Further, activity-based learning has a higher probability of producing greater achievement than the non-manipulating lesson [18]. Problem-based learning through activities highly increases the enthusiasm of the students due to the following reasons: involvement of students in problem-solving authentic problem and in working with others and building real solutions with the use of new technological innovation. Problem-based learning through activities have a high potential to enhance deep understanding because the student needs to acquire and apply information, concepts, principles and they have the potential of improving competence in thinking (learning and metacognition) because students need to formulate plans, track progress, and evaluate solutions [8].

4.2. Kolb's experiential learning circle

Kolb's experiential learning circle could provide much support toward the educational development process in several situations [19]. **Figure 2** shows the four-stage process of Kolb's experiential learning circle.

Further, Kolb's experiential learning theory [17] described as follows:

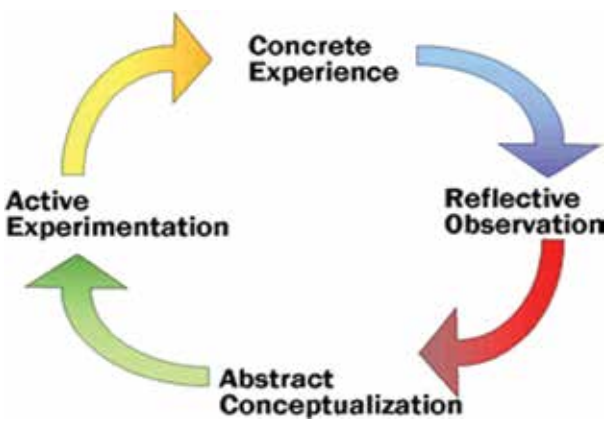

Figure 2. Kolb's experiential learning circle (based on [17]).

Stage	Description
Concrete experience (CE)—DO	Where the leaner is actively experiencing an activity (e.g., a laboratory session, field class)
Reflective observation (RO)—OBSERVE	Where the learner is consciously reflecting back on that experience
Abstract conceptualization (AC)—THINK	Where the leaner is being presented with/or tries to conceptualize a theory or model of what is (to be) observed
Active experience (AE)—PLAN	Where the learner is trying to plan how to test a model or theory or plan a forthcoming experience

Table 1. Kolb's experiential learning circle [11].

Stage	Description	Activities to help
Concrete experience	Kolb's cycle starts with a concrete experience. In other words, it begins with doing something in which the individual, team or organization is assigned a task. The key to learning, therefore, is active involvement. In Kolb's model, one cannot learn by simply watching or reading about it, to learn effectively, the individual, team or organization must actually do.	Laboratory experience, reading, team games, problem solving, discussion, practical exercises, field work.
Effective observation	The second stage in the cycle is that of reflective observation. This means taking time-out from "doing" and stepping back from the task and reviewing what has been done and experienced. At this stage, lots of questions come out from "doing" and stepping back from the task and reviewing what has been done and experienced. At this stage, lots of questions are asked and communication channels are opened to other members of the team. Vocabulary is very important and is needed to verbalize and discuss with others.	Ask for observation, write a short report on what took place, give feedback to other participants, brainstorming sessions, rhetorical and thought questions, completing learning logs or diaries.
Abstract conceptualization	Abstract Conceptualization is the process of making sense of what has happened and involves interpreting the events and understanding the relationships between them. At this stage, the learner makes comparisons between what they have done, by reflecting and what they already know. They may draw upon theory from textbooks for framing and explaining events, models they are familiar with, ideas from colleagues, previous observations or any other knowledge that they have developed.	Lecture, papers and present models give theories, facts, project and analogies.
Active experimentation	The final stage of the learning cycle is when the learner considers how they are going to put what they have learnt into practice. Planning enables taking the new understanding and translates it into predictions as to what will happen next or what actions should be taken to refine or revise the way a task is to be handled. For learning to be useful most people need to place it in a context that is relevant to them. If one cannot see how the learning is useful to one's life then it is likely to be forgotten very quickly.	Give learners time to plan, use case studies, use role play, ask learners to use real problems.

Table 2. Learning theory of Kolb's experiential learning cycle.

Concrete experience	Reflective observation	Abstract conceptualization	Active experimentation
Reading, examples, fieldwork, laboratories, problem sets, trigger films, observations, simulations/ games text reading.	Logs, journals, discussion, brainstorming, thought questions, rhetorical questions.	Lecture, papers, projects, analogies model building.	Projects, fieldwork, homework, laboratory, case study and simulations.

Table 3. Different learning aspects of Kolb's experimental learning circle [11].

Kolb's experiential learning cycle is the most widely used learning theory in experiential research due to its implementation feasibility with educational activities (**Table 1**). The abstract—basic principle of Kolb's reflective process for education development [20, 21] is shown in **Table 2**.

Table 3 summarizes the activities that support the different aspects [17] of Kolb's experiential learning circle.

4.3. The universal facial expression of emotion model

The universal facial expression of emotion model and stakeholders' feedback play a major role in quality evaluation in the teaching and learning paradigm [18]. Developed countries use evaluation of quality through facial behavior of teachers in teacher training programs as well as in implementing such programs in their schools. The universal facial expression model shows different stages of the facial expression of emotion model. The changes come in seven stages. The seven stages are: happy, surprise, contempt, sadness, fear, disgust and anger [18].

5. Importance of pedagogical techniques in ICT education and general education

It is believed that quality ICT education is dependent on nine factors [22, 23]. In this regard, national goals, country expectations, budget allocation, international benchmarks and standards related to quality ICT education such as (1) infrastructure facilities, (2) human resource facilities, (3) maintenance and sustainability plans, (4) software, (5) curriculum implementation facilities,(6) policy matters, (7i) support from the administration and supportive initiative, (8) research and development and (9) budget allocation and country expectations are considered essential factors toward quality with ICT education.

Further, the investigation reveals that pedagogical techniques greatly contribute to the maintenance of quality with ICT education [23] together with the nine quality factors mentioned. Therefore, to determine its application to the Sri Lankan context, a sample survey was conducted with the following sample.

In the sample survey, the following sources were used to collect the required information in connection with ICT education in Sri Lankan schools using three structured questionnaires. Thirty-five principals, 1295 students and 48 ICT teachers from 35 schools in five districts participated. In addition to this, a variety of stakeholders (e.g., Ministry of Education (MOE), National

Institute of Education (NIE), Universities and ICT experts in industry, etc.) in ICT education and different methodologies (classroom observation and workshops) were used in the survey. As fact gathering instruments, questionnaires, unstructured interview schedules, classroom observation sheets and workshop monitoring sheets were designed and used to gather information related to the pedagogical usage of ICT education in Sri Lankan Schools. It took more than 6 months for the data collection process in the sample survey that included both privileged and underprivileged districts. Random judgment sampling technique was used to select the sample.

The Kruskal-Wallis test on total ranks for usage of pedagogical techniques under the curriculum implementation facilities/technique on ICT teachers and principals' point of view is used to prove the attitudes toward the usage of pedagogical techniques for the implementation of ICT education. Used in the Sri Lankan ICT context, the results revealed to be very poor and lacking in many respects. The confidence interval for the mean and median also support the same. Based on the outcomes of the literature review and sample survey, it was concluded that there is a lack of pedagogical involvement in ICT education in developing countries, including Sri Lanka. Considering the abovementioned issues, the experimental application model was designed and implemented under a test environment to minimize the lack of pedagogical usage and incorporate the blended learning technologies into ICT education.

6. Experimental application model for enhancement of quality ICT education

The abovementioned exploration shows that there is a lack of pedagogical techniques and blended learning activities in the ICT educational development process in developing countries, including Sri Lanka. Further, it was highlighted that the quality of ICT education can be increased incorporating pedagogical and blended learning approaches to the teacher training programs and subsequently classroom teaching activities with students [23].

Toward enhancing the quality of ICT education, the following experimental model was designed and implemented on an experimental platform in selected schools in Sri Lanka. This model was tested in two stages. In stage 1, the implementation of the proposed experimental application model was with selected teachers (as training of trainers). With their feedback and other reflective aspects, the model was smartened. In stage II, the enhanced model was implemented in the school environment with the support of the trained teachers referred to above, and with their students. Based on their feedback and practical complications, the model was further smartened as appropriate. In designing the application model, the revised Bloom's taxonomy was used as the key methodology of the study and e-learning concepts, principles in Kolb's Experimental Learning Circle, activity-based learning, peer learning, and other theoretical and practical activities were used as supplementary techniques of the application model.

The experimental application model consists of six activity levels including the traditional face-to-face learning as activity level one besides other five activity levels. The other five activity levels cover one or two levels of the revised Bloom's taxonomy incorporating the other

techniques especially in blended learning activities with reflective practice where necessary. All the activities are designed to achieve the best possible outcome in the learning domains such as knowledge, attitude and skills.

The application model was developed by incorporating all the abovementioned theoretical aspects and validated with the practical implementation platform. Stage I was tested by an expert panel comprising an ICT domain expert, an ICT instructor and nine leading ICT experienced teachers through a series of face-to-face and e-learning activities inclusive of all the abovementioned activities and pedagogies.

In addition to the stakeholders' feedback and suggestions, the success of the model was evaluated using the implementation of the seven-stage facial expression model. Outcomes of the seven-stage facial expression model were used to smarten and fine-tune the experimental application model. Stage I also made use of two submodules that are as follows: (1) Sub Module 1: Master Teacher and Teacher Trainers' Model—initially master trainer implemented the abovementioned experimental pedagogical model with his/her trainers [hereafter referred to as: training of trainers (i.e., with the selected nine teachers)]. In implementing Sub Module I of Stage I of the Model, the master trainer provided facilities to use Sub Module II of stage I. (2) Sub Module II: Peer-to-Peer Learning Model: the main task of this submodule is to share or transmit knowledge among the different stakeholders using the application model to mitigate the knowledge gap. This model used peer learning activities through digital learning approaches like e-learning approaches, usage of learning management systems (LMS), discussion forum and reflection guidelines.

The second stage of this model was experimentally implemented by the nine trained teachers with 61 students from three different schools. The second stage too consists of two submodules: (1) Sub Module (III)—Trained Teacher-Student Model and Sub Module (4)—Peer-to-Peer student model. The implementation of Sub Module (3) and Sub Module (4) are similar to the implementation of Sub Module I and Sub Module II, respectively. However, the implementation of stage I is handled by a master trainer with teacher trainers (training of trainers), while stage II is implemented by the trained teachers with their students. This is the only difference. The implementation and final evaluation were based on the outcomes of students' activities carried out by the nine trained teachers referred to, abovementioned text, in three different schools with the help of the researcher. Finally, the proposed application model was further fine-tuned using the fundamental theory embedded in Kolb's Experiential Learning Circle when practiced in the school environment.

7. Sample presentation of the activity models

The proposed experiential application model consists of six activity models. The first activity model (Activity Level 1) includes the existing face-to-face traditional approach while the other activity model covers one or two levels of Bloom's taxonomy. Each activity model included other pedagogical techniques already discussed in addition to the e-learning approaches. As a sample approach, Activity Model 2 is represented as follows:

7.1. Activity Model 2

This sample Activity Model 2 covers the first level of Bloom's taxonomy (keywords are used according to similar verbs given in **Figure 1**) and it was implemented according to the guidance given in Kolb's Customized Reflective Learning Circle guidelines given in **Figure 2** and **Tables 1–3**.

7.2. Implementation of the second activity model of the proposed approach

This sample question is based on the first level of Bloom's taxonomy and it covers all four stages of Kolb's Experiential learning Circle in addition to other techniques.

Exercise 1.1. Define the basic data types used in Python programming language. List how different data types can be used to solve application with problem-solving activities. You may use simple examples to illustrate the answer.

The abovementioned exercises were introduced in four stages so as to provide comprehensive learning experiences to the stakeholders.

Stage 1: Activities in connection with concrete experience in Kolb's Experimental Learning Circle

i. Provided lecture notes, e-materials, sample solved related questions.

ii. Granted access to online help facilities with the Python programming language.

iii. Provided facilities for peer discussion to further strengthen individual answers.

Stage 2: Activities in connection with reflective observation in Kolb's Experimental Learning Circle

i. Conducted brainstorming session in connection with the different data types in Python, their applications and how to apply these data types with activities related to problem solving with real life applications.

ii. Provided environment to judge own solutions in connection with different data types and applications.

iii. Provided facilities to maintain a reflective log in connection to the outcomes to the question in activity model 1.

Stage 3: Activities in connection with abstract conceptualization in Kolb's Experimental Learning Circle

i. Conducted a series of lectures in connection with the following methodologies: Bloom's taxonomy and its application, blended learning approaches (e.g., to use e-materials, educational websites, familiarizations with LMS and online courses) in connection with the data types and application in Python provided in the sample course materials.

ii. Provided facilities to use stage 1 of Bloom's taxonomy in connection with data types and their application.

iii. Provided guidance to design learning activities using the first level of Bloom's taxonomy to achieve the learning outcomes. Guidance was given for the preparation of examination questions using the first level of Bloom's taxonomy.

iv. Provided facilities to discuss/create a forum on some important contents of programming and problem-solving activities through an online discussion forum making use of individual answers and explored possibilities to enhance the definition using e-materials in educational websites.

v. Provided facilities to conduct a rhetorical and thought question session related to covering the learning outcomes coming under the first level of Bloom's taxonomy.

vi. Provided facilities to use LMS activities in connection with activities and evaluation related to the different data types and problem-solving activities in Photon programming languages using the first level of Bloom's taxonomy.

vii. Provided facilities to discuss within peer-peer student groups and master teacher-student approach related to the first level of Bloom's taxonomy.

Stage 4: Activities in connection with the active experimentation in Kolb's Experimental Learning Circle

i. Provided a brainstorming session to encourage the use of Bloom's taxonomy, blended learning approaches, LMS, Kolb's experiential reflective learning session and stakeholder feedback for further enhancement.

ii. Provided facilities to prepare own learning materials using peer-discussion, blended learning approaches (e-learning materials, LMS), brainstorming sessions according to the first level of Bloom's taxonomy.

iii. Provided facilities to design own evaluation materials using the abovementioned methodologies for practice with their students according to the first step of Bloom's taxonomy.

Other activity models cover the remaining stages of Bloom's taxonomy and within each level of Bloom's taxonomy executed at all the stages of Kolb's Excremental Learning in addition to the other blended learning technologies. This proposed model is expected to achieve both surface and the deep learning outcomes based on the mixture of traditional pedagogical techniques with modern e-learning techniques in a collaborative and active learning platform.

8. Methodology for the validation of the model through statistical investigation

Students' knowledge about programming and problem solving were tested at six activity levels, which is the application model previously discussed. They were activity levels 2, 3, 4, 5 and 6 against the initial level (activity level 1: face-to-face traditional approach). The evaluation of the activity levels with a common series of evaluation papers were used in three different schools and their feedback collected. For the outcome of the evaluation test at each level

of activity, paired t-test was used to determine the improvement among the levels of each activity (hereafter called treatments). In all, five hypotheses were used and each hypothesis was used to determine improvement between two consecutive activity (treatment) levels.

The following five hypotheses were tested and labeled as hypothesis 1–5:

Let μ1, μ2, μ3, μ4, μ5 and μ6 were population mean marks at face-to-face traditional approach (Activity Level 1) to Activity Level 6 (proposed different levels), respectively.

As the first hypothesis, Activity Level 1 and Activity Level 2 were used as follows:

H0: μ1 = μ2 (mean values of marks are same in both treatments).

H1: μ1 < μ2 (mean marks of treatment 1 < treatment 2).

Similarly, other four hypotheses were used for pair's treatment as follows: μ2 versus μ3, μ3 versus μ4, μ4 versus μ5 and finally, μ5 versus μ6, and hypothesis were labeled as hypothesis 2, hypothesis 3, hypothesis 4 and hypothesis 5, respectively.

The outcome of the paired t-test of each hypothesis was obtained. It was decided that the acceptance of hypotheses or rejected, based on the 5% significant level P value ($p < 0.05$, then the null-hypothesis can be accepted).

Further, to investigate any variations in the outcomes of the experimental model school wise (analyze the difference between the groups), the analysis of variance (ANOVA) statistical model was used.

8.1. ANOVA test for comparison of performance school wise

To test the difference between the schools' performance in connection with the outcome of the implemented application model, the hypothesis 6 was used.

Hypothesis 6:

H0: students' performance in School A, School B and School C is the same (i.e., H0: μ School A = μ School B = μ School C).

H1: students' performances are different in at least one school from others (H1: At least one mean mark is different from the others).

Based on the P value of ANOVA table, one can decide whether H0 can be rejected. If 95% confidence interval level p value is greater than α (0.05), therefore, H0 cannot be rejected.

9. Implementation of the experiential application model under the test platform

According to the methodology described earlier, the implementation of the proposed model was carried out and few samples of the implementation are represented in **Figure 3**.

Figure 3. (Left) Implementation of application model to the introductory session. (Right) Introduction to Bloom's taxonomy and how to apply Bloom's taxonomy to the teaching and learning.

The session output shows that the teachers were motivated to learn Bloom's taxonomy and motivated teachers used Bloom's taxonomy in their teaching and learning paradigm of ICT, which was embedded in the proposed application model. During and after the series of Stage 1 of the study, the success of the session was observed and analyzed using the facial behavior of teachers using the Seven Universal Facial Expressions of Emotional Methodology.

According to the analysis outcome of the seven universal facial expressions of emotional methodology, on average, 74% of teachers happily did the activities included in the application model. This result shows a 24% of increase with respect to the initial situation (before implementing the application model).

9.1. Implementation of the proposed model in respective schools

Activities, implementation procedure and results of the trained teacher-student and peer-to-peer student model (the Sub Module 3 and the Sub Module 4) are as follows:

The activities used in Sub Module 1 and Sub Module 2 were applied to the implementation of Sub Module 3 and Sub Module 4 using the role model approach. Initially, teachers conducted the face-to-face session using course materials provided at the training of trainers' implementation sessions as in the role model approach. Some trainers (teachers) had also prepared daily course materials and activity sessions based on the experience obtained from the series of workshop sessions in Sub Module 1 and 2. Further, trainers provided facilities to conduct peer student group discussions as they learned from the series of workshops. Samples related to the implementation of the proposed model in schools using the role model are shown in **Figure 4**.

In implementing Sub Module 3 and Sub Module 4 in the respective schools, trainers used blended learning approaches learned from Sub Modules 1 and 2. Teachers applied the application model activities learnt from Sub Module 3 and Sub Module 4 in a reflective and enhanced manner. On some occasions, the researcher gave feedback through classroom observation sessions. The evidence can be seen in **Figure 4**.

The application models were implemented and tested fulfilling the specified requirements in selected schools using the role model approach and using the design approach shown in model. Teachers were able to fine-tune the application model with their students with the help of the

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Figure 4. Sample event at the implementation of the proposed model in respective schools.

researcher. At the beginning, students also used face-to-face activities toward their learning process. After a series of lessons, they were motivated to use blended approaches to enhance the learning process. Based on the feedback of students, teachers and the ICT instructor, the researcher was able to judge the success of the application model through the facial behavior of the students and outcome of the inferential statistics analysis.

10. Outcomes of the study

The following section shows the results in implementing the proposed experimental application model in selected schools. Based on the statistical analysis techniques, as shown in the following sections, it proved the validity of the experimental model and its suitability for a developing country like Sri Lanka.

10.1. Evaluation of the proposed application model

The final evaluation of the proposed application model is based on the outcome of students' activities carried out by the trained teachers in three different schools with the help of the researcher.

A sample of 26 students from School A, 16 students from School B and 19 students from School C were selected based on availability. Students' knowledge about programming and problem solving were tested at six levels. They were face-to-face, Activity Level 1, Activity Level 2, Activity Level 3, Activity Level 4, Activity Level 5 and Activity Level 6. The mean mark of each block at each treatment level was calculated and is given in **Table 4**.

Treatment	Block		
	School A	School B	School B
(1) Activity Level 1 (face-to-face)	40.50	47.25	42.00
(2) Activity Level 2	42.20	49.25	43.67
(3) Activity Level 3	46.21	51.80	47.74
(4) Activity Level 4	50.35	56.06	54.72
(5) Activity Level 5	55.20	59.60	58.39
(6) Activity Level 6	60.00	67.31	63.00
	N1 = 26	N2 = 16	N3 = 19

Table 4. Mean marks of each block at each treatment.

Further, during the implementation, test cases were performed. In all test cases, common evaluation activities were given. These activities were prepared at the implementation of the application model stage with teachers. **Table 4** shows the students' mean marks for different treatments.

According to the abovementioned results, it was concluded that there is a gradual increase in students' performance when proper implementation of the application model is carried out. For each treatment, paired t-test was used and the following outcomes were obtained. As input to the paired t-test, mean data given in **Table 4** was used. Further, paired t-test was used to test the improvement between the levels of each treatment.

Similarly, **Table 4** shows that $\mu 2 < \mu 3$, $\mu 3 < \mu 4$, $\mu 4 < \mu 5$ and $\mu 5 < \mu 6$. In other words, students' performance has increased in an incremental manner.

In addition to the outcome of the hypothesis testing, **Figure 5** shows the performance of students with different activities.

Figure 5 shows students' performance increasing at each activity level. Further, all the schools show a pattern of increase in performance behavior.

The inferential outcomes and the graphical representation from implementing the proposed application model helped to conclude that the activities contained in the activity series contributed toward increased student performances.

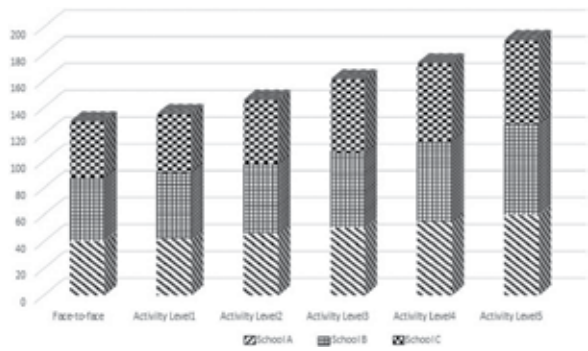

Figure 5. Stack chart to represents students' performance in different activities in three schools.

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To investigate school wise variations (analyze the difference between the groups) in the above conclusion, the following analysis of variance (ANOVA) statistical model was used.

10.2. ANOVA test for comparison of performance school-wise

To test the difference between school wise performance in connection with the outcome of the implemented application model, the following hypothesis was used.

Hypothesis:

H0: students' performance in School A, School B and School C are the same (or HO: μ School A = μ school B = μ School are same).

H1: Students' performances are different at least in one school from among others (or H1: At least one mean is different from the others).

P value of ANOVA is 0.416. So that 95% confidence interval level p value is greater than α (0.05). Therefore, H0 cannot be rejected. It is not evident that performances are different by school wise. Ninety-five percent confidence interval for mean marks also confirms the same (confidence intervals are overlap). According to the outcome of the abovementioned statistical model, it was concluded that students' performance increase remains the same in all three schools (**Table 5**).

The application model confirmed its validity through the explored statistical models. It is interesting to note that the general view of the teachers who participated in the testing of the application model in schools was that the model looks feasible toward enhancing the quality of ICT education in Sri Lanka and, with proper investigation it can also be extended to other developing countries.

Source	**DF**	**SS**	**MS**	**F**	**P**		
School	2	114.2	57.1	0.93	0.416		
Error	15	920.2	61.3				
Total	17	1034.3					
S = 7.832 R-Sq = 11.04% R-Sq(adj) = 0.00%							
Individual 95% CIs For Mean Based on Pooled StDev							
Level	N	Mean	StDev	− + −	− + −	− + −	− + − ---
AnulaVidyalaya	6	49.077	7.583	(−----------*----------)			
Samudra Devi Bal	6	51.587	8.435	(−----------*----------)			
Thursten College	6	55.212	7.442	(−----------*----------)			
− + −	− + −	− + −	− + −				
45.0	50.0	55.0	60.0				
Pooled StDev = 7.832							

Table 5. One-way ANOVA: marks versus school.

11. Conclusion

The proposed experimental application model contains a mixture of traditional educational pedagogies and modern blended learning technologies to address the issue regarding enhancement of quality ICT education in Sri Lanka. The model has proved that Bloom's taxonomy levels provide more skills enhancement to teachers as well as to students in an effective manner if it is blended with e-learning technologies. Further, the model reduces the complexity of the TLA process and helps in achieving learning outcomes. Incorporating features like Kolb's Reflective Learning Circle and other techniques such as activity-based learning and problem-based learning in different levels of Bloom's taxonomy has proved that more skills development of teachers and students can be achieved effectively compared to the existing methodologies. When the model was implemented, differences in performance levels of students in different schools were not noticed and this fact has been proved through the statistical analysis. It has also been proved that the proposed application model is suitable to enhance the quality of ICT education in Sri Lankan schools. Therefore, it can be concluded that the application model using a researchable framework could help improve the quality of ICT education and enhance the teaching, learning and assessment (TLA) process in Sri Lankan schools effectively. Hence, it is recommended that the proposed experimental model can be used first to train the teacher-trainers island-wide. However, once trained, teacher-trainers need to actively practice and sustain with their students what was newly learned. To conclude, the usage of the proposed framework would, undoubtedly, help to improve the existing methodologies along with pedagogical techniques and e-learning approaches in ICT education of Sri Lankan schools as well as in other developing countries. Adhering to the process, probably, would help to overcome global ICT challenges in the schools' environment.

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Chapter 2

The Use of the ASSIM Model for Technology Integration in Instructional Delivery by Faculty Members and Pre-Service Teachers

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Additional information is available at the end of the chapter

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Abstract

This chapter presents an instructional model that promotes and facilitates the changing role of both the learner and the teacher in a twenty-first century teaching-learning environment that is technology driven. The model provides a pedagogical approach that is student centred with the teacher assuming the role of a facilitator in the student learning process. Qualitative methods of data collection were used in collecting the data that were used in the development of the model. Document analysis and focus group interview were used for data collection at the preliminary stage of the study while developing the model. The model was tested for a period of 3 years. Interview and observation were used for data collection during and after the testing period. Document analysis was used in analysing the data collected from documents while content and thematic analysis were used in analysing the data collected from interviews and observations. Findings from the study indicated that the use of the model facilitates the development of inquiry skills, critical thinking and problem-solving skills among the pre-service teachers who participated in the study.

Keywords: technology integration, twenty-first century pedagogy, twenty-first century teaching-learning environment, social sciences, changing role

1. Introduction

Information technology (IT) has over the years made remarkable impact in the education industry at all level and in the world over as applicable to other sectors of the global economy [1]. Advancement in the IT sector has made the web a source of unlimited content for all subject disciplines that can be accessed anytime anywhere in the world over. This development has necessitated a shift in the role of teachers from that of being knowledge providers to that

of facilitating the process of accessing information to develop and construe knowledge by learners. Thus, teaching and learning is gradually becoming more students centred, activity-oriented and inquiry-based. Teachers are now faced with the challenge of designing instructions that promote the use of student-centred pedagogy, encouraging students' inquiry as a base for knowledge construction. It has help to improve the process and quality of instructional delivery, learning and research, as well as facilitating access to educational products (knowledge, values and skills) and services to global community of learners, educational practitioners and the industry [2, 3]. Generally, educational practices and it products at all levels revolve round the use and dissemination of information relating to knowledge, values and skills development for the overall improvement of the human race as responsible citizens of a global society [4]. Innovative use of IT facilities in the education industry has made this process easier, faster and convenient. Educational practitioners can now collaborate globally with their peers in conducting researches and in instructional delivery as distance across the globe is no longer a barrier to communication of any nature.

From nineteenth century to date, stakeholders of the education industry are continuing to provide educational institutions with information technology (IT) equipment of different nature to improve educational practices [5, 6]. Schools and institutions of higher learning are now equipped with computers and internet while students goes around using different kind of internet enabled devices (laptops and Smart Phones) as their learning tools [7, 8]. This development has revolutionised the process of teaching and learning in educational institutions making ICT an integral part of the teaching-learning process [9], thus ushering the twenty-first century teaching-learning environment that is technology driven [10]. The emerging twenty-first century teaching-learning environment has transformed the role of parties involved in teaching and learning [11, 12]. Learners are now actively involved in the process of building knowledge, whereas teachers mentor and facilitate the process of construing knowledge by learners [13]. Instructional objectives are now directed toward the development of skills for life-long learning and knowledge construction for problem solving and decision-making in a global economy [14]. New pedagogical designs to meet the demand of the twenty-first century learner and the twenty-first century teaching-learning environment are now fast emerging, and the process of instructional delivery is taking a new dimension [15, 16]. This chapter considered some theoretical underpinnings explaining the emergence of twenty-first century pedagogical designs and also present an instructional model for the attainment of twenty-first century instructional objectives in the arts and social sciences.

2. Theoretical considerations in the development of twenty-first century pedagogical designs

The 'teaching-learning environment' (as referred in the context of this study) is a platform where learners acquire knowledge, values and skills (education) through instructional delivery. Instructional delivery on the other hand is the process of providing relevant information that can help the learner acquire knowledge, values and skills needed in problem-solving and decision-making. The two concepts ('teaching-learning environment' and 'instructional delivery')

can be formal (in a school setting with a well-structured curriculum) or informal (outside the school with no structured curriculum). In whatever form they exist, the two concepts are dynamic (changing over time and space in history). In the context of this work, we are particularly concern with the formal situation (that is instructional delivery in a school setting). Traditionally, instructional delivery in a school setting has to do with a face-to-face interaction between the teacher and the learner. In the process of such interaction, the teachers provide learners with information and explain relevant concepts, theories and processes that can help the learner acquire education in a given subject area. There are different ways, techniques and approaches to instructional delivery (pedagogy) that the teacher can use. Instructional delivery is a very complex process that requires careful planning and implementation; this has to do with the choice of pedagogical design and how it can be used to achieve instructional objectives.

The choice of a pedagogical design for instructional delivery is largely influenced by the nature of the learning environment where the instructions would hold; nature of the subject content to be delivered and characteristics of the learners [17]. Thus, the teacher is expected to have a good knowledge of pedagogy, subject content and knowledge of educational psychology to be able to design and deliver a face-to-face classroom instruction. As a result of these, curriculum studies and educational psychology (theories of learning) in addition to knowledge of specific subject disciplines becomes the major knowledge domains of pre-service teacher education and training [18]. Knowledge of the interplay between subject content knowledge and knowledge of pedagogy in instructional design and delivery becomes additional knowledge domain known as pedagogical content knowledge (PCK) in teacher education [19, 20]. However, changes in the nature of the teaching-learning environment as influenced by the presence of information and communication technology (ICT) have made the choice of pedagogy for instructional delivery a more complex process.

With computers and internet as new features that have come to stay in the twenty-first century teaching-learning environment [21], knowledge of curriculum, educational psychology and pedagogical content knowledge are no longer enough in designing and delivering instructions using ICT [22, 23]. Knowledge of technology (use of ICT) is critically needed in pre-service teacher training and education in preparing teachers to teach in the computer and internet age [24]. This situation has made the TPACK (Technological, Pedagogical and Content Knowledge) theory relevant for twenty-first century teacher education and training [25]. In addition to the knowledge of curriculum, educational psychology and pedagogical subject content [19] as core knowledge domains of teacher education, 'technology' is now added [22]. Adding technology to the core domains of teacher education has ushered in additional sub-domains of equal importance in teacher education; that is, technological content knowledge (TCK), technological pedagogical knowledge (TPK) and knowledge of the interplay of all the domains combined known as technological, pedagogical and content knowledge (TPACK). The TPACK theory provides a framework that build on the Shulman theory by integrating the knowledge of technology into pedagogical practices and teacher education. The theory emerged as a result of the concern over the persistent criticism on the lack of theoretical framework and underpinnings for technology integration in educational practices. Driven by this concern, the theory attempts to capture the essential qualities of teacher knowledge required for technology integration in teaching. The framework provides a complex and

new approach that is all embracing in pedagogical practices, teacher education and teacher training in line with societal reality of the present information age. The focus of the theory is on the complex role and interplay of 'content', 'pedagogy' and 'technology' in teacher education and general pedagogical practices. The framework for teacher education and training that emerges from the TPACK theory provides seven knowledge domains that are critically needed in training the teachers who can bear relevance to the emerging twenty-first century teaching-learning environment and the need of the twenty-first century learner. The seven knowledge domains are briefly explained below:

1. *Content Knowledge:* as conceived in the theory refers to the knowledge of the actual learning content, skills and values of specific subject discipline that is to be learned or taught. That is knowledge of the teaching subject in the case of pre-service teacher training. It implies the need for teachers (in the case of pedagogical practices) and pre-service teachers (in the case of teacher education and training) to have a proper and in-depth understanding of the subject (they teach or are to teach) as the case may be. This would include concepts, values, skills, theories and procedures within a specific subject discipline (teaching subject) [22]; knowledge of explanatory frameworks that organise and connect ideas and knowledge of the rules of evidence and proof [24]. It also entails the need to know and understand nature of inquiry and knowledge in other subject disciplines to be able to understand why and how a proof in maths, for example, would have to differ from that of historical explanations [24].
2. *Pedagogical Knowledge:* has to do with the need for teachers to have a proper understanding of teaching methods for instructional delivery as relate to the overall goal and values of education in society. This knowledge for the teacher is generic involving all issues relating to classroom learning; classroom management; development and implementation of lesson plan and the evaluation of students learning [22]. As applicable to this study, it entails the need for teacher educators to equip pre-service teachers with the necessary knowledge that would help them in understanding the: techniques and methods of classroom instruction; nature of the students in view (to teach) and the strategies of evaluating students' achievements in the learning process. As noted in literature, a teacher with deep pedagogical knowledge will have a good understanding of how students understand and construct knowledge; acquire skills and develop habits of mind and positive disposition toward learning [22]. As such, it requires an understanding of cognitive, social and developmental theories of learning and how they are utilised in classroom situation.
3. *Pedagogical Content Knowledge:* as consistent to what Shulman in his theory conceived as 'knowledge of pedagogy' applicable to a particular subject discipline, pedagogical content knowledge (PCK) entails knowing the appropriate teaching methods for specific (topics of the) learning contents and an understanding of how learning contents of subject disciplines can be arranged and rearranged to facilitate the process of classroom teaching and learning. It therefore involves: the development and representation of concepts, values and skills; pedagogical techniques; knowledge of what makes concepts, values and skills easy or difficult to understand and learn; knowledge of students background in the subject area and epistemological theories of the subject discipline. It requires teachers to have knowledge of teaching strategies that incorporates appropriate conceptual representations to address learners' difficulties and misconceptions [22]. It involves:

a. Knowledge of what the learner brings to the learning environment may be either facilitative or dysfunctional to the learning activities at hand.

b. Knowledge of students learning strategies, prior conceptions (naïve and instructional).

c. Knowledge of possible misconception that students may have on specific areas.

d. Knowledge of possible misapplication of previous knowledge and learning experiences.

4. *Technological Knowledge:* is the knowledge that teachers and pre-service teachers need to have about 'standard technology' and 'advanced' technology; particularly, those considered to have potential usability in educational practices. 'Standard Technology' as conceived in the TPACK framework refers to the conventional instructional materials such as the chalk board, books, pictures, manual projectors, posters and maps as used by teachers in traditional classroom settings. The 'Advanced Technologies' on the other hand is referred to the computer, internet, software and digital video (digital technology or modern ICT). For the later, it implies the need for teachers to have:

a. Knowledge and skills of operating systems and computer hardware.

b. Knowledge and skills of using the internet; the ability and competence to use the tools and facilities in computer software/applications.

c. Knowledge and skills of software instillation and removal.

d. The ability to attach and remove computer peripheral devices.

In teacher education programme, this implies the need for teacher educators to make provisions in their pedagogical practices that would help the pre-service teacher in acquiring this knowledge. However, because of the rapid changes of the advanced technologies, the structural framework for the provision of this knowledge to teachers and pre-service teachers need to be dynamic [22, 24].

5. *Technological Content Knowledge:* is a knowledge domain that entails the need for teachers understanding of how 'technology' relates to 'subject content' in pedagogical practices and how knowledge of the two can be integrated and utilised to advantage in pedagogical practices. It involves knowledge of how subject content can be changed or represented by the use and application of technology in classroom instructions.

6. *Technological Pedagogical Knowledge:* is the knowledge of how particular technology can be effectively utilised in facilitating specific teaching-learning process and how instructional processes and pedagogical practices are likely to change as a result of using such technology. Thus, teachers and pre-service teachers need to know and understand that lots of digital tools exist that can be used in facilitating instructional delivery. Teachers should therefore have the skills and knowledge of selecting appropriate technological tools that can fit into particular pedagogical designs and can facilitate the attainment of instructional goals and objectives. This would require:

a. Knowledge of pedagogical strategies.

b. Knowledge of technology and its application in educational practices.

c. Knowledge and skills of integrating the two in instructional practices.

d. Application of the integrated knowledge for specific instructional delivery in classroom learning.

7. *Technological Pedagogical Content Knowledge:* is all embracing of the six knowledge domains identified above. It is an emergent form of knowledge that goes beyond all the three major components of teacher education. It differs from knowledge of a subject discipline, knowledge of technology and also from general pedagogical knowledge shared by teachers across disciplines [22]. It requires the need of not only understanding the six types of knowledge identified above as being necessary in teacher education and pedagogical practices, but also:

a. the ability to integrate the six types of knowledge into a single knowledge base and framework that can be used for instructional delivery;

b. the ability to utilise the integrated knowledge base effectively in teaching-learning situation to facilitate the attainment of educational goals and objectives and

c. an understanding that the framework of teacher education training and general pedagogical practices in schools and colleges is likely to change as a result of this knowledge and its application in education.

This knowledge should form the foundation needed for technology-based instructional delivery in a twenty-first century teaching-learning environment [22]. The technical application of this knowledge in teaching-learning situations would require:

a. The knowledge and skills of concept representations using technology.

b. The knowledge of pedagogical strategies that accommodates the innovative use of technology for content delivery in classroom instruction.

c. The knowledge of students learning process, what makes concepts difficult or easy to learn and how technology can be used in addressing such learning difficulties in classroom situations.

d. The knowledge of epistemological theories.

e. Knowledge and application of technology in developing epistemological theories.

Instructional design and delivery in the twenty-first century teaching-learning environment requires knowledge of TPACK [26]. The teacher would have to consider the instructional objectives to be achieved in the instruction as stated in the curriculum in relation to the peculiar nature of the learners to be taught [27]. This consideration should guide the teacher in his selection of the learning content to be delivered [28]. The teacher would have to make a decision on what teaching method (pedagogy) to be used in delivering the selected learning content [29]. This decision should be influenced by the learning objectives to be achieved, nature of the learning content and characteristics of the learners [30]. Then, select suitable technologies that can on one hand facilitate the delivery of the instruction and, on the other hand, facilitate learning [31]. The choice of technology to be used has to be influenced as well by the nature of instructional objectives to be achieved, characteristics of the learners to be taught, nature of the subject content to be delivered and the pedagogy to be deployed [32]. Above all, the teacher

would have to consider the overall philosophy, goals and objectives of education of the nation as may be defined in the national policy on education [33]. This complex process of decision making as influenced by quite a number of interdependent considerations in the design of instructional delivery has necessitated the emergence of innovative pedagogical designs. Consequently, a number of instructional models guiding the application of the TPACK theory in different subject areas have emerged of recent. In this chapter, an instructional model guiding the use of TPACK in instructional designs for arts and social science education is presented under the 'model of instruction for twenty-first century pedagogical design'.

3. The changing role of teachers and learners in the twenty-first century teaching-learning environment

The use of computer and internet in educational practices over the years has encouraged the changing role of teachers in the teaching-learning process. During the pre-computer and internet age, the teacher in a face-to-face classroom instruction is considered a source of knowledge for learners. The teacher who is expected to have a good mastery of the subject content of his discipline is expected to provide learners with information and explain concepts, theories and demonstrate procedures where applicable. The learner on the other hand is expected to sit, listen and watch the teacher to understand the information being provided by the teacher. The teacher in this process is the provider of knowledge. Teaching and learning is therefore teacher centred. The students rely on the teacher as the source of subject content for learning. The classroom in this system is a place for giving and receiving lectures. This approach to instructional delivery only appeals to the cognitive development of the learner and rely heavily on paper-pencil examination technique in evaluating learners achievement in the instructional process; thus, undermining the process of developing learners critical thinking skills and innovation. The traditional teacher-centred pedagogy as largely practiced lay emphasises on acquisition and retention of knowledge rather than on it application. With advanced information technologies deployed in the twenty-first century teaching-learning environment, the situation is no longer the same.

With computer, internet and the World Wide Web, learners no longer need to rely on the teacher for information on subject content. Learners can on their own access wide range of information for their learning anytime and anywhere on the web [34]. Learners now have unlimited access to learning content in word/pdf, video and audio formats. Students can chat, discuss and share learning resources through different online communication channels. With technology, learners have the information they need for their learning at their fingertips. With this development, the role of the teacher has to change from that of a knowledge provider and a source of information to that of a facilitator in the students learning process. The passive role of students listening to the teacher for learning content would also have to change. Learners would now have to be actively involved in the process of building and construing knowledge for themselves through the process of scientific inquiry: data collection, interpretation, analysis and interactive discussions. Interaction between teachers and learners would have to take a new direction. The classroom should no longer be a venue for lecture but a place where learners and teachers meet for reflection, critical discuss, problem solving, decision making

and to work on learning projects. The instructional model presented in the next section after the methodology should help teachers to assume their proper role as facilitators of students learning process in instructional delivery that is students centred, inquiry-based, project and problem-solving oriented.

4. Methodology

Qualitative research approach using documentation, interviews and observations were used as sources of data collection for this study sequentially. Documentation in a qualitative research design has to do with document analysis where the researcher identify, review, analyse and interpret or make meaning out of relevant documents for specific reasons. Such reasons may be for the purpose of gaining a deeper understanding of issues or situations under investigations; to clarify issues of interest; verify an assumption or to provide evidence that can help in answering research questions as may be applicable. In the case of this study, document analysis was used to verify the basic assumptions that provided the justification needed for this study. At the preliminary stage of the study, existing documents on theories of educational technology, theories of instructional designs and research findings relating to technology integration in educational practices were reviewed and analysed using 'content and thematic analysis'. Content and thematic analysis of documents has to do with critical review of documents and coding the content of the documents into themes and subsequent interpretation of the themes based on the understanding of the researcher. Three types of documents were analysed at the preliminary stage of this study. The first category of documents analysed was published articles in learned journals relating to technology integration in educational practices, theories of educational technology and instructional design. The second category of documents analysed is public documents available in schools, colleges of education and universities. Such documents provide information on curriculum content, the approved scheme of work for instructional delivery for the curriculum content; instructional objectives to be achieved and the recommended instructional strategy and resources to be employed in the instructional delivery process. Personal documents of school teachers and faculty members are the third category of documents analysed. The documents in this category provide the researcher with information about the kind of instructional strategy and resources that teachers and faculty members used in their instructional approach. Content of the three types of documents mentioned above was critically reviewed, interpreted and coded into emerging themes by the researcher.

Interpretations made by the researcher on the first category of documents analysed reveal that there are in existence quite a lot of varying theories of educational technology and instructional designs. However, detailed explanation and procedure of how such theories can be applied in instructional delivery for specific subject disciplines (particularly in the Arts and Social Sciences) in relation to specific curriculum content are needed. For example, the TPACK theory as discussed in item 2 in Section 2 provided a general justification for the inclusion of educational technology as a core component of teacher education domain to facilitate pre-service teachers' preparation for the use of technology in educational practices. But the theory

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did not provide the model of application for instructional delivery at the pre-service teacher training level or for subject disciplines at the school level. The researcher's interpretation of document content of published research findings relating to technology integration reveals that not much of the technologies provided in schools and institutions of higher learning are being effectively used in instructional delivery. It also reveals that technology integration in educational practices at all levels of learning is faced with varying challenges that differ over time and space. Interpretations of the content of the second category of documents analysed in this study reveal that teachers at all level are encouraged by the curriculum documents to shift away from the use of teacher-centred pedagogy to learner-centred pedagogy. The documents encourage teachers to develop skills of critical thinking, inquiry and problem solving among learners. But on the contrary, analysis of documents in category three shows that the use of teacher-centred pedagogical approach is still a dominant practice in schools and among faculty members. Teachers and faculty members still prefer the use of traditional lecture and demonstration approach at most using power point slides. Based on these interpretations, the researcher find justification to uphold the basic assumptions earlier developed to guide this study. Meaning that, there are justifications based on the document analysis conducted to develop technology integration instructional model for specific subject disciplines. Instructional models that can help teachers to assume the role of facilitators and learners to be actively involved in the process of building knowledge by themselves through inquiry and project-based learning in the instructional process.

Focus group interviews were conducted at the second phase of the study. Focus group interview is a method of data collection in qualitative research. The method allows the researcher to interact with all the selected participants as a group to discuss over issues of interest to the researcher. Such an interaction of the researcher and members of the focus group can be face-to-face or online as may be preferred. Members of the group can listen and make comments on each other's response to the questions raised. This approach encourages free flow of ideas, and each idea presented is shaped by the critique of others in the group. In this study, eight (8) participants were selected for the focus group interview using purposive sampling technique. All the selected participants are faculty members from two different universities. Two of the participants are faculty members in the Department of Arts Education; two from the Department of Social Sciences Education; two from the Department of Multimedia Education and two others from the Department of Educational Technology and Instructional Design. Four focus group interview sessions were conducted at weekly intervals. The four interview sessions were moderated by the researcher and lasted for about two to two and half hours each. The objective of the first focus group interview session was to generate data that can help the researcher to develop an instructional framework for Arts and Social Science subject disciplines where the teacher would only be a facilitator in the teaching-learning process. During the interview session, a research assistant was employed to write down the ideas presented. The transcribed ideas generated during this interview was later reviewed, interpreted and coded into themes. The second interview session was scheduled a week later. During the second interview session, the researcher presented an instructional framework that was developed from the ideas presented by the group during the first interview session. The group examines the framework presented and made further observations on how it can

be improved. The group suggested that each instructional activity in the framework should have a clear objective. Members of the group provided ideas on what should be the objective for each instructional activity in the framework. The research assistant was writing down the ideas presented. The session lasted for two and half hours. The transcribed data generated were sorted out, interpreted and coded into themes by the researcher after the session. The third interview session focuses on generating ideas on what kind of technology to be used for each instructional activity in the framework and how the framework can be tested. The session lasted for 2 hours. The fourth focus group interview session also scheduled a week thereafter lasted for 2 hours. The objectives of the last focus group interview was to generate ideas that can help the researcher in designing and developing an observation checklist and an interview protocol to be used for data collection during and after the testing period. The data collected during the third and fourth focus group interview sessions were also transcribed, sorted, interpreted and coded into themes. Thus, the ASSIM Model presented in the next section was developed from the ideas generated during the focus group interview sessions.

The ASSIM Model was tested for a period of 3 years—2014, 2015 and 2016—by faculty members. It was used in teacher education instructional delivery in the Arts and Social Sciences in four Colleges of Education. One week workshop on how to use the model was organised for the faculty members (in the department of Arts and Social Sciences Education) that tested the model in pre-service teacher training. Thirty-four faculty members attended the training workshop; 8 of the 34 faculty members who attended the training workshop adopt the use of the model for instructional delivery in their teaching. The pre-service teachers who participated in the testing of the model were randomly selected. Observation checklist and interview protocol earlier developed from the data generated during the focus group interview sessions explained above were used in collecting data during and after the testing period. The observation checklist was used during the testing period to observe how faculty members apply and use the ASSIM model in their instructional delivery. The observation checklist was also used after the testing period to observe how pre-service teachers apply and use the ASSIM model during their 1-year teaching practice assessment period. The interview protocol was used in collecting additional data from the participating pre-service teachers at the end of the testing period. Eight (8) pre-service teachers were randomly selected for the interview. Four of the pre-service teachers (two males and two females) were selected from the Department of Arts Education. The other four of the pre-service teachers (two males and two females) were selected from the Department of Social Science Education. The transcribed data collected from the observations checklist were sorted, interpreted and coded into themes. The orally recorded data collected from the interviews were transcribed, sorted, interpreted and coded into themes. Based on the interpretation of the researcher, findings from the data collected and analysed show that the use of the ASSIM instructional model in pre-service teacher training facilitates: 1. development of inquiry skills; 2. development of critical thinking skills; 3. development of problem-solving skills and 4. the use of information technology in teaching among the pre-service teachers who participated in this study during their teaching practice. The researcher considered the four items listed above as the emerging themes of the study to be presented and discussed in detail as findings of the study in Section 6 of this article.

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5. Model of instruction for twenty-first century pedagogical design

The presence of information technology in our institutions of learning has transformed educational practices in its totality. Education in general is now geared toward preparing the learner for global citizenship [35]. To achieve this, the education industry is now directing its effort toward the development of life-long learning skills [36], critical thinking skills and reasoning [37, 38], skills of informed decision-making and problem-solving skills [39]. The Arts and Social Sciences Instructional Model (ASSIM) presented in **Figure 1** is designed to facilitate the design and development of twenty-first century pedagogy that caters for the changing role of the teacher, the learner, the learning environment and the use of information technology in the teaching-learning process.

The ASSIM model of instruction presented in **Figure 1** is suitable for twenty-first century teaching-learning environment that is technology-driven as influenced by the philosophy

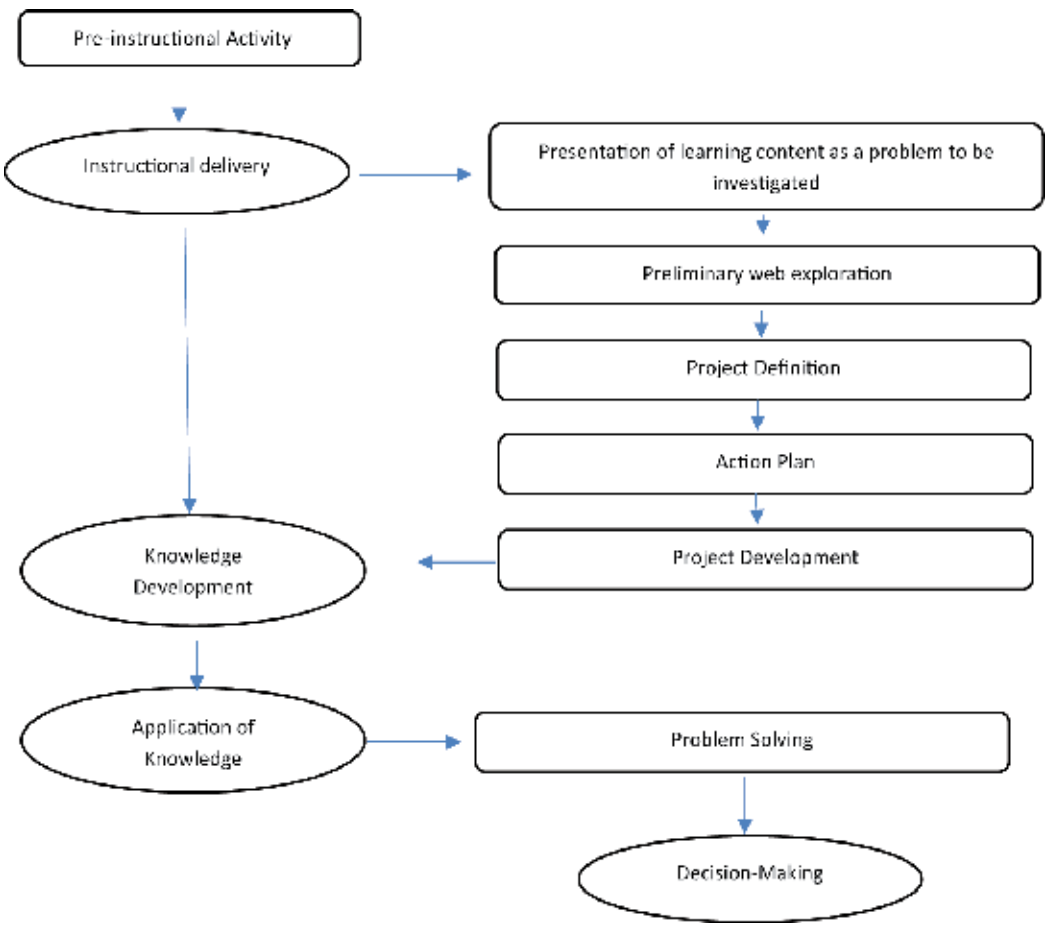

Figure 1. Arts and Social Science Instructional Model (ASSIM) for twenty-first century teaching-learning environment.

of globalisation. The model entails the blending of variety of teaching methods with the use of technology in a single pedagogical design for the teaching and learning of Arts and Social Sciences subject content in the twenty-first century teaching-learning environment. The model limits the role of the teacher to that of a facilitator in the teaching-learning process and promotes students' web-based inquiry, critical thinking, collaboration and team work in accessing and managing information to construe knowledge. Learning using the pedagogical design as presented in the ASSIM model would be learner centred and activity oriented using technology. Design of the model is influenced by the TPACK theory and the GPM instructional model.

6. Operational use of the model and its instructional benefits

6.1. The pre-instructional activity

As suggested in the model, teaching and learning in the Arts and Social Sciences should start with 'Pre-instructional Activity'. At this stage, the teacher should upload the summary of learning activities for the week in the student learning portal or the course website as may be applicable. In the absence of students learning portal or course website, email or alternative online means of communication can be used. The information to be uploaded or communicated to students prior to the commencement of face-to-face classroom interaction should consist of:

1. Summary of the course content to be covered for the week.
2. Learning activities scheduled for the week.
3. The learning objectives to be achieved for the week.
4. List of relevant concepts and theories.
5. List of web links for student's exploration.
6. The pre-instructional task to be completed before the commencement of the face-to-face classroom interaction.

The pre-instructional activity aims at helping the learner to have a picture of the overall goal of the course in view; and in particular, the learning objectives to be achieved on weekly basis and per learning content. The list of relevant concept and theories; web links for relevant learning content provided and the pre-instructional task to be completed would help the learner to utilise the web on his own to explore information that can help him/her (the learner) to have preliminary general understanding of the course and the learning activity for the week.

6.2. The face-to-face instructional delivery process

Step 1. Presentation of learning content as a problem to be investigated.

This is a teacher-centred face-to-face classroom activity. The teacher at this stage should make a short presentation of the learning content combining the use of lecture and demonstration

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methods as well as questioning technique. The presentation can be supported with the use of video clips, projected images and powerpoint slides. The presentation should not be aimed at explaining concepts, theories or procedures, rather a presentation of facts that depicts issues and problems in real-life situation related the learning content in view. At the end of the presentation, learners should be able to see real-life issues and problems that need to be addressed. The teacher should be skilful in his presentation to guide learners in understanding that there is the need for further investigation of the issues and problems presented if lasting solutions are to be suggested. Learners should understand from such presentations that critical thinking, inquiry and use of knowledge are the basis of decision-making for problem solving. At the end of this stage, therefore, learners should be able to identify real-life issues and problems requiring attention as relate to the course learning content. Thus, this stage is evaluated by the ability of learners to picture and identify issues and problems for further investigation. Once this is achieved, the teacher can proceed to the next step in the instructional delivery process that is 'preliminary web exploration'.

Step 2. The preliminary web exploration (hands-on-technology).

This activity is learner-centred and web-based. Now that learners were able to identify issues and problems, the teacher should give the learners some time to explore the web for information that can help them understand further the nature of the issues and problems identified. This should be done in the classroom and students can work individually or in groups depending on the size of the class and as may be agreed upon by both the teachers and the learners.

This activity should end with an interactive session or discussion under the guidance of the teacher. During the interactive/discussion session, learners should be guided to:

1. define the issues and problems identified;

2. establish the scope of each problem identified;

3. arrange the problems in their order of importance based on their magnitude;

4. decide on which issue or problem to work on as a project of the week.

Step 3. Project definition.

This step is still a learner's interactive session under the guidance of the teacher. Learners are to decide on what they want to do in addressing the issue or problem they have chosen to work on as a project. Learners at this stage should be able to:

1. develop basic assumptions, raise research questions and hypotheses if applicable;

2. decide on how and where to collect data or materials for the project;

3. decide on what to do with the data or materials collected for the project;

4. share responsibilities and

5. set rules of participation in the project.

Step 4. The action plan.

Learners at this stage are to breakdown their project work into units of activities and set timeline. They are also to decide on how many times the group members are to meet (face to face or online) as they may prefer.

Step 5. The project development.

This is an out of class learner's activity. The teacher has little or no role at this stage. Learners are to work on their project based on their action plan. The activity may involve data collection and analysis to answer research questions or test hypothesis depending on what they wanted to do.

6.3. Knowledge development

This is the second stage of the instructional delivery process where learners individually or in group present their findings. Learners are to critically examine their findings and suggest how it can be applied as knowledge. This may involve developing a model or building a knowledge-based procedure for addressing the issue they were investigating.

6.4. Application of knowledge, problem solving and decision making

Learners at this stage are to work on how to apply the knowledge construed/developed practically (pilot-testing) in addressing the issue under investigation. Learners are also to decide on what is needed in applying their solutions. It is at this stage that learners should develop and write their project report for submission to the teacher. The report should have a problem statement, objectives, methodology and solutions.

7. Findings of the study

7.1. Development of inquiry skills

Findings from this study show that the use of the ASSIM model in pre-service teachers training instructional delivery helps in developing skills of inquiry among the pre-service teachers. Continuous engagement of the pre-service teachers in preliminary web exploration during the second stage of the face-to-face instructional delivery process helps them to acquire and master the skills of web search. One of the interviewees reported that 'I was having difficulty with this activity at the initial stage but with the help of my friends in the class and constant practice; I have now mastered how to use keywords in different ways to search for the information I need on the web'. 'The web exploration activity in the classroom has helped me to understand the importance of the internet as a source of information. Instead of asking people for information now I prefer to Google' said another interviewee. Exposing the pre-service teachers to the web exploration activity has also helped them to acquire the skills of screening and sorting out online information. Data collected from the interview shows that most of the interviewees indicated that the result of a single search gives you an option of so

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much information that you get confused of which information to click and read. One of the interviewees reported that, 'when I realised that most of us have this problem of not knowing how to handle the result of our web search result in the classroom. I seek for help on my Facebook page and my friends on Facebook responded with lots of ideas and web links to articles that can help me with the skills of web search and data screening. The next day I share with the rest of the class members'. Another interviewee said 'this activity help us to have a more informed and wider view of the issues under investigation. It helps us to look at issues more from a global perspective'.

The use of the ASSIM model helps the pre-service teachers involved in the study to acquire the skills of building basic assumptions to guide research project. 'The information we gather during the preliminary web exploration help us build assumptions and we use such assumptions as guide for our literature review' said one of the interviewees. Analysis of the observation checklist shows that pre-service teachers were able to build basic assumptions and develop research questions and possible hypotheses from the assumptions. It was also observed that participants in the study (pre-service teachers) have acquired the skills of using the basic assumptions they have developed as a guide for their literature review. Analysis of the observation checklist also indicated that the pre-service teachers involved in this study have learnt to use different methods of data collection for their project and have learnt different methods of analysing their data. 'Sometimes we use the Facebook for data collection. It is very effective and very fast way of getting feedback' said one of the interviewees.

7.2. Development of critical thinking skills

The use of the ASSIM model helps to improve the critical thinking skills of the pre-service teachers involved in the study. Critical thinking is the objective, rational and unbiased analysis of situations or information to build factual evidence as a base for decision making and problem solving. It is a rational reasoning and reflection over information or situations. It is generally described as the ability to think clearly and rationally about what to do or what to believe [39]. It is a complex mental process that requires one to identify, construct and evaluate arguments; understand the importance and relevance of ideas and the logical connections between ideas presented as information, as well as to reflect on the justification of one's belief and values [40]. A critical thinker is any person with the ability to source and use information (knowledge) for problem solving and is able to deduce consequences from what he has known [41]. Critical thinking in educational practices is a mental process of rational reasoning and reflection that requires certain skills as listed below:

a. *Seeking Information*: meaning the ability to search for evidence, facts and knowledge. Based on the analysis of the observations made during the study, it was noted that the use of the ASSIM model has helped to improve the participants' skills of searching for information both online and offline. Engagement of the pre-service teachers in the preliminary web exploration activity in the ASSIM instructional design was particularly instrumental for the observed improvement in the skills for online information search. The pre-service teachers who participated in the study were also engaged in the process of data collection offline

using questionnaires, interview and observations for various learning projects. This activity has helped to improve their skills of offline data collection.

b. *Interpretation*: is the ability to understand given information and the ability to communicate the meaning of the information to others. It is a process of decoding and communicating information with clarity. Pre-service teachers involved in the study were engaged in interpreting the data they collected during the preliminary web exploration and the main data they have collected through questionnaire, interviews and observations for their learning project. Doing these activities over and over again for 3 years has helped them to master the skills and art of interpreting data for different purposes.

c. *Analysis*: breaking things (situations, information or objects) into components/segments in order to determine and understand their features, functionality and relationships. It is the ability to assemble bits of information together to determine the meaning of what the information represents (that is the ability of a person to identify the hidden meaning of information). It has to do with the ability to examine pieces of information, assemble them and make a meaning out of them. Anytime the pre-service teachers involved in this study collected data for their project, they have to analyse the data and make a meaning out of it in their attempt to answer the research questions they have raised earlier for their project. Performing this activity over time has made the participant skilful in the process of data analysis using both qualitative and quantitative approaches (statistical analysis for quantitative research designs and thematic analysis for qualitative research designs).

d. *Discriminating:* ability to identify differences and similarities between information, situations, issues and objects. It also has to do with the ability to rearrange things, situations, issues or objects in an orderly manner that makes a meaning based on a given principle. Participants in this study were engaged in this kind of activity regularly. The ASSIM model of instruction is an activity-oriented pedagogical approach for instructional delivery. One of such activities in the instructional design is the engagement of learners in the process of generating or collecting data for problem solving. Whenever data are collected, learners have to sort and group the data based on their similarities and differences and then rearrange them in an orderly manner that it can make a meaning related to the basic assumptions guiding the project at hand. As observed during the study, doing this activity has improved the participants' skills of discriminating data as a preliminary requirement for effective decision making in problem solving.

e. *Evaluation*: ability to assess the credibility of series of data (in written documents or oral records) that makes up information to determine the validity of the information being presented. It is the ability of an individual to measure the reliability of information by checking and assessing the credibility of the source of the information. Evaluation of information after data collection is one of the instructional activities to be performed by learners when using the ASSIM model of instruction. Learners would have to evaluate the information they have collected during the preliminary web exploration and during the main data collection. This activity is to make sure that all information used in the learning process was reliable. This activity in the learning process has made the participants in this study (pre-service teachers) to learn and use different evaluation methods in screening the data they have collected.

f. *Applying Standard*: the process of assessing and judging things, situations, issues and information based on established rules, theory or criteria. The use of the ASSIM model of instruction facilitates the development of this skill among the participants. The data collected from observation and interview in this study show that the pre-service teachers who participated in the study always employ the use of theoretical and conceptual frameworks. They have learnt to do this on their own. One of the interviewees said during an interview session that, 'after each preliminary web exploration we analyse and interprets what we jotted during our interactive session with the aim of understanding the nature and scope of the problem or issue under investigation. Once this is done we still go back to the web to search and find out if similar investigations were conducted before. It is during this process we learn about the use of operational models, conceptual and theoretical frameworks in research studies; and now we use them a lot whenever applicable'.

g. *Explanation*: ability to add clarity and perspective to information that can help others understand the meaning of the information. It is the ability of an individual to present information in a manner that the listener or target audience can easily understand. An ability to present complex information that is education related (or scientific knowledge) in a simple manner or words that an ordinary or an average person can understand [42]. The use of the ASSIM model promotes inquiry and project-based learning for problem solving. Learners would therefore have to interact with the wider community for data collection and to communicate their findings. These activities have made the participant learn the art and skills of explanation. The researcher observed that the participants in this study (pre-service teachers) use a variety of methods in communicating their findings either to the college community or the wider society at the end of each project. Such methods include creating posters and flyers, Facebook page, organising public lecture and radio programs. Because of these activities, the participants have acquired reasonable skills of presentation to explain their findings in such a way that it is understood by the general public.

h. *Inference:* an ability to make meaning and draw conclusion that can be justified by evidence from an existing information or a situation [43]. The use of the ASSIM model has also helped participant in this study to acquire reasonable skills of making inferences. This is because the use of the ASSIM instructional model encourages the participants in the study to search and collect data for the purpose of building facts and evidence that they can use to address the issues they were working on as their project. They will always have to make inferences at the end of each project.

i. *Predicting:-* envisioning an outcome or a plan and it consequences. The preliminary web exploration activity in using the ASSIM model involves predicting. Participants in the study were engaged in making assumptions at the end of each preliminary web exploration activity. This has help to improve the participants' skills of making knowledge or evidence-based predictions.

j. *Self-regulation:-* ability to assess your own thinking ability, determine your strength and weakness and the willingness to admit and accept responsibilities associated with your weakness [44]. It has to do with the ability and willingness to leave what you cannot do for others that can do better [45]. It also deals with the ability of an individual to

separate or remove personal bias or self-interest when making decisions that involve others. The use of the ASSIM model provides room and encourages learners to practice self-regulation in the teaching-learning process. Teaching and learning using the ASSIM model is learner activity oriented. After the preliminary web exploration activity, learners would have to share responsibilities in carrying out their learning project in groups. This process has made the participants to know and understand their areas of strength and weakness in their respective groups. Thus, responsibilities in each group are given based on proven ability.

Critical thinking is a mental process that helps to improve learner's ability and competence to survive the challenges of living in the present era of globalisation and knowledge-based economy that is technology driven. It helps to improve the creativity of the learner in problem solving and helps the learner to develop life-long learning skills.

7.3. Development of problem-solving skills

The ASSIM model of instruction promotes the development of problem-solving skills among learners. Problem solving is a process of proposing solutions to issues and situations based on knowledge and evidence. The process involves a number of step by step activities that can be mentally challenging. The number of steps or stages involved in problem solving differs from one model to another. Though the activities are the same in all the models, what differs among the models is the orderly arrangement of the stages or steps. The activities involved in the process of problem solving require some skills such as creative thinking, decision making and learning skills. Creative thinking has to do with the process of thinking out of the box to generate new ideas and to identify new connections between existing ideas and concepts. Decision-making skills have to do with the ability to choose between options. Learning skills on the other hand as relate to problem solving has to do with the ability to make meaning out of information to construe knowledge and the ability to apply the knowledge in making decision over available options for problem solving. The activities involved in problem solving include:

7.3.1. Understanding the problem

This is the first thing to do in problem solving. Understanding the problem requires one to first identify that there is a problem. There are different ways of identifying a problem depending on the organisation. Issues and problems generally in society are first noticed through observation. For example, a head teacher in a community primary school may notice that the number of pupils coming to school has reduced. This observation is an indication that there is likely to be a problem. The next thing to do is to find out what exactly is the problem. This can also be done in a number of ways depending on the institution and what was observed. Using the example given earlier of the head teachers' observation, the next thing to do is to: (1) find out if actually the observation made was true; (2) find out the actual number of people involved; (3) find out why the pupils involved stopped coming to the school and (4) find out since when has that started. Understanding a problem requires one to know what exactly is the problem: The issue or the concern? Why is the issue or the concern a problem?

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How does it the issue or the concern become a problem? What is the implication of the problem, the issue or the concern? What happens if the problem the issue or the concern remain unattended? Finding answers to the questions raised above in an attempt to understand the problem would require some preliminary investigation and data collection. In the case of the head teacher, he can interview the class teachers, parents of the pupils affected and the pupils themselves.

The use of the ASSIM model of instruction provides room for learners to practice the activities described in the paragraph above. The instructional activities for step 1 (Presentation of Learning Content as a Problem to be investigated) and step 2 (Preliminary web exploration) under the face-to-face instructional delivery process in the ASSIM model are designed to accomplish the same objective. Learners are expected to notice and identify a problem requiring an investigation from the introductory presentation of the facilitator in the step 1 activity. The preliminary web exploration in step 2 activity is for learners to make preliminary investigation for the purpose of understanding the problem to be investigated. These two learning activities in the ASSIM instructional model facilitate the development of the skills needed in defining and understanding problems, issues and concerns to be investigated for problem solving. These learning activities also help to improve the participants' skills of developing good problem statement that provide answers to the five questions raised in the paragraph above in a manner and language that can be clearly understood.

7.3.2. Data collection

This is the second step and activity to be performed in problem solving. The activity involved building basic assumptions, raising research questions and developing possible hypotheses as may be applicable. These should be guided by the data collected during the preliminary investigation conducted in the step 1 activity. The basic assumptions, research questions and hypotheses to be developed should be based on the problem statement developed with the data collected at the stage of understanding the problem. The data to be collected at this stage should therefore be directed toward answering the research questions raised and testing the hypotheses developed and to verify the basic assumptions earlier build. There are different methods of data collection depending on the nature and type of the research questions developed. Some research questions may require the use of interview, observations or focus group brainstorming, whereas some research questions may require the use of questionnaire to get the information needed. Once the needed data or information are collected using any of the methods mentioned, the problem-solving activity can move to the next step, that is, 'analysis of data to identify possible solutions'.

Step 3 activity in the ASSIM model of instructional design is for learners to be engaged in the same activity as described in the paragraph above. During this instructional activity, learners are expected to develop basic assumptions, raise research questions and hypotheses if applicable; decide on how and where to collect data or materials for the project; decide on what to do with the data or materials collected for the project; share responsibilities and set rules of participation in the project. Engaging learners in doing these activities would help them to develop the skills of selecting the appropriate population to be used for data collection; choosing

appropriate instrument for specific data collection; designing the procedure for data collection and administering the selected instruments for data collection. The observation data collected for this study indicated that the use of the ASSIM model of instruction has helped the pre-service teachers involved in this study as participants to acquire and master the skills of data collection.

7.3.3. Data analysis

At this stage of the problem solving, the data collected are analysed in relation to the research questions raised earlier and the earlier hypotheses developed. Depending on the nature of the research questions that guided the data collection and the kind of data collected, there are different types of data analysis that the problem solver can use. If the data collected are quantitative in nature, descriptive or inferential statistical methods of data analysis may be used; but, if the data are qualitative in nature (collected through the use interview, observations or documentation), such data may be analysed using content and thematic analysis. Analysis of the data collected should provide answers to the research questions raised; from such answers, possible solutions to the problem, issue or concern under investigation can be deducted.

The instructional activity in step five (5) of the ASSIM model is for learners to be engaged in doing the activity described in the paragraph above. During the step five (5) activity in the instructional design, learners are expected to analyse the data they have collected using the method as may be appropriate to answer their research questions, test their hypotheses (if applicable) and verify the basic assumptions guiding their study. Learners are to draw tentative conclusions from the analysed data as findings to apply in solving the problem under investigation. This activity has helped to improve the skills of data analysis and making inferences among the participants involved in this study.

7.3.4. Selecting the best solution

At this stage of the problem solving, one is required to study, compare and select one out of the possible options available. It is a process of making a choice between two or viable potential solutions to the problem, issue or concern under study. The decision should be based on research findings and pertinent information from the review of existing literature [45]. Before making any choice, one need to consider the consequent implications and merits of each possible solution identified. In doing this, one need to be careful and make sure that he or she is not influenced by his emotions. Effective decision making at this stage requires one to carefully and effectively analyse each possible solution. This can be done by considering a flowchart tracing each solution's pathway from inception to conclusion and critique of each possible solution by stakeholders and professional opinion. Stakeholder's confidence over the use of a particular possible solution is an indication leading to a successful decision making and eventually an effective problem-solving approach.

The learning activity in the second phase of the instructional delivery process (knowledge development) of the ASSIM model allows learners to be engaged in doing this activity. At the knowledge development stage of the instructional delivery process in using the ASSIM model,

learners are expected to make a presentation (individually or in group) of their research findings and the tentative conclusions they have drawn from the findings of their study to the class for critique. Each finding is to be deliberated upon by the entire class members. Based on the comments and critique of the class members, learners would be able to make a better decision of which finding or solution should best be selected and applied to the problem, issue or concern under study. This activity has helped the participant in this study to acquire the skills of selecting the best option to be applied in problem solving.

7.3.5. Implementation and review

This is the last stage of the problem-solving steps. It is at this stage that one is expected to come up with the plan on how to implement the application of the best solution chosen and how to get feedback on how well the selected solution is doing. The last instructional activity in the ASSIM model provides learners with the opportunity to practice the use of this skill. Learners at this stage are to work on how to apply the knowledge construed/developed practically (pilot-testing) in addressing the issue under investigation. Learners are also to decide on what is needed in applying their solutions. It is at this stage that learners should develop and write their project report for submission to the teacher. The report should have a problem statement, objectives, methodology and solutions.

7.4. Use of information technology in teaching among the pre-service teachers used in this study during their teaching practice

It was observed that the pre-service teachers involved in this study made effective use of the available information and communication technology equipment at their disposal in their teaching and learning during their teaching practice activities. 'I search the web for relevant and up to date materials to prepare myself for my classes on daily basis and in preparing my lesson' said one of the participants during an interview session. The researcher observed that most of the participants were communicating with their students via emails. They were also sharing learning materials and engaging their students in group discussions using Facebook. They were using powerpoint slides to project images and relevant video clips from YouTube. This, by implications, means that the use of the ASSIM model in pre-service teacher training can help to prepare the pre-service teachers to use technology effectively in their professional practices.

Technology integration in educational practices as used by the pre-service teachers who participated in this study during their practicum can make teaching and learning a fun for the learner as we noticed [46]. We also noticed that the pre-teachers were guiding their students to acquire the skills of using some applications in the computer. In particular, we have witnessed how one of the pre-service teachers was trying to show one of his students how to animate the powerpoint slides he had prepared for his presentation and we noticed the excitement on the students' face as he learns the new skills.

The pre-service teachers' use of technology in their teaching has helped to retain their students' interest in the learning activities they were performing. The researcher also observed

that the pre-service teachers were modelling the use of the ASSIM model with innovative modifications. Because of this, the instructional delivery was more students centred. The students were innovatively engaged in series of learning activities that can help them to construe meaning of certain concepts. This was interesting and the students were happy doing what they were doing. This was an indication that the use of the ASSIM model in teaching can help to motivate learning.

8. Conclusion

The ASSIM instructional model presented in this work is design to promote learner-centred pedagogy in twenty-first century teaching-learning environment that is technology driven. It promotes the integration of information technology in instructional delivery. The model accommodates the use of multiple or blended pedagogy in instructional delivery and facilitates the use of web-based inquiry in developing learners skills for critical thinking and reasoning, problem-solving, life-long learning and informed decision-making skills. The use of the model can help learners to acquire life-long learning skills. That is the ability to learn independently. It promotes interaction between class members as they have to work in team; thus, promoting the spirit of team works. The approach help learners to acquire some values needed in team work. Learners have come to understand the need to tolerate one another in order to accomplish the task of the team. Working as a group help learners to learn to listen to one another and appreciate the views of one another. Team work as necessitated by the use of this model in instructional process would help learners to acquire the skills and values for both leadership and followership. The design of the model is influenced by the TPACK theory and GPM (Giving, Prompting and Making) model.

The inquiry-based and problem solving nature of the ASSIM model of instructional design would help to develop the analytic and creative thinking skills of the learners. This is because problem solving requires the use of both analytic (logical) reasoning and creative reasoning. Some problem solving would require the use of scientific procedures and rules that appeal to logical reasoning, while some would require thinking out of the box that appeals to the use of creative reasoning (lateral thinking—this has to do with using one's imagination to create ideas). Some issues would require doing both simultaneously and sequentially.

Adopting the use of the ASSIM model of instructional design in pre-service teacher training would help to prepare the kind of teachers needed in the twenty-first century teaching-learning environment. The kind of teachers that can assume the role of facilitators; thus, making instructional delivery learner centred, activity oriented, inquiry and project-based. Teachers who can use classroom as not only a place for learning but also a place for acquiring the skills needed to survive the challenges of the twenty-first century. Teachers trained with the use of the ASSIM model would acquire the competence needed to effectively employ the use of technology in their professional practice and would have the expertise of helping the learner to acquire the skills of inquiry, critical thinking, creative thinking, decision making and problem solving.

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Chapter 3

Academic Training in the Double Degree on Teacher of Pre-Elementary and Elementary Education: A *Reciprocity* Model Among Three Agents Based on the Audiovisual Narratives

Moisés Selfa Sastre

Additional information is available at the end of the chapter

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Abstract

The academic training carried out in teacher degrees refers to the period where the undergraduate faces the significantly diverse realities of education and teaching. During the entire building process, there are three main important agents involved: the trainee student and the supervisors from both the faculty and the school where the training takes place. Since the 2015–2016 school year, these three agents have been involved in joint sessions in the Faculty of Education during the academic training period (I and II) of the double degree of pre-elementary and elementary education (FEPTS-UdL). In these joint sessions, each trainee student, together with their school and faculty supervisor, has presented a significant educational action of 20′ in an audiovisual document to the rest of their classmates and supervisors. This project is created with a two-fold objective in mind: (a) to reflect on the undergraduate's teaching and (b) to show a work experience in class to the rest of the educational community that can be uplifting for everyone. The presentation of this activity allows the rest of the trainee students and the school and faculty supervisors to reflect on other teaching models that can be enriching when building their professional identity.

Keywords: teacher, academic training, audiovisual narratives, hybrid spaces, reciprocity

1. Introduction

The framework from the *Program of Improvement and Innovation in the Teacher Training* (MOBMIF, for its acronym in Spanish) has the purposes of (a) contributing to the graduate's improvement, and (b) supporting the start-up process of the pilot offer about the double

graduation of pre-elementary and elementary education in the universities willing to offer such option. One of the pillars in the training of the graduates in teacher degrees is to promote the development of academic training in educational contexts. This period of educational training needs to be considered as a fundamental moment in the training of these graduates-to-be. From this perspective, the process of reconciling the university degrees in Europe is an attempt to establish the European Space of Higher Education. As a result, this process encourages university degrees to provide the undergraduate not only with knowledge but also with strategies to keep learning and developing their training throughout their lives [1]. It has become increasingly necessary that the curriculum includes enough practical credits (the named *Practicum* in teacher degrees) and provides the possibility to develop their knowledge by being close to the professional reality.

Academic training is understood as the period where the undergraduate in a teacher degree faces the problems about education and teaching. The main objective of the academic training is to prepare and improve the professional abilities of those who are involved in it. Teaching is considered to be fundamental in the process of training the undergraduate. This is because the teachers-to-be can contrast the pedagogical theory with the educational reality and be aware of their future role in the educational institution [2].

The practicum mainly aims at favouring the construction of the student's practical knowledge. In this way, students can revise and consolidate the theoretical foundations previously acquired and integrate them in the professional reality sphere. Hence, the intention is for the student to observe, analyse and reflect on the strategies, techniques, instruments and actions that are normally developed in the class. This is an intellectual attitude of constant openness, review and improvement that students would have to share with their teachers and supervisors.

2. Objectives and methods

Since the 2015–2016 school year, the academic training's main objective in the double degree of pre-elementary and elementary education (UdL) is that of sharing peer-to-peer the professional knowledge acquired through audiovisual narratives. In order to share this knowledge, some sessions are organised in the Faculty of education (UdL) with two objectives:

(a) Design, develop and analyse the formulas of interrelation between the students and the educational reality in the schools. These formulas of interrelation are developed in hybrid spaces where trainee students can present, listen and exchange teaching experiences that could uplift the other members. Furthermore, they are able to revise their own teaching practices. As claimed by [3], "los ambientes híbridos de aprendizaje combinan instrucción cara a cara con instrucción mediada por las tecnologías de información y la comunicación. Detrás de esta definición existe una intención de combinar y aproximar dos modelos de enseñanza-aprendizaje: el sistema tradicional de aprendizaje cara a cara y el sistema e-learning, con el propósito de no renunciar a las posibilidades que ofrecen ambos."

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(b) Analyse the impact of these interrelation formulas through audiovisual narratives. Hence, different agents participating in the practicum are able to analyse specific teaching situations. Accordingly, as stated by Costa Sánchez and Piñeiro-Otero [4] "el ser humano necesita contar historias. Necesita explicarse a sí mismo y poner sentido en el mundo que lo rodea."

In order to develop these two objectives, two different strategies are used. First, two sessions with the students are organised. Second, two hybrid space meetings are held by the supervisors from both the school and university and the students involved in academic trainings. These sessions and meetings in hybrid spaces are not two separate moments for learning, they are actually complementary for the achievement of the work objectives.

Tutorial number 1 was attended by the double degree students, the supervisors and the support personnel in order to pool the educational interventions that would take place during the practicum I and II. This space was also used to share an explanatory document and to solve doubts about the methodology approach that is to be developed. In the same way, the importance of students developing an active role was emphasised as a possible way to improve their teaching training process.

In tutorial number 2, the students and a support person, expert in audiovisual language, met so as to talk about diverse matters. First, different aspects based on the elaboration of audiovisual narratives. Moreover, they also discussed the documentation of teaching-learning interventions in the schools during the development of practicum I and II. This tutorial was designed to facilitate the elaboration of audiovisual narratives, to share possible doubts about the project and to try and solve them together through significant photos of the practices carried out by the students. In addition, a reading and analysis of the articles by Dussel and Gutiérrez [5] and Hernández [6] was suggested.

The hybrid space number 1 is a meeting point for students, school supervisors, academic supervisors and support personnel. The monitoring of the practicum takes place in this space and it is completed through the presentation of audiovisual narratives (videos or photographs) created by the students. The main objective of the aforesaid presentation is that of reflecting on the students' own training and the school contexts where the practicum is developed. It also allows the teachers and professors themselves to improve their professional activities. A number of 13 students presented their experiences and reflections in front of their classmates and supervisors during the first session.

In the hybrid space number 2, a number of 17 students continued with the video presentations in front of the rest of classmates, the school supervisors, the academic supervisors and the support personnel.

Two groups of students were created in an attempt to carry out two sessions in the hybrid spaces. These groups shared their experiences in the big group consisting of classmates and supervisors in order to discuss *what* aspects they had to deal with during the Practicum (competences and content) and *how* they approached them. First of all, students presented the audiovisual narratives individually or in pairs. Subsequently, questions were answered and some aspects were discussed by both the school supervisors and the students.

3. Recording instruments and data analysis

On the one hand, the project considers the videos made by the students, and on the other hand, considers the video recordings of the sessions in the hybrid spaces.

The videos created by the students are instruments used in this teaching project in order to analyse and reflect on the activities, content and competences acquired by the students in the school contexts where the practicum takes place. These videos are called audiovisual narratives. As claimed by Dussel and Gutiérrez [5], the aforesaid narratives are aimed at suggesting other bonds between words and images. These bonds help to analyse their content load, to reflect on their specificity and to relate them with other images, stories, speeches and interpretations of that reality.

These audiovisual narratives are defined by five features that allow us to talk about a story as such: "(a) Tiene un comienzo y un final, lo que genera la sensación de cierre; (b) se trata de una secuencia doblemente temporal, la del acontecimiento narrado y la del acto enunciativo en sí mismo; (c) esto implica, entonces, que la narración es un discurso, y en esa medida remite necesariamente a un sujeto de la enunciación; (d) a pesar de que pueda ser basado en una historia real, el relato no es la historia en sí, por lo que siempre *irrealizará* el hecho narrado; (e) un relato muestra un conjunto de acontecimientos, y estos son sus unidades fundamentales." [4].

In order to make that possible, the trainee students were asked to elaborate a video of 45–60′ in length that included the educational interventions carried out during the practicum I and II. Moreover, students were required to create a summary in video format in order to present their project to the rest of the classmates during the hybrid spaces. This summary had to last about 20′ and it had to include the essence of the work that had been carried out.

With regards to the elaboration of the video, students were given a written guide with the basic aspects of audiovisual language so that the video would be of high quality and have a narrative sense. Furthermore, classes and voluntary tutorials were simultaneously offered. In this way, students were provided with an individual and personalised monitoring of each of the audiovisual narratives and the processing of the images.

In relation to the videos of the hybrid spaces, they were videotaped during their presentation by the support personnel. This was done in order to carry out a posterior analysis since diverse voices and reflections arose from the students and the school supervisors. The analysis of these voices indicates to what extent these meeting points favour the learning of other educational models for the building of the own professional identity.

4. Observed results from the audiovisual narratives

4.1. Result 1

The students organised and planned educational activities in order to create learning spaces. This was attainable due to the creation and implementation of the teaching sequence as well

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as the short interventions and the everyday nature in class. In this way, the visual narratives were useful to define, document and describe the educational interventions, reflect on them and, in some cases, modify them. As a student explains,

> *Given these audiovisual narratives, I find myself in a point of reflection where I understand that these photos and videos are useful to bring me closer to my environment and to the class reality. Moreover, the audiovisual aspect helps to have a more realistic notion of what is happening and of what is done at any time than if it was in a written format. However, I also believe that a photo or video only shows a small part of reality. (LT)*

4.2. Result 2

Not only were the videos analysed, but also the reflections that arose during the presentation of the educational interventions in the hybrid spaces. This interpretation showed how some students have developed a critical and reflexive view regarding the observed teaching models. This is stressed by a student,

> *Doing the training and being able to observe the videos and photos has been useful to realise that I do not want to repeat the models I have seen. I want to take the best aspects of each of the contexts that I have observed in order to use them in my educational practice. (A)*

4.3. Result 3

Self-management is a competence that has been observed throughout the whole process, both in the implementation of the teaching sequence and in the creation of the videos and the photographic material. It is important to consider that not all of the school contexts facilitated the attainment of the photos due to the law on the protection of children's personal data. Nevertheless, students found the way to explain their experiences with both inventiveness and the knowledge about the basic aspects of audiovisual language (composition, sound, edition). Hence, students venture to develop their professional training and to create the audiovisual works through actions, which were not initially defined by the teaching members.

4.4. Result 4

Both online and cooperative works are evinced to develop expressive and communicative competences. For instance, some students created teaching sequences based on the *Pinocchio* tale that were combined and interconnected albeit coming from different school contexts. In this way, students not only achieve heterogeneous and collective processes but also diverse significant learning situations. Therefore, it is more than necessary to empower online work in higher education in order to obtain learning results, and consequently, to revise the own learning practice.

4.5. Result 5

A wide range of voices have emerged through the use of videos documenting the teaching sequences by students, children and the educational institutions where the training

is carried out: "el derecho a participar ha sido resumido en el concepto de *voz*, que se ha constituido en una metáfora muy potente para identificar, describir y denunciar las relaciones de poder y representación que se establecían en las instituciones y los grupos sociales" [7]. In this sense, the voice in this paper is seen as the abilities to participate, interact and empower demonstrated by the participants in the different school contexts where the practicum was conducted.

In an attempt to reflect on the real participation of the students, the R. Hart scale was considered. The aforesaid scale describes the levels of action in a participative educational project with children. The author places the categories of *no participation* on the first three steps, which go from manipulation or ruse to symbolic participation. The other five steps are considered participation models and their educative and participative value increases according to its position on the steps. These five steps symbolise an *authentic participation* because they consider key elements such as the choice, information, enquiry and being part of decision-making (**Figure 1**) [8].

4.6. Result 6

After watching the 20′ videos created by the students from the practicum, it is plausible to say that they have delved into the observation and the comprehension of school contexts. Consequently, it can be stated that educating the gaze and work on the audiovisual language allows students to "alcanzar un mejor modo de ver más crítico, emancipado o liberador. Ayudar a abrir los ojos, es decir, a ser conscientes de lo que realmente sucede en el mundo, ayudarlos a reconocer el modo en que sus miradas están generalmente atadas a determinadas posiciones y perspectivas" [9].

Figure 1. The scale of children's participation. Source: Wikipedia.

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5. Conclusions

The incorporation of new information technologies in the Higher Space of European Education has resulted, among other advantages, in the access to immaterial information that can be shared peer-to-peer. This information is of a great quality since it is rich in images and sounds that can be easily distributed. Furthermore, this information is always under an ethical code that permits its use for educational purposes only [10].

In this sense, the audiovisual narratives facilitate the building of the own professional identity during the practicum. This is plausible due to a previous selection process of content and images that have to show and describe the tasks carried out in the class. It is not just about providing audiovisual material for recording and editing audiovisual material. In fact, a posteriori process of selection and reflection on what is to be shown is equally or even more important. This is because it is there where the professional identity is being shaped.

Once the selection of the audiovisual material has been accomplished, a process that is mainly individual, the peer-to-peer analysis of audiovisual narratives takes place. This process allows students to critically reflect on the own positioning of the professional practice. Observing *what* and *how* teachers behave in school contexts and reflect on that observation helps to acquire good professional models and to modify the own workaday behaviour.

Digital technologies have long been incorporated to teacher education and it has been observed that the needs and appropriation ways of the media by the audience are essential. That is what determines the efficacy and permanence of a specific technology or language. These changes allow the identification of new aesthetic, formal and semiotic possibilities, with the increasing hybridisation of genres and narrative multiple formats [11].

The six results presented through the work of peer-to-peer audiovisual narratives help to opt for a training model where the reflection through a posteriori observation is prioritised in the Faculties of Education [12]. The teaching intervention is so absorbent that it is indispensable to revisit it in an attempt to improve and work on it. It is necessary to devote some time for reflection that facilitates taking new decisions so as to enhance the teaching practices. The reflection in the pedagogical process needs to be promoted. Opening spaces to the own questioning and foster the open dialogue are important procedures that those responsible for the teacher training should advocate. The formula of the hybrid space, understanding it as a place where peers dialogue through multiple languages, is an option that needs to be examined.

The audiovisual narratives permit revising the teaching practice since they favour the reflection and both the mutual and external knowledge about the professional teachers' interventions. This revision, as it has been seen, is based on the visualisation of interventions in a hybrid space where the educational agents dialogue from a significant audiovisual document. That is the only way of building a real professional identity which, as it is known, is in a continuous process of revision and improvement.

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Chapter 4

Distance Continuous Training of School Managers

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Additional information is available at the end of the chapter

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Abstract

The chapter deals with the continuing education of school administrators of basic education in partnership with the Brazilian public university through the implementation of postgraduate courses in School Management (Lato Sensu) in the distance teaching mode in agreement with the National School Program Managers of Public Basic Education (PNEGEB) of the Ministry of Education (MEC) in Brazil. To bring them together in this text is to expose to debate the importance of continuing education in the postgraduate course with the perspective of the articulation between the training of school managers in effective exercise in the public school system and the possible changes in the pedagogical practice that leads to. The methodological approach of the present work is based on the bibliographical review, a qualitative approach, which allows to work with the material during the research, with its organization and greater exploration, making possible the articulation between the theoretical presuppositions of the study and the data of the reality for a better understanding of the phenomena that need to be unveiled. The proposal of these policies of continuing education through distance education to train school principals demonstrates awareness of the importance of training a critical professional in school work, a manager of the development of participatory and collective planning, allowing a constant reflection on the responsibilities of a school committed to the real learning of its students and of effective democratic management.

Keywords: National School of Management Program, continuing education, distance education, school pedagogical work

1. Introduction

The article deals with the continuous training of school administrators of basic education through a partnership with the Brazilian public university through the implementation of postgraduation

courses in School Management (Lato Sensu) in the distance teaching modality in agreement with the National Program School of Managers of Public Basic Education (PNEGEB) of the Ministry of Education (MEC) in Brazil.

This initiative has been developed through PNEGEB. Initially, the program was started in 2005 as a pilot project for extension in school management offered by the National Institute of Studies and Educational Research Anísio Teixeira (INEP). On an experimental basis, the pilot project in comparing five programs aimed at training school managers, indicating their main characteristics in relation to new educational trends. These are distance learning program for school managers—PROGESTÃO; national program of basic education managers—PNEGEB; continuing education program for early childhood and fundamental education managers—PROGED; and interdisciplinary continuing teacher training center—CINPOP, Brazil [1].

The general objective of the program (PNEGEB) is to form, at the Lato Sensu specialization level, effective educational managers of the public schools of basic education, including those of youth and adult education, special education, and vocational education. These will only be established and carried out through well-prepared professionals committed to building knowledge and sharing experiences that are experienced on a daily basis.

Based on the local reality and the search for new ways for the school manager to direct his pedagogical practice to carry out the actions determined for the improvement of teaching quality, PNEGEB is a component of the All for Education Commitment, which is a goal plan Education Development Plan (EDP), aimed at contributing to the improvement of the basic education development index (IDEB) of schools and education systems.

The National School of Managers Program has been a continuous professional training structure, characterized as a distance learning modality, as well as a space for reflection and debate among the participants, who in turn have direct involvement with basic education. Its importance lies in the link between the school environment in harmony with various themes of education and the virtual environment in the process of continuing education, which implies relevance and concreteness to this approach. We perceive that it is necessary to seek to. The teacher is urged to take a new stand in the face of such a scientific, technological, and cultural revolution. It will no longer be the center of pedagogical practice, of the process of knowledge transmission [2], but will necessarily become an organizer, planner, and articulator of information dispersed, tacit knowledge, and scientific knowledge, (re) constructing, linking, (res) meaning, and integrating them into a critical-reflexive process that understands or helps to know how the determinants of information and communication technologies by manifesting themselves in the school space from the perspective of a group of school managers who are enrolled in the said course.

The expansion of the offer of postgraduate courses has been trying to resignify the formative processes from the reconsideration of the necessary knowledge to the teachers, besides the purpose of granting a legal qualification to the professional practice of teaching. In this perspective, it is understood that the training courses can articulate the actions of the teachers with the pedagogical practice through the reality and the school experience.

The expansion of the locus of initial and continuing teacher training has proved to be one of the important demands for updating and training teachers.

It should be noted that the 1990s are marked by great interest in the formation of educational managers, propagating in Brazil the dissemination of the expression continuing education as a modality of improvement of the educator in the exercise of his/her function, becoming in recent times a theme present in the discussions in the national and international academic scene.

It has been highlighted in the field of continuing education the evidences that there is unanimity in pointing to distance education as a fundamental mechanism for the implementation of distance courses by higher education institutions (HEIs) in Brazil. These experiences are gradually being affirmed as innovative pedagogical experience for the formation of citizens, which has its peculiarities and reveals itself as a prosperous field of study.

Taking stock of existing initiatives in higher education institutions (HEIs) in Brazil, the reflections emanating from the experiences and the work carried out in the postgraduate course of the Federal University of Viçosa by the authors served as motivation for the elaboration of this chapter. We take as a starting point the experiences of the team that makes up the National School of Managers Program (PNEGEB) in the respective HEIs, in order to present its importance for the ongoing training of in-service school managers in public basic education. It is worth mentioning that despite the fact that so many other Brazilian public universities are committed to the educational demands aimed at systematizing the goal and proposal of the training program, each institution brings its existential experiences, but with a single common goal, which is to open spaces to build a process of training school managers that contemplates the conception of the right to school education and the perception of the public school in the perspective of social inclusion and human emancipation.

The methodological course of the present work is based on the bibliographical revision, through theoretical productions that guide the research work in the understanding of questions, concepts, or phenomena, describing them and interpreting them in order to subsidize information, affirmations, and statements that justify the research work, as well as the systematization of the bibliographic studies carried out, in order to know the paths that point to the discussion of the proposed themes [3]. Lüdke and André [4] show that the approach taken shows that the approach taken by school managers in Brazil, in partnership with the MEC training policy, qualitative, enterprising, and methodologically rich, allows to work the material during the research, with its organization and greater exploration, making possible the articulation between the theoretical presuppositions of the study and the data of the reality to better understand the phenomena that need to be unveiled.

2. Distance education

It should be noted that government investment has been fundamental in the search for partnerships with higher education institutions for the implementation of distance learning courses.

Distance education (EaD), understood in the context of education in general and organized to train the new generations, transmits the scientific and cultural knowledge produced by society as a whole, becoming an option for the citizen of the twenty-first century, bringing limits and contradictions of modern society and also the possibility of social inclusion.

According to Faria [5], distance education has been associated throughout the world with the democratization of access to new information and communication technologies, being recognized as a public policy with potential for the training of subjects, as well as a sign of the construction of new paradigms in the expansion of knowledge.

For Mello and Soares [6], the advancement of information technology and telecommunications, as well as the emergence of the Internet, has made the EaD to renew itself and cover courses of differentiated levels, such as undergraduate and postgraduate courses in different levels of knowledge. In this context, with numerous educational proposals at a distance, the Federal Government created its own legislation in 1996 in order to regulate EaD and to promote the accreditation of public and private institutions able to launch courses in this modality. The legal bases for EaD in Brazil were established by the Law of Directives and Bases of National Education (Law 9394, dated December 20, 1996), regulated by Decree 5.622 of December 19, 2005[1].

Mello and Soares [8] point out that the important advance of Law 9394/96 was to ensure the right of young people and adults who could not complete their school life at regular age, the right to provide studies through distance education. It is also worth noting the participation of the public power in the incentive to the development and promotion of programs of distance education and teacher training, as well as the regulation of the requirements for the examination and registration of diplomas related to distance education courses.

By recognizing the changes in the world scenario and, consequently, in the educational scenario, it is expected that teachers are also in the process of change, after all, they must be in tune with all the novelties that are inserted in the school context. The new technologies impose on the human being in the face of the epistemological, social, and technological transformations that take place.

Gadotti [9] allows to produce knowledge based on the various media sources. "Educators, in an emancipatory vision, not only transform information into knowledge and critical awareness, but also form people."

According to Mello and Soares [8], it is important to understand and identify the different conceptions that underlie the different modalities of education with or without the use of technologies. There are courses of EaD focused on the transmission of content, communication in conventional formats in EaD, with contributions in the industrial way of teaching and learning or, at the opposite extreme, to justify the use of communication networks to promote interaction, reflection, the collaboration and the construction of knowledge in any learning environment, whether it is face-to-face or at a distance. In this point of view, Aretio [10] differentiates several types and modalities of education with the use of information and communication technologies (ICTs). Among them, it highlights: (A) online or virtual education; (B) distance learning; (C) total distance education; (D) e-learning; and (E) blended learning.

[1]Education is a pedagogical process consisting of teaching and learning, that is, teaching and learning (or teaching-learning). The importance of bringing up this understanding of education lies in our discomfort of using, in the scope of distance education, the terms teaching or distance learning. We consider inappropriate the use of distance teaching or distance learning, because it ignores the indispensable junction of teaching and learning. Only the terminology education would embrace this conception by Mill [7].

Online education or virtual education or education supported by new ICTs involves both the face-to-face and distance education modality. It is developed by telematic means, for example, the Internet, videoconference and teleconference television, and digital telephony. Communication can occur synchronously (communication occurs at the same time), or asynchronously, in situations of regular and/or corporate courses, in diverse levels and educational modalities (from basic to postgraduate education). ICTs can also be used in totally virtual programs, without physical contact between tutors and students, in semipresential courses, in regular classroom courses with activities that complement each other beyond the classroom, through the Internet. Interactivity can favor interaction and communication one by one (e-mail between two people); one-to-many communication (discussion forums, chats); and communication of many people to many people (website or the creation of a collaborative virtual community) in which everyone participates in the creation and development of the community itself.

In the semipresential EaD, the physical separation between teacher and students is partial, that is, part of the course is structured considering the occurrence of physical encounter(s) between educators and students and part of it is effective at a distance, in virtual environment or the use of other technologies (self-instructional material, audiovisual resources, and others).

The total EaD does not predict physical face-to-face meeting between teacher-student. However, there may be simultaneous synchronous communication, via computer, Internet, telephone, or asynchronous, through electronic mail and virtual learning environments. In this case, the course is structured to happen entirely at a distance, using audiovisual resources, printed or electronic self-instructional materials (as in correspondence courses, television, and CD-ROM among others). It can also be structured in the virtual or online EaD format, which takes place through virtual learning environments.

Aretio [11, 21] describes e-learning—electronic learning—as a form of distance education with exclusive support in digital (Internet) systems. It has been used to promote the training of people and employees, with a view to improving organizational processes. Research by the author reveals, however, that in e-learning, the interactive, collaborative activities, problem-solving, exchange of experiences, and information are very small, which has been generating, according to the author, low student productivity.

Blended learning or b-learning, according to Aretio [11, 21] and Belloni [12], is the education trend of the future. In this educational modality, the public or private conventional HEI can implement courses that take place in mixed environments and combined education and integrated between online education and distance education. They are called by some as bimodal EaD mode, partially distance, or semipresential with times distributed in present moments and distance and other electronic formats. However, it is not a question of simply "blending," "mixing," or "combining" teaching formats. It is a question of "integrating, harmonizing, complementing, and combining the most appropriate means, resources, technologies, activities, strategies, and techniques to satisfy each concrete learning need," in the search for the maximum balance between these curricular variables [13]. Thus, there is a strong propensity to combine online education, distance education, and face-to-face education, which is already a reality in several HEIs. It means that the "future of higher education will not be online, but in networks between us, computers, classrooms, and the place where each student and teacher are."

One cannot fail to consider as fundamental for the training of managers the great expansion of offers of courses in the distance modality by the Institutions of Higher Education, which instigates the development of the education process, since this happens to have its peculiarities, but reveals a thriving field of study. In this perspective, distance education has been providing profound changes to the situations set in the organization of the educational process, serving as an alternative to empower and make available the knowledge to an increasing number of individuals interested in improving their knowledge, to update or to qualify. However, in higher education, in a special way, the expansion movement of postgraduate courses has been growing in significant indices beyond the sphere covered by the face-to-face education.

This type of education is associated with the strong development of digital technologies, mediated by new information and communication technologies. In this perspective, the National Program of Basic Education Managers has as one of the main axes distance education, evidencing the possibility of democratization of knowledge, consolidating as a strategy of in-service training policy for school managers and a vehicle for dissemination of content aimed at adapting the school with a fundamental role in this process of democratization.

Sette [14] adopting creative proposals and possibilities for good school management opens space for a more active and permanent participation of all actors in the educational process, which, combined with the use of information and communication technologies (ICTs), enhances the process of knowledge construction, citizenship, as well as facilitates the interaction between the actors of the educational process, extending the special frontiers, reaching external partners outside the school, the city, and perhaps the country. According to Teixeira [15], it is the one that enables the attendance of a significant number of subjects in their places of work with a reasonable cost. In her research work, the author reports that the Ministry of Education (MEC) is interested in the dissemination and use of distance education and justifies its position affirming the need for flexibility in the organization and development of the students throughout their studies, since, according to the MEC, this would strengthen the intellectual autonomy and guarantee access to the TICs. In addition, the author argues that EaD is a modality that facilitates, at least from an economic and practical point of view, initial and continuing training programs in countries with a broad territorial extension, such as Brazil.

3. Continuing education and ICTs

Candeias [16] implies that the search for continuing education under the perspective of postgraduate distance courses deserves to be highlighted, due to the fact that we will have an increasing contingent of teachers who will make the option of a training linked to a Lato Sensu Postgraduate course, something that is not decontextualized from the reality of basic education, which is configured as a constant and that seems to have come to stay, imposing on the universities and, in particular, the Postgraduate Programs of all Brazil, the debate about their role. In addition, establishing an analysis of the continuing education of basic education teachers articulating with information and communication technologies and postgraduation has been the challenge in the present time. The importance of the relationship between these themes is in line with the vision of Mill [7] that investigated CAPES bank, theses, and

dissertations that bring tangible points, to the growth in the country about the appearance of information and communication technologies (ICTs). The author noted that there are few academic papers that relate continuing education of basic education teachers to information and communication technologies and postgraduation, as well as most initiatives are restricted to specialization or improvement courses.

Distance education, mediated by the different information and communication technologies, has been used as an alternative to expand the offer of continuing and postgraduate courses, especially in regions where the offer of training alternatives is still insufficient. At the heart of this debate, Mill [7] and Candeias [16] impose questions that point to the need for this articulation. For these authors, it is still necessary to make much progress in this articulation between a model of teacher training committed to educational changes, under the dynamics of ICT within the perspective of postgraduate studies, from the design and structuring of the matrix curricular of the course, going through the structural aspects, such as access to computers and concreteness, among other issues.

In this sense, the continued formation of managers has been widely questioned and investigated, although we do not want to exhaust the causes, we seek to emphasize that this resource is at the service of the development and learning of students, effectively favoring the possible democratization of the teaching, and becoming through this ongoing mechanism accessible to all of the public school. In this context, it is not enough just to build knowledge, but also, access to it which through distance education, provides technical support in line with the didactic-methodological context of the formative process capable of creating a protagonist position on the pedagogical work necessary to the demands and expectations of changes in management and in school.

In view of the technological revolution, one of the most visible consequences of this process was the incorporation of information and communication technologies in data organization and in the intensification of online access that collaborate to boost educational performance.

Hessel [17] inserted in a social space where there is a growing need for interaction and participation of the subjects to face their challenges, the educational agency can facilitate connectivity, with the adoption of ICT. The issue is not limited to assimilating ICT as a teaching and learning tool, research, routine automation, or as a provider of managerial information. It is about supporting and expanding communication channels, whether internally, because decentralization of power should promote the integration of school staff, either externally, because the school needs to share information, establish contacts of all kinds, and to activate a communicative network that facilitates the interaction among parents, students, teachers, etc.

This situation is anchored in the search for an understanding of the relations that are established in the interaction of the education and technology components. If we take into consideration the thematic axes of work and discussed in each discipline of the postgraduate course in school management, all planned as a means of possible intervention in the school reality, we must realize that ICTs have been raised as new perspectives for the management of the educational process, with a view to promoting initiatives that stimulate the involvement of the trainees and as a work strategy of the professionals in EaD. It means to say that regarding the professionals working in higher education establishments and in tune with the use of ICT cannot lose sight of the use of these to interpret the new and advance the

didactic-methodological content of the training process from the experience and the experience of each student in his way of being and unveiling the school reality.

In this sense, distance education has been stimulated as the fastest and most economical means of responding to the legal requirements of teacher qualification, which in the context of school organizations has affirmed principles and practices of school management. Castro [18] points out that the implementation of policies and training programs in management aims to strengthen leadership, communication, negotiation, and problem-solving skills, and teamwork to optimize the opportunities that the autonomy brings to school.

Belloni [12] studied that in the first decade of 2000, courses, especially at a distance, were launched, either online or semiresources, directed at educational managers, carried out nationally on a large scale by the Ministry of Education, the National Institute of Education Studies and Research Anísio Teixeira (MEC/INEP), and by the National Council of Secretaries of Education (CONSED), as well as others offered by companies and higher education institutions, both public and private, since, during this period, efficient and effective management was prioritized as an essential element for the good quality of the education system and school, that is, management focused on the responsibility for raising the quality of teaching in public schools, as well as the emphasis on democratic management as a social achievement. This process resulted in the final proposal of the specialization course in school management, in the form of distance education, with the aim of expanding the possibilities of acting and training of school managers by reflecting on the issues involved in democratic management and the apprehension/construction processes and procedures that favor the practice of management and the realization of the right to basic education. This requires radical changes in the field of education to which it is necessary to reevaluate theories and to reinvent strategies and practices in which the quality school will have to integrate the new communication technologies in a way efficient and critical, without perceiving the humanist ideals of modernity.

The creation of the Open University of Brazil (UAB), by Decree no. 5800 dated June 8, 2006, institutionalizes distance teacher training programs as a teacher training policy, with the objective of expanding and internalizing the offer of courses and public higher education programs, at a distance, offering, as a priority, courses undergraduate and initial and continuing training of teachers of basic education, higher courses to train managers, managers and workers in basic education. Behind these guidelines, there is a need for pedagogical assistance, technical and educational training, with the aim not only of training people capable of using computers, but also of questioning, creating, and using this means of communication as a means of participation in society. These translate into the innovation of pedagogical processes when giving teachers and managers access to new knowledge of distance learning.

By empowering manager-trainees to use the virtual learning environment, it is hoped to support school management in promoting the autonomy of the subject, interaction in learning, and knowledge construction that helps the school understand its current level of organizational development. Therefore, the use and appropriation of technologies should be used as a means and not as an end, in a resized vision in the relation action /reflection/constant action and emphasis in the practical application in the teaching work, reflecting its effectiveness.

In this sense, adopting creative proposals and real possibilities of carrying out a joint work is of paramount importance. We reinforce the idea that teacher training is the first step toward the

completion of the renovation project in order to truly introduce change in school, as well as discovering its potential to provide a new environment for questioning and transforming education.

Aretio [10] and Belloni [15] found that the answers to this question are many and far from being unanimous, but they seem to signal a tendency to group around the idea of reflection (emphasis added) on the pedagogical practice conducive to integration, the technical means of communication and computer science and to the educational processes, since the reflection on the practice itself "necessarily leads to the creation of a specific knowledge and linked to the action, that can be acquired through the contact with the practice, because it is tacit knowledge, personal, and not systematic." As a process of professionalization, the reflection must be directly articulated to the expansion of the decision-making capacity and the interpretation of the social and school dynamics, by the teacher. In this sense, the principle of a formation that seeks to transform social reality, which is at the heart of the formative policies and especially to the graduate programs of all Brazil, the debate about its social role.

It is also important to consider encouraging the creation of distance education courses, such as initiatives and training programs for educators and the concern with the objective conditions of work that teachers involved with virtual distance education are submitted.

With this in mind, citizenship training, government investment, and the search for partnership reveal indispensable instruments, particularly favoring good training or professional qualification, since the number of people who have access to available technologies in the field of education. Currently, education has been widely questioned and investigated, but with the great expansion of offers of courses in the distance modality by the Institutions of Higher Education, instigates the development of the process of training of school managers.

Brazil [19, 22] continuing education has its peculiarities, but it proves to be a prosperous field of study due to its importance related to the link between the virtual environment and the school environment, as it aims to provide opportunities for capacity building such as analyze and solve problems, elaborate and develop projects and activities in the management area with the support of information and communication technologies (ICTs).

The involvement of the Federal University of Viçosa (UFV), in the process of continuous training in partnership with the MEC/National Program School of Public Basic Education Managers, intended to establish a link between this institution and the MEC/SEB training policy. A process of knowledge production, beyond the training of state education professionals, will allow the construction of a potential institutional space for teachers, technicians, and students. The basic objective of the program is to contribute to the effective training of public school professionals so that they have theoretical and practical elements that enable a basic school education with social quality. The All for Education Commitment and the Education Development Plan (EDP) relate to the mobilization around the improvement of basic education in Brazil, contributing to the improvement of the IDEB of schools and education systems.

For the development and offering of the postgraduate course in school management, the multidisciplinary team is composed of tutors, effective teachers of the UFV Education Department, temporary teachers, and coordinators, as well as administrative and technological support, highly qualified to offer a teaching of quality. Without elaborating the function of each one in detail so as not to exhaust the pertinent subject to the competences that the function requires,

these professionals keep as general traits the relevance of performance in EaD with differentiated and clear characteristics as to the role, since each one in its specificity has been an incentive for students seeking knowledge in the distance learning modality.

In EaD, ICT can be adopted with the aim of facilitating the teaching-learning process, either to construct the educational material or to stimulate the collaboration and interaction among the participants of a course, facilitating the collective construction of knowledge. Many educational platforms and environments have been created to promote learning through the use of an Internet-connected computer. These environments favor access to educational technologies, such as platforms or learning environments, we mention—PVANET (PVA of the expression Pavilion of class and net, of the Internet)—virtual learning environment developed at the Federal University of Viçosa in Minas Gerais to Courses in distance mode. This environment allows you to create, maintain, and administer Internet-based courses.

The methodology of the course is based on students' own knowledge construction. They experience dialogs with videos, chats, forum, online evaluations, mural, questions and answers, reports, and virtual library, in order to answer, question, and appropriate new knowledge. These resources are at the service of the development and learning of students, effectively favoring the democratization of education, and becoming, through these mechanisms, the necessary instrument for their formation in a form accessible to all who participate in it.

In developing and answering questions about particular subjects, students develop a critical attitude toward learning and build their own knowledge. In addition, addressing different perspectives for implementing changes in school and constructed experiences may lead us to rethink the practical activities of students, their reflections, and their critical questions.

The search for distance learning courses, evidenced by the rapid increase in the search for enrollment in the course of managers of the Federal University of Viçosa, sends us, without pretending to be audacious, to meet the demand and the quality of courses in the mode of distance learning. Therefore, for the seventh consecutive year, the institution has been contemplated with the renewal of a contract with the MEC, a fact that has generated a continuous flow with the institution.

Moreover, each year and each course, the demand for professionals in the field of education who choose to take Lato Sensu Course through this mode of teaching grows, as it makes it accessible to all. And there are several reasons: the convenience of studying anywhere, at any time, and sometimes even the way to organize time are the great attractions for those who choose this mode of teaching. We may also notice that in many cases, these subjects have discontinued their studies for some reason, and are able to return through distance learning. Each day distance courses are becoming common for those seeking qualification and career plan and in this panorama, in the course offered in partnership UFV/MEC/School of Managers, there is a demand around 400 students enrolled and divided into 10 classes so that they can have better use and follow-up.

The ease that these perspectives engender for the academic work and for the managers-students allows to reach goals that previously seemed impossible. These initiatives suggest a process of constructing a new paradigm in educational projects in Brazilian society, in which the question of the training and qualification of these professionals in education is brought

to the center of the academic discussions, the communication, pedagogical and interactive potential they come promoting in the possibilities of socialization and learning, since, the performance of the manager in the school context consists of a space of mobilization, organization, and involvement in the educational processes, that by their active and competent participation, promote the accomplishment of its objectives.

Felinto [6] explained that with regard to the EaD in this program, it is important to emphasize that it plays an important role and is perhaps an indispensable condition for its accomplishment, since it makes it possible to attend a significant number of subjects in their work places at a reasonable cost. In her research work, the author reports that the Ministry of Education (MEC) has an interest in the dissemination and use of the modality, and justifies its position affirming the need for flexibility in the organization and development of the trainees throughout their studies, since, according to the MEC, this would strengthen the intellectual autonomy and guarantee access to the TICs. In addition, the author argues that EaD is a modality that facilitates, at least from an economic and practical point of view, initial and continuing training programs in countries with a broad territorial extension, such as Brazil.

These aspects are part of the proposed structure initially planned for support. If we take into account the supports of the program and distance learning courses using a variety of digital technologies, we might think that the greatest desired change in education should be associated with how these educational resources will be designed, developed, managed, and to be made available and appropriated by the trainers.

In this sense, the training of school managers becomes a necessity and a challenge for the education systems. It is common, in training programs, to hear some participants express that "in practice, the theory is different." Such an understanding in Lück's [20] view can be explained by the theorizing, content and book character of training programs, without the need to show, through situations that are simulated, by dramatizations, case studies, and other exercises, to application and the expression in reality, of the theoretical conceptions treated.

In order to revert this picture, propositions of activities in the course are woven to rethink the commitment that the managers-curators have with the exercise of their profession. Within this perspective, it is possible to search for the elements that would be "constituting," such as its attributions, tensions, challenges, and problematizations for the definition of pedagogical guidelines and to give a broad knowledge to what has been happening in basic education. Lastly, monitoring, stimulating, and provoking some tensions and promoting their periodic review has been the minimum differential for the completion of the course and for the implementation of a meaningful and transformative formation of the education by the managers-students.

The process of continuous training presupposes the exercise of reflection for professional development. For this, it is fundamental to create solidly grounded and critically situated study opportunities. It should provide a deeper understanding of the school reality, the transformation of pedagogical practices and working conditions, as well as the consolidation of the identity of the education professional. At the same time, it must consolidate an understanding of the school as a formative space, in the perspective of which it is fundamental to construct, in the school routine, moments, spaces, and processes in which teachers and other subjects of education develop training practices articulated to educational practice.

4. Final considerations

The text points to the fact that with the growth of distance courses in the country. The School of Managers of the Federal University of Viçosa has been qualitatively determining the horizon of professional development and adequate continuing education for those who seek to improve their professional training.

The proposal of these policies of continuing education through distance education to train school principals demonstrates awareness of the importance of training a critical professional in school work, a manager of the development of participatory and collective planning, allowing constant reflection on responsibilities of a school committed to the real learning of its students and of effective democratic management.

In this way, to lead the Institution of Higher Education that promotes the participation of all the actors involved in the formative process, so that the search for improvement of the educational process in a democratic way takes place, it needs to help it to relate the didactic exercise of accomplishment of the activities with the concrete situations of its pedagogical practice, in order to continually improve it, has at its base the academic management, the use of EaD, and the opportunity of a variety of activities of innovative learning.

The challenge in the present tense is the ability to know how to use them and the skill that is gained through practice. It is a well-known fact that the EaD has received many criticisms, which instigates us to inquire about what is manifested and what is proposed in educational actions, regarding the use and appropriation of information and communication technologies in the school space. And it is around this question and because of it that it constituted the path that we seek to probe and to perceive, so that we can know the behavior of the students, desires, anxieties, desires, and their conceptions through the proposed actions that should contemplate in the internal structures in the school, relevant knowledge acquired during the course in the course of the School of Managers.

The identification of the need to prepare school managers in the field due to their important task in basic education has led us to seek to establish the mission and objectives both the policy of continuous training that proposes access to all and the actions of the coordination of the course together. To the MEC for the inclusion of teachers in the course, for believing that in the future, these may be future managers of basic education.

We have a transparent and ethical commitment to call into question the meanings of formation and the contexts that shape it, which now show the possibility for action by the students, who now break with the contradictions that emanate education. And from this, it is important to emphasize that in the form of institutional organization of the policies of continuing education has brought positive marks and that has enabled the search to deepen the discussion and reflection on the degree of effectiveness of this professional qualification of school managers in EaD programs.

Faced with the reflections emanated in this study, the perception regarding the quality of the postgraduate course in school management is centrally related to the persistence, dedication, and motivation of academics, tutors, and teachers due to professional commitment, seriousness,

commitment, and constant search of quality. We value the deepening and improvement of the knowledge of the school managers, in a continuing education and distance education course, based on the theoretical and daily development of school management, in order to promote dialog and interaction among peers, so that they understand the historical, political, social, technological, and organizational contexts involving their school and themselves as professionals.

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Chapter 5

In the Spotlight: Supporting Focus Teachers in Video-Based Collaborative Learning Settings

Nicole Bannister and Fran Arbaugh

Additional information is available at the end of the chapter

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Abstract

In this chapter, we explore the role of the focus teacher—the teacher in the spotlight—in video-based collaborative professional development settings for the purpose of understanding variation in the felt risks of the focus teacher in relation to their learning goals. Using a comparative case study design, this research documented the differential impact of felt risks associated with the spotlight teacher role. This exploratory study contributes insights that help guide the essential support and facilitation work mathematics education leaders must provide for developing, supporting, and sustaining video-based professional learning communities.

Keywords: video clubs, teacher learning, teacher communities, professional development, mathematics education

1. Introduction

In the past decade, video clubs have become a popular means of classroom-based professional development for mathematics teachers. Video clubs are professional meetings that support teachers' collective inquiry into student thinking as it occurs in video excerpts of their teaching [1–3]. Teachers who participate in these clubs bring samples of student work and video clips from recent lessons, share these artifacts with colleagues, and then engage in discussions of teaching and learning.

This type of professional work intentionally orients teachers' interpretations of significant classroom interactions around student thinking, which is a critical step toward teaching for understanding [4–6]. Video clubs offer an effective collaborative structure for supporting,

sustaining, and assessing the growth of developing professional teacher communities in relationship to student learning [7, 8]. Smith described engagement in such activities as "practice-based professional development," where

> *teachers develop the capacity to see specific events that occur in the practice of teaching as instances of a larger class of phenomena. That is, generalities are abstracted from examining particular situations, and these in turn become practical wisdom that will inform teachers' practice*. ([9], p16)

We know from research about video clubs that they have the potential for transformative teacher learning. In their study of video clubs, Sherin and Han argue that teachers, like their students, "need opportunities to construct new understandings and to reflect on their learning" ([1], p163) as opposed to simply being told what to do [13]. The authors found that as a result of video club, what teachers discussed and how they discussed it changed over time—the conversations shifted from issues of pedagogy to more complex concerns related to student conceptions. Discussions progressed from simple restatements of students' ideas to detailed analyses of students thinking. These changes indicate a shift in what teachers' found important, which suggests "they now valued making sense of student thinking and were willing to discuss such issues in detail and at length" ([1], p174).

Similarly, Sherin and van Es found that over time teachers took on a more interpretive as opposed to evaluative stance toward classroom events occurring on video excerpts [2]. As teachers adopted a more interpretive stance, they began to ground their interpretations with evidence from the video. This is significant, because a shift from giving anecdotal advice to seeking an understanding based upon evidence signals increasing engagement in and with the messiness of teaching. Sherin and Han argued that the learning that occurred during video club promoted development of teachers' professional vision [1], which Goodwin defined as "socially organized ways of seeing and understanding events that are answerable to the distinctive interests of a particular social group" ([14], p606). In the context of video club, the authors found that teachers "learned to attend to particular kinds of events that happen in a classroom and they learned to reason about these events in particular ways" ([1], p179).

1.1. Limitations alongside learning potential

Despite its many benefits and potential for transformative teacher learning, limitations exist within the video club model. Watching a short clip from a lesson is typical of video club. This clip is taken out of the context of both the class period from which it was drawn and the long-range plans teachers have for their students. Although the teachers who are being watched are present, time constraints restrict the ways in which teacher can fill in these gaps for others. It is possible that teachers may have more to say on issues that emerge from watching and discussing the video excerpt but do not have the opportunity to reveal their thoughts.

Moreover, although the video club model has strong potential for advancing collaborative professional learning and making space for developing teacher learning communities in ways likely to transform classroom practices over time, van Es cautions that "simply bringing teachers together does not ensure community development" ([10], p182). Watching and discussing video footage of a colleague's classroom is inherently vulnerable work, especially

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for spotlight teachers whose classroom video excerpts are viewed and discussed [7]. Even in the best of circumstances it is hard not to be guarded when one's teaching is the subject of discussion [21, 22]. For example, consider the following quote made by a teacher participant in our video club study:

> *I enjoy critical feedback in my room. Like I said, you can come in here anytime and just rip me apart. I would enjoy that. But to put it in a room full of people I really respect, you know? But even if any one of those individually, like Rose, if they came into my room and we were just one-on-one and then they just ripped my lesson apart I would be happy with that. But, for some reason, it's too scary a thought of having them all witness me [fussing] at a girl for trying to measure the hypotenuse.* (James)

In this quote, James expressed the discomfort that many teachers have about sharing classroom video clips with colleagues. As explored in more detail later in this chapter, James felt that being the focus teacher—the teacher in the spotlight—was risky for a number of reasons. At the same time, however, he was able to realize the benefits of volunteering to be the spotlight teacher. This tension reinforces the important role mathematics education leaders play in accomplishing the goals of video club, primarily through skilful, adaptive facilitation of socially complex sites for collaborative teacher learning [11, 12]. In this chapter, we explore these risks and benefits by presenting cases of two spotlight teachers with an eye toward how mathematics education leaders can support spotlight teachers in the context of video clubs.

1.2. The spotlight teacher role and opportunities to learn

Despite possible limitations of the video club professional development model, the potential benefits on teacher learning outnumber the risks, thereby highlighting a need for research on how to support teachers who are the focus of the video clip experiences or how professional development leaders can support the teachers in the spotlight. The strong potential for video club to function as a transformative professional development experience brings the spotlight teacher role into focus for mathematics education leaders. In an effort to shed light on this pivotal role and how to support spotlight teachers, we explore the following question in this chapter:

> *How does the vulnerability associated with the spotlight teacher role impact the spotlight teachers' opportunities to learn from the video club experience?*

2. Methodology

This study took place in context of *Adaptive Professional Development for High School Mathematics Teachers* (Ilana Horn, Principal Investigator), a 6-year design research project situated in a large Northwestern school district in the United States. The professional development (PD) leadership team used learning principles for teachers in the design of program activities for participating teachers, such as prioritizing opportunities and support for teachers to deprivatize their classrooms through viewing and explaining classroom interactions [1].

2.1. Video club professional development context

At the time this study was conducted, this PD project was in its second year of a video club sponsorship. All mathematics teachers from three partnership high schools received monthly invitations to participate in video club. Participation was voluntary, and no one was excluded from participation. Meetings lasted for about 2 hours, with an average attendance of 11 teachers. All participants were encouraged to take a turn as the spotlight teacher, although this was not required for participation. Some teachers were more comfortable with filming their classrooms than others, and so spotlight teachers were ultimately selected based on interest and logistics associated with filming (e.g., parent permission forms, classroom schedule).

After filming the spotlight teacher's class and making them a copy of the footage, one of leadership team members created a 5-to-7 minute clip of student-centered footage for use at the video club meeting. The spotlight teacher's preferences for clip selection were taken into consideration—the spotlight teacher always maintained veto power—and they were provided with a copy of the clip prior to the video club meeting. As a rule, the chosen video clips did not contain footage that featured lengthy turns of teacher talk or instances of student misbehavior, since the goal of video club was to better understand student thinking about mathematics.

The first part of the video club meeting was dedicated to completing the mathematical task that was featured in the spotlight teacher's video and then developing solutions that students might develop in response to the task. The goal of this first discussion was to help teachers deepen their understanding of the mathematical content while developing their knowledge of students' mathematical learning. Next, the spotlight teacher set up the video clip for participants to help provide any necessary context for understanding what they would see in the video clip.

The teachers focused on this question when watching the clip: *Using evidence from the video, what can we tell about what students understand about the mathematics?* A member of the PD leadership team served as facilitator and helped the group follow the established community agreements for safe discussion boundaries, which included implementing the following discussion protocol: (a) a minute of silence after watching the video for teachers to have private think time as well as time to jot some notes to guide their contributions to the discussion; (b) the spotlight teacher has first turn of talk, providing evidence from the video about what the students understood about the mathematical goal of the task; (c) other teachers provide feedback on the focus question. The goal of this discussion was to help teachers develop the kind of formative assessment that productively informs instructional decision-making.

2.2. Participant selection for video club study

Two teachers from the pool of spotlight teachers from the video club cycle volunteered to be in this study, Linda Wesson and James Stone (all names are pseudonyms). Linda and James taught at neighboring high schools in the same school district, were both relatively new teachers (less than 2 years of experience), used the same curricular materials, and had similar course schedules (i.e., ninth-grade math and pre-calculus). We found Linda and James to be

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interesting comparison cases because while both expressed eagerness to grow through the spotlight teacher experience, we observed differences in their relative comfort with peer review and discussion of their classroom video footage prior to filming their classrooms for video club purposes. Linda appeared to be much more comfortable than James with this process, and so we theorized that these differences would uncover interesting variation across their spotlight teacher experiences and offer insights related to their differential needs for support.

2.3. Data collection strategy

This study utilizes interview data as the main data source. Audio-recordings, field notes, and lesson artifacts from monthly video clubs meetings in which spotlight teachers participated served as secondary data sources, and were collected to verify findings from the main data source. All data were collected during the video club cycle from the second year of the project's video club program. The overall data collection strategy was to interview the two spotlight teachers at four points in the video club process to capture their perspectives at different stages of the work (see **Table 1** for summary). Nicole, the first author of this chapter, conducted all of the interviews for this study.

As a unique part of this study, participants were asked to watch the video clip on their own in preparation for a semi-structured interview [15, 16] prior to the video club meeting (the *Video Club Preview* interview, 2_VCP_SS). This 2-hour interview was guided by prompts related to the lesson and to the selected video clip, what the spotlight teachers expected their peers to learn at the video club meeting, and their perceived risks associated with being videotaped. An elicited task [15], specifically an additional viewing and debriefing of the video clip with the spotlight teacher, was included as part of the *Video Club Preview* interview.

The two video club meetings for the spotlight teachers in this study were typical with respect to established protocols and routines. Nicole interviewed the two participants informally for about 10 minutes following the video club meeting in which they were the spotlight teacher (the *Video Club Reflection* interview, 3_VCR_SS). Data collection concluded with a final semi-structured *Spotlight Teacher Reflection* interview (4_STR_SS) that was similar in nature, format, and content to the *Video Club Preview* interview, although it did not include an elicited task. In its place, James and Linda were asked to discuss and compare their viewing and debriefing experiences across different parts of the process.

Interview name	Abbreviation	Length of interview	Purpose of interview
Video lesson reflection	1_VLR_IC	10 minutes	Immediate thoughts on videotaped lesson
Video club preview	2_VCP_SS	2 hours	Discuss video lesson before video club
Video club reflection	3_VCR_IC	10 minutes	Immediate thoughts on video club meeting
Spotlight teacher reflection	4_STR_SS	2 hours	Discuss spotlight teacher experience

Table 1. Summary of primary interview data sources.

2.4. Data analysis procedures

This study utilized a comparative case study design, chosen for the purpose of making meaning of the "richly brewed particulars" ([17], p2) of each spotlight teacher's experiences. Data were analyzed by inductive methods of constant comparison [18] for the purpose of understanding the spotlight teachers' felt risks in context of what they found important in their classroom video excerpts and what they wanted to learn through the spotlight teacher experience. Data analyses ended with a cross-case examination for themes within and across cases in order theorize more generally about the experiences and needs of the spotlight teacher [19].

3. Unpacking the spotlight teacher experience

As a preview to the individual case studies presented next, we begin this section with more general findings that emerged during data analysis. Linda and James both attended to aspects of their video lessons that they found problematic, as student engagement in the enacted lesson was different than what they had intended in their respective lesson plans. In addition, both teachers expressed a belief that critical feedback from peers would help them grow their craft. With that said, James and Linda differed in the ways they took up problematic aspects of their video lessons. Linda used the interview discussion prior to video club to gain specificity with the classroom problem she wanted to solve, and then leaned on her colleagues at the video club meeting to help her develop an instructional response. James used the interview discussions to give blow-by-blow assessments of his teaching, which we deemed as overly harsh in many instances. Overall, the findings presented here suggest that Linda and James were differently impacted by the vulnerability associated with peer review and discussion of their classroom video footage, which highlights contrasting individual needs for support within the spotlight teacher experience.

3.1. The case of Linda Wesson: How do you teach kids presentations?

Linda's video footage featured presentations given by her ninth-grade students. The presentation task was adapted from an instructional unit that required complex planning and problem solving related to a hypothetical group expedition [20]. Linda based the success of the lesson on expectations for presenters to explain their group's mathematics and for audience members to "[call] people out on stuff that doesn't make any sense" (*LW: 2_VCP_SS*). Linda was disappointed in the lesson because of problematic mathematical explanations from presenters and lack of engagement by, and respectful press for clarification from, the audience:

> *But a lot of the kids just did not even recognize the fact that four blankets for 24 people was probably going to be less than what you would ideally have. And they were not being critical in that way… Kids were just doing it to try and get out of there as fast as possible, were not really willing to share anything that they had done—which made me wonder what they had done… [T]here are not many people into it, you know?* (LW: 2_VCP_SS).

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Linda questioned the mathematical and social merits of presentation tasks in response: "But then what's the point of doing an assignment if everybody does it and doesn't make it so that it makes any sense?" (*LW: 2_VCP_SS*). Linda focused the remainder of the *Video Club Preview* interview on her felt need to teach students how to give presentations and be good audience members. Linda recognized that audience members did not have anything to do in her lesson, and reflected that she needed to teach them "how to care—or why they should care" (*LW: 2_VCP_SS*). Linda hoped her peers would brainstorm specifics around her dilemma with presentations at video club.

When prompted to reflect on her comfort with video review across contexts, Linda noted that it was easier to watch and discuss the video with Nicole because she found it easier to talk one-on-one and also because Nicole had been in her classroom and knew the entire lesson context:

> *I think when it's Video Club I definitely get more embarrassed—like, when I am rambling and making up things…but that's kind of more embarrassing in a big group of teachers than might be more critical.* (LW: 2_VCP_SS).

Despite her potential felt risk for embarrassment, Linda explained her student presentation dilemma at the video club meeting and invited discussion related to strategies that might help students learn to be active listeners. Linda tried some of these strategies in her classroom the following week, noting in the *Spotlight Teacher Reflection* interview that she had been working with her students on presenter and audience member roles through peer exchanges and revision cycles. She was energized by immediate improvements with students:

> *One group did 'Eating at McDonalds' and they found…if all kids at [our school] eat McDonalds 4 days a week—because that's what they thought, that was their test for how many times a week students eat at McDonalds…Then the school spends $23,000 a week at McDonalds…And so it was really interesting that they had this moment of realistic stuff kicking in while they were doing the actual math. But it was really hard for them too. They were like, '23 thousand dollars? Is that right?' And they'd go back and do it again. And I said, 'Yeah, that's right.'…I was like, 'You guys could do it in terms of calories and how much it takes to walk off the calories' and stuff…So, it was a good activity for getting students engaged and for pushing them to the level they are comfortable with.* (LW: 4_STR_SS).

Although Linda was disappointed by student engagement in presentations prior to video club, the peer support offered at the meeting helped her develop classroom conditions that supported the productive student presentations she imagined in her lesson plans.

3.2. The case of James Stone: Why did everything go wrong today?

James' video footage featured the second day of an indirect measurement lesson task selected from his ninth-grade curriculum materials [20]. The task involved using mirrors to figure out the height of different objects posted around the room. James based the success of the lesson on student engagement "every minute of the day," which functioned as a proxy for learning:

> *Mark, even though he's over there, he is engaged…And Donald's just copying stuff down. Jim is learning. Preston is a genius. So, he's fine. The kid in the gray, he's engaged. Donald's not. Now there's one I was disappointed in.* (JS: 2_VCP_SS).

Although James stated that "the lesson was good" and "kids learned," he was initially concerned that the second day of the task "was almost kind of pointless because it was just computation. It was just putting into practice what we had already done" (*JS: 1_VLR_IC*). James revised his thinking in the *Video Club Preview* interview after watching the video footage, noting that the application task helped students solidify their understanding of indirect measurement:

> *I guess there was conceptual stuff going on, because until they put it into practice…I could definitely see some of the kids' eyes light up when they finally realized that what we were talking about in class was applicable.* (JS: 2_VCP_SS)

Although James verbalized a few of his strengths in the interviews, such as excellent rapport with students and inquiry strategies, James gravitated toward criticisms of his teaching. For example, James noticed that he answered his own questions:

> *I felt like in the beginning I pulled information out of the kids…But then there's also times when I am asking a question and I am pointing at the 'w' and that's the answer…[I]t's a hard habit to break. You just want so badly for them to get it, that you tell 'em!—rather than them getting it. You know what I mean?* (JS: 2_VCP_SS)

James scolded himself when we watched this section of the video during the elicited task, saying: "That's not a question, when you're pointing at the answer!" (*JS: 2_VCP_SS*). While James' assessment seemed fair, and his frustration understandable, his self-criticisms also seemed overly harsh at times. For example, while watching his video, James chided himself for being condescending to his students. This ran counter to what Nicole observed during classroom observations-that James is a positive, energetic, and caring teacher.

When prompted to discuss what he hoped to gain from the video club meeting, and as quoted at the beginning of this chapter, James confirmed that he felt a high degree of risk as spotlight teacher for the next video club meeting:

> *I enjoy critical feedback in my room. Like I said, you can come in here anytime and just rip me apart. I would enjoy that. But to put it in a room full of people I really respect, you know? But even if any one of those individually, like Rose, if they came into my room and we were just one-on-one and then they just ripped my lesson apart I would be happy with that. But, for some reason, it's too scary a thought of having them all witness me yelling at a girl for trying to measure the hypotenuse.* (JS: 2_VCP_SS)

James' discomfort escalated during the video club meeting. Even though James felt that "everybody was supportive" and not being critical, he still felt judged: "It's not that I took it personally, but I really took it more of a 'let's all critique James' rather than 'let's all learn from this videotape'" (*JS: 4_STR_SS*). The actual meeting proved overwhelming for James:

> *There was just so much information coming in that a couple times I just shut down and did not even hear. I mean I was staring right in their eyes… and I had no idea what they were saying, because it was just too much.* (JS: 4_STR_SS).

When prompted, James explained that even though watching the tape with Nicole made him nervous, he did not feel like Nicole was judging him, whereas he did feel judged at video club. Even so, James feels that he "was putting that on [himself]", and that the whole video club experience "was very worthwhile, that's all I know. I'm glad I did it" (*JS: 4_STR_SS*).

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3.3. Summary

Linda and James both expressed interest in taking on the spotlight teacher role, and both indicated that the experience supported their professional growth. In addition, both teachers observed problems with student engagement when reviewing and reflecting upon their own video lessons. However, James and Linda differed in the ways they took up the problems they identified. After zeroing in on problems with productive student presentations, Linda brought up this issue with her peers at video club and used the meeting as a problem solving space for developing her practice. James was critical of his teaching practices in ways that made taking up these issues with colleagues at video club prohibitively risky for him, although he found peer review with Nicole to be a helpful form of professional development. These findings suggest that Linda and James were differently impacted by the vulnerability associated with peer review and discussion of their classroom video footage, which highlights contrasting individual needs for support within the spotlight teacher experience.

4. Discussion and implications

Although research has found that video clubs can be sites for transformative teacher learning [1, 2], it is clear from the findings presented in this chapter that Linda and James had very different experiences when they were the spotlight teacher in this video club, which we contend impacted their learning. The extent to which they had the opportunity to learn from being the spotlight teacher was also impacted by extent to which they experienced a sense of vulnerability associated with peer review and discussion of their classroom footage at video club. Linda's relative ease with the process promoted her use of the video club meeting as a sense-making space for an emergent problem of practice, thus providing her an opportunity to learn as a result of being the spotlight teacher. On the other hand, James' discomfort with the risks that came along with watching an everyday example of his teaching with a group of colleagues rendered him unable to think clearly during the meeting, thus limiting his opportunity to learn from being the spotlight teacher. So, while Linda and James appeared to have the same experience—the two video club meetings looked very similar from the outside looking in—they actually experienced very different things based on their interpretations of the video club events. The interviews that Nicole conducted for this study allowed us access to Linda and James' inner dialog about being the spotlight teacher and illuminated that Linda and James had very different experiences. This is something that we might not have seen had we simply analyzed data collected during the video club meeting (i.e., analyzed the teacher discussions).

The cases of Linda and James highlight contrasts in individual needs for support for the spotlight teacher experience. Teachers who seem less impacted by risks associated with group review of their classroom video footage, as was the case with Linda, may benefit from reflective work prior to the video club session in order to sharpen their opportunities to learn during the meeting. Teachers who are new to videotaping or who are more sensitive to feeling judged by peer video review, as was the case with James, may need face-to-face support prior

to the professional development meeting since the spotlight teacher may not be physically able to get what they need during the meeting.

It is important to note that James is not alone in his discomfort, as is it normal and typical for teachers to find the experience of peer video review and discussion nerve-racking, especially in the beginning [7]. The study shared in this chapter captured James' perspective at a moment in time when he was relatively new to teaching and brand new to classroom videotaping. While we do not know if James' extreme discomfort eased over time, extant literature supports a dynamic understanding of this possibility [1, 7], thereby motivating mathematics education leaders' continued investment in spotlight teachers who do not immediately present like Linda. Both Linda and James said that one-on-one review with a trusted peer felt safer, which suggests that non-evaluative classroom coaching may be a good place to start this work.

The findings of the study also have in-the-moment implications for teacher leaders who facilitate video clubs. An attuned facilitator might notice the "zoning out" of a spotlight teacher (as James noted happened to him) and pause the action for spotlight teacher to take a minute to reflect on a colleague's comment or to think of a follow-up question to ask. Facilitators can and should pay close attention to the spotlight teacher's affect during the debriefing portion of the video club to ensure that spotlight teachers do not experience a barrage of suggestions or criticisms. Keeping the focus on student learning would also help to mitigate feelings such as what James experienced. Lastly, closely-followed discussion protocols for this type of work, such as those created for use in critical friends groups, can help to create safe learning spaces for spotlight teachers [21].

Although this study analyses the experiences of only two spotlight teachers, their experiences resonate broadly with the lived experiences of teachers who have varying degrees of comfort with video-based collaborative learning. With the assumption that both of the spotlight teachers' experiences are typical, we used the cases of Linda and James to theorize more generally about the importance of tuning into and supporting the varying needs of the spotlight teacher in context of their felt risks, observations, and learning goals. This research contributes insights that help guide the essential support and facilitation work mathematics education leaders must provide for developing, supporting, and sustaining video-based professional learning communities.

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Chapter 6

Outdoor Learning Activities as Facilitators in the Construction of Environmental Citizenship

Maria Eduarda Ferreira and Rui Pitarma

Additional information is available at the end of the chapter

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Abstract

The results of an educational research project on a teaching and learning practice developed in the context of primary school teachers' continuing education in which didactic-pedagogical practices of outdoor learning are given a main role are analysed. The research followed a qualitative approach. It was assumed that environmental literacy is based on the premise of training for critical and responsible citizenship, with the aim of developing knowledge and skill for active participation in making decisions and following behaviours, of social-environmental interest. In this context, a didactic pedagogical component on the topic of "Water" was developed and implemented. The didactic strategy followed was that of outdoor learning, with a teaching learning perspective based on the interrelationship between the sustainability of natural water resources and individual behaviour. The following categories of analysis were used: didactic transformation of curricular content; environmental literacy; science-child-environment interaction. This training course highlighted the acquisition by this group, primary school teacher's, of skills that are fundamental to the development of a teaching and learning process that promotes environmental citizenship through the discovery of the surrounding natural environment.

Keywords: continuing education, primary education, environmental citizenship, water, outdoor learning

1. Introduction

Primary education is a privileged opportunity for children's environmental literacy, in line with the construction of environmental citizenship. Children at the beginning of compulsory schooling should have educational practices that allow them to understand the importance of their role in the construction of a society committed to environmental citizenship in a daily base

practice (behaviours). According to Roth [1] there is a causal relationship between environmental literacy and environmental impacts associated to behaviour. The environmentally literate individual understands the existence of interconnection between nature and human societies [2]. We share these convictions and we conclude that an environmentally literate individual must have knowledge, abilities, values, attitudes and behaviours committed to solving environmental problems. In short, critical scientific literacy should be developed in the child. Children must develop skills to analyse critically what they learn. They need to use this scientific knowledge to control, solve problems along their lives, in particular those related to their relationship with nature. The Organization for Economic Co-operation and Development (OECD)/Program for International Student Assessment (PISA) states:*"Scientific literacy is the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity"* [3].

The teaching-learning process, in the context of interaction with problems generated at the local natural/humanized environment, can provide opportunities to experience. That is, the context provides the scenario for a meaningful learning. It propitiates the acquisition of scientific knowledge interconnected to the appropriation of ecocentric values. It prepares the children for exercising an active participatory citizenship. Then, children develop a critical and committed citizenship to the protection, the preservation of the environment and the resolution of environmental problems. Primary school is the formal context that has the tools to develop in children critical scientific literacy and make them environmentally literate. The approach to the ecocentric concept [4], the child must understand that children are part of all ecosystems that constitute the ecosphere. That is why it should be provided education for the exercise of active and critical environmental citizenship from the very beginning of the compulsory school. Primary school teachers play a fundamental role in the appropriation of these skills. The teaching strategies used the most are the transmission of factual knowledge and memorization [5]. The professional development of teachers is subject to a triad of interrelated dimensions: research-action-training. This interdependence must always be present throughout his career [6].

The higher education institutions specialized in initial and continuing education has domain in the diversity of didactic-pedagogical arena. Thus, they play a fundamental role in promoting education for environmental citizenship (environmental literacy). Consequently, they contribute to developing critical scientific literacy in science.

In this research, we analyse the results of a pedagogical-didactic experiment carried out as an outdoor learning activity. The experiment was developed with a group of primary school teachers attending an in service training course at a Higher Scholl of Education.

The core of the didactic experimentation was the relation between contextualization-relation of sciences concepts with surrounding everyday reality. It intended to give meaning to the interrelation between scientific knowledge, values and attitudes for a participatory environmental citizenship.

Water was the natural resource selected for this experiment. The topic "Water" makes part of the curricular area of "Study of the Environment" the Portuguese primary education. The following content was explored: physicochemical characteristics of the molecule; components

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of the physical environment; natural resources of the environment; quality of water and existence of living beings in ecosystems; pollution of watercourses; preservation of water resources. The choice of the topic "Water" is justified by the local region having rivers, hot springs, recreational areas framed by river banks and by the scientific community acknowledging that drinking water is determinant for the survival of living beings and a basic right of humanity to meet their vital biological needs. We are living in a time when prospects of guaranteeing drinking water for all are threatened, not only because of availability limitations of this natural resource, but also because of the growing consumption of water by Western societies due to cultural practices, believes and anthropomorphic values (nature exists to serve humanity). Quality water alteration in natural ecosystems has consequences on population health. Even more, it has widespread environmental consequences. Each year, about two million people, mostly children under 5 years of age, die of diseases associated to water quality. For example, in Sub-Saharan Africa, 65.2% of the population does not have access to clean water [7]. According to the latest report of the Intergovernmental Panel on Climate Change, the threat of hunger, water rationing and extinction of species is a reality. It is recognized, therefore, the need of the individuals to have interventions for preservation and solving environmental problems of local and global society.

2. Theoretical background

It is a major challenge for teachers of primary education the promotion of interaction with the surrounding natural/humanized environment in a non-formal context, in order to develop skills for environmental responsibilities. Competences of the individual *"integrates knowledge, skills and attitudes and can be understood as knowing in action or in use"* [8]. According to Ref. [9], *"the change in behaviour resulting from learning usually comes from a series of practical experiences and interactions with the environment"*. The sooner the child understands how fundamental it is to value the local natural/humanized environment and develops attitudes based on critical and participative responsibility, in the preservation of this environmental heritage, the greater the possibilities, as an adult, of coming to exercise an active and responsible citizenship. Exercising an active and critical environmental citizenship is participating with environmental literacy.

The Portuguese Law of Fundamentals of the Educational System [10] states that compulsory school starts with primary education. One of its general objectives is: *"To ensure that in this stage of education know-how, theory and practice, school culture and everyday culture are interrelated"*. These goals can only be achieved if the child has the opportunity to interact with the natural and humanized contexts of the environment in which he lives (family, school, social, cultural and environmental contexts). Along his life, the child experiences and acquires knowledge, practices (behaviours) and values that condition his development, the relation with his community, and the global society.

The curriculum of primary education in Portugal [11] recommends that in the curricular area of "Study of the Environment": *"Students will deepen the knowledge of Nature and Society, and it*

will be up to the teachers to provide them with the necessary tools and techniques in the way they can construct their own knowledge in a systematic way". It also states that: *"All human activity leaves traces and causes changes in nature. In this sense, attitudes related to conservation and improvement of the environment, the rational use of natural resources, and active and enlightened participation in solving environmental problems should be promoted"*.

It is recognized the importance of developing interdisciplinary pedagogical-didactic practices. Thus, it has to be centred in real word contexts and focused on the articulation of scientific knowledge with the development of capacities. These conditions lead to exercise a critical, responsible and participatory citizenship for solving environmental problems.

There is an interrelation between education about the environment, education for the environment and education into the environment. Indeed, the outdoor learning activities allow the use of natural/humanized spaces in the vicinity of the school as natural laboratory of: knowledge, attitudes and values that promotes the practice of a participatory and critical environmental citizenship [12]. Outdoor learning *"is a method where parts of the everyday life in school are moved out of the classroom into the local environment"* [13]. Underlines the need to develop a comprehensive and proactive pedagogical approach, oriented towards solving concrete problems of the environment through interdisciplinary approaches and active and responsible participation of each individual, and of the community [14].

In the structure and programming of the Portuguese primary education [11], it is stated *"the need to carry out active, meaningful, diversified, integrated and socializing learning experiences. This statement is in the guiding principles of pedagogical action"*.

The curricular area of "Environmental Studies" [11] can still be the motive and the engine for this type of learning. Consequently, it could be example of practicing interdisciplinarity among other fields of primary education in Portugal. According to Ref. [15], *"if several subjects are grouped under a common root that meets the interests of the students by combining activities – till now hitherto compartmentalized – they will increase their performance"*.

The methodology of teaching-learning applying outdoor activity stimulates the development of interdisciplinarity among all study fields of the primary education program. This is favourable to the student-centred active learning environment. These activities bring great benefits for achieving the objectives of the educational program, even more, the physical and emotional development of the child can also be enhanced [16]. In fact, the lack of opportunities may result in *"nature deficit disorder"* [17]. It is therefore up to the teacher *"to organize demanding and stimulating learning contexts, that is, formative environments that favour the cultivation of healthy attitudes and the unfolding of capacities, which purpose is the development of skills that allow the students to live in society, that is, to participate and intervene in interaction with other citizens"* [18].

The Ref. [19] divide attitudes into four main categories: (a) attitudes are persevering; (b) attitudes are acquired; (c) there is an association between attitude and behaviour; and (d) attitudes are dependent on individual values. The attitudes can influence cognitive, affective and behavioural structures [20].

Outdoor learning is a pedagogical-didactic resource that provides children with interaction with the natural/humanized environment, and affective attachment to local and global

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heritage. It contributes to the development of research capacities and critical and reflective thinking [21]. Outdoor activities are preferred in promoting conservation and environmental protection [22].

Before beginning any outdoor learning activity the teacher should reflect on the following aspects [21]: *"How can learning outdoors enhance and deepen learning within curriculum areas?; Which experiences are best suited to a combination of indoor and outdoor learning?; How can learning indoors best be consolidated, progressed or enhanced using the outdoors?; What opportunities exist for linking learning across the curriculum?"*.

The curricular area of "Environmental Studies" of Portuguese primary education [11] is organized in groups of subjects. The *"In the discovery of the natural environment" group of subjects states that "the teacher should promote in his students attitudes of respect for life and nature, as well as sensitize them to the aesthetic aspects of the environment"*. The *"Discovering the interrelationships between nature and society"* group of subjects states *"teachers should promote attitudes related to the conservation and improvement of the environment, the rational use of natural resources, as well as an informed active participation in solving environmental problems"*. The education in primary school should be committed to provide skills that empower children for a proactive citizenship. Then, they will be capable of finding solutions to local and global issues (environmental literacy).

Students have *"rudimentary, subjective, incoherent, inexperienced knowledge, and they are incapable of grasping the complexity of the environment"* [11]. Martins et al. [23] highlights *"the importance of the mental implication of the individual as agent of their learning so that school learning will be seen as a process of (re) construction of this knowledge, and teaching will be seen as facilitator of this process"*. The beliefs of individuals are result of their experience of life, their acquired knowledge and their values [24].

Educating behaviours is a complex and multidimensional task since they are rooted in individual and societal beliefs. Nevertheless, we consider that environmental citizenship attitudes must be learned in practice acquired during the development of children when attending primary school.

The teacher realizes the importance to implement teaching strategies for children to develop skills to solve problems and make decisions [25]. But, the way in which scientific knowledge is introduced can be a serious obstacle to learning. Teaching methodologies are necessary to provide learning for understanding. Problematizing, and exploring situations and phenomena constitute moments of discovery, knowledge and opportunities to raise awareness for participation in order to preserve the environment and solve environmental problems [26].

The line of thinking quoted above was possible to be experienced with a group of teachers of primary education that were attending an in-service training course about pedagogical-didactic strategies. In this context, the group developed a didactic pedagogical intervention on the curricular content "Water". The didactic strategy followed was that of outdoor learning. They were taught about: promotion of participation, interventional and committed citizenship with values for preservation of natural/humanized environment; analysis of the pedagogical-didactic potential of outdoor learning activities, with student-centred active learning, in the development of environmental literacy.

3. Issues and objectives

In this investigation, we have considered the following research questions:

(a) Do the activities of outdoor learning itineraries constitute proper didactic resources for the transformation of scientific content based on the assumption of promotion of children's environmental literacy?

In this case, the topic "Water" the curricular area of "Environmental Studies" is explored beforehand in theoretical-demonstrative dialogue session with teachers.

(b) Do have pedagogical-didactic possibilities within the scope of curricular interdisciplinarity?

(c) Do the itineraries of outdoor learning activities promote the articulation of science-child-environment under a scope of child's environmental literacy?

Thus, to provide answers to the questions we raised, the following learning objectives were defined for the pedagogical-didactic:

(i) To revisit of the scientific concepts related to the water molecule; (ii) To highlight the ecocentric vision of the natural water resource; (iii) To discover/highlight the potential of outdoor learning activities as a didactic resource of the teaching-learning process in the study field content, from an interdisciplinary perspective to contribute to environmental literacy; (iv) To construct an outdoor learning guide to teach the topic of "Water" based on a perspective of interdisciplinarity and student-centred active learning environment. The didactic resource should provide active, meaningful, diversified, integrated, socializing learning experiences. It must contribute to the appropriation of values and attitudes that promote practices of responsible environmental citizenship, it mean an active, critical and engaged citizenship.

4. Methodology

This pedagogy research was carried out under a qualitative approach [27]. The interpretive nature of this research leaded the researcher to have a participant-observer role.

The following categories of analysis were considered: didactic transformation of study field content; environmental literacy; articulation among science-child-environment.

The data were obtained using the following instruments: observation (direct and participant), the construction of learning itineraries, and the collection of considerations raised by the participants.

A group of 30 primary teachers participated. The pedagogical study was developed within an in-service training course (continuing education course) for teachers on new methodologies for teaching-learning.

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5. Development of the pedagogical-didactic intervention

The conceptual map followed in this pedagogical-didactic study is presented in **Figure 1**. A conceptual map is a strategy that could potentially facilitate meaningful learning [29].

This pedagogical-didactic study was structured in two phases (three sequential moments).

Phase I (Theoretical-demonstrative session lasting 3 hours): (1) transmission of articulated concepts to ecocentric perspective of the natural/humanized environment; demonstration of didactic activities in a non-formal context based on examples.

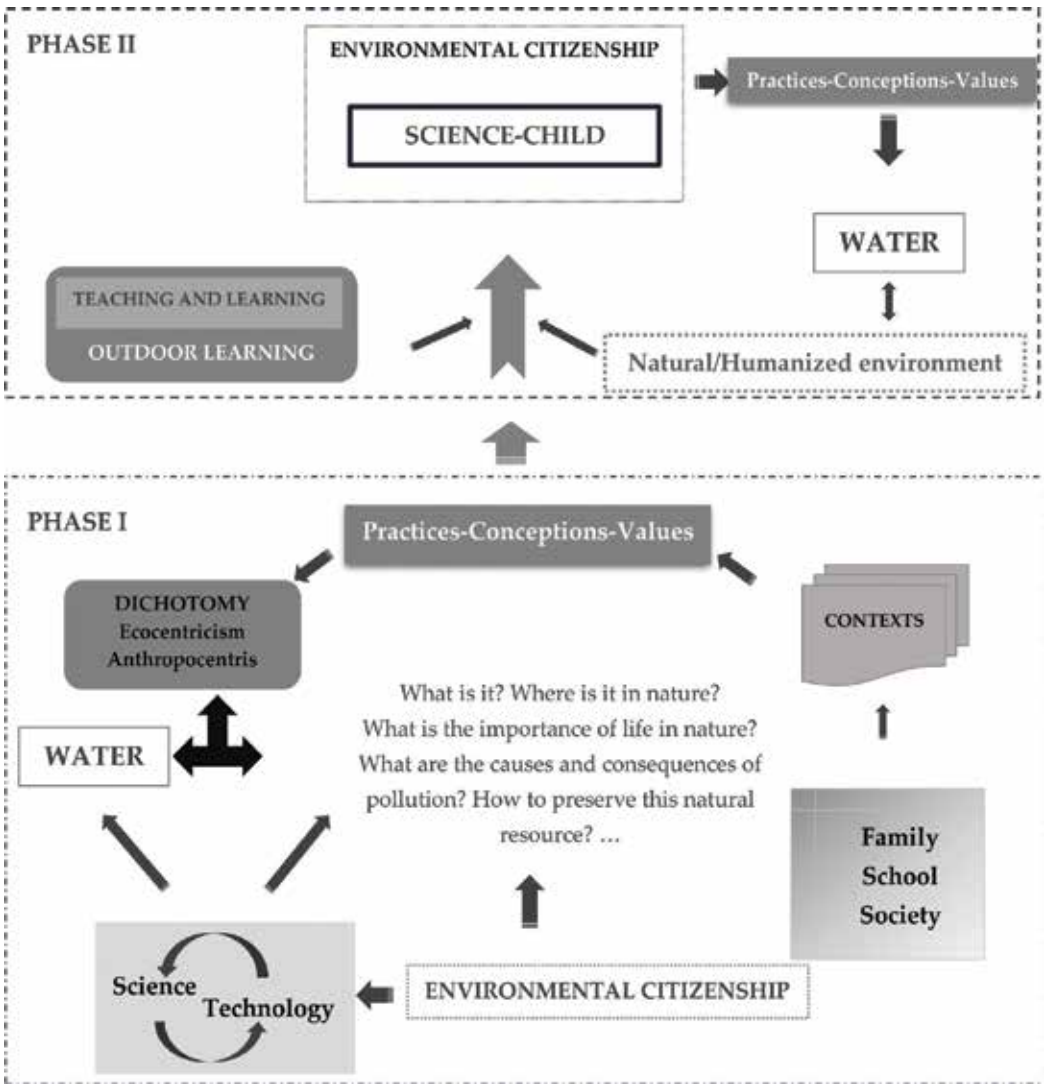

Figure 1. Conceptual map to approach the topic of "Water".

Phase II: (1) participative construction of didactic itineraries for outdoor learning activities; (2) After 2 weeks of autonomous work carried out in group, there was the delivery of the scripts and a written essay on the relevance of outdoor learning activities for children (exercising of decision-making capacities oriented to the resolution of environmental issues/problems based on ecocentric values and critical analysis of scientific knowledge).

Table 1 presents the sequence followed in the theoretical-demonstrative dialogue session for the pedagogical-didactic approach about the topic of "Water" (Phase I of the pedagogical-didactic activity). The PowerPoint tool was used as a pedagogical resource to illustrate concepts and environmental practices. It shows moments in classroom exposition, the valuation of believes in the learning of scientific knowledge as well as in the transmission of ecocentric values and attitudes of environmental citizenship.

Table 2 presents the framing the content of the topic "Water", presented in the theoretical-demonstrative dialogue session, in the programming the curricular area of "Environmental Studies" for primary education.

For the autonomous work of the group carried out outside the classroom (phase II), it was proposed to create didactic itineraries of the outdoor learning activity, a didactic resource for primary school children, according to what they should foster: (i) knowledge about the content of the water, whose content is part of the curricular area of "Environmental Studies" (terms/concepts); (ii) develop skills such as: observe, describe, record, interpret, evaluate, criticize and decide; (iii) develop ecocentric values and attitudes of environmental citizenship in relation to the natural resource water.

Sequence	Content	Verify/Develop/Explore
1°	Recognition that water is a universal heritage. Extensive topic to be expressed through art (painting, music and dance) and literature.	Believes, ecocentric values.
2°	Characterization of chemical and physical properties. Relation with living matter and existence of life. Understanding the role of water in natural ecosystems.	Believes, scientific knowledge, ecocentric values, environmental citizenship attitudes.
3°	Discussion of the impact of water pollution on human populations and the biosphere.	Believes, scientific knowledge, ecocentric values, environmental citizenship attitudes.
4°	Reflecting on practices and behaviours resulting from human cultural metabolism in water consumption. Discussion on practices and behaviours of preservation of water valorization and preservation.	Believes, scientific knowledge, ecocentric values, environmental citizenship attitudes.
5°	Understanding the potential of outdoor learning activities in teaching-learning contents in the context of natural/humanized environment.	Scientific knowledge, ecocentric values, environmental citizenship attitudes.

Table 1. Sequential development of the theoretical-demonstrative session.

Sequence	Field content [11]
1°	"… experiencing the activities of plastic expression, contact with nature, knowledge of the region, (…) are opportunities for enrich and broaden the students' experience and develop their sensitivity to aesthetics (p. 89). Collection of diverse human expression forms and forms on how nature expresses itself (p. 139)".
2°	"Recognize the different forms water is found in nature (rivers, streams, wells…) (p. 115)"; "recognize different environments where animals live (earth, water, air) (p. 116)"; "identify some environmental factors that condition life of plants and animals (water, air, light, temperature, soil) (p. 117)"; "identify some physical properties of water (colourless, odourless, tasteless) (p. 123)"; "observe the effects of temperature on water (boiling, evaporation, solidification, melting and condensation) (p. 126)".
3°	"Identify and observe some factors that contribute to surrounding environment degradation (dumps, polluting industries, historical heritage destruction…); enumerate possible solutions; identify and participate in ways of promoting sound environment practices. Water quality: recognize some forms of pollution of watercourses and oceans (sewers, industrial fluids, black tides…); identify some environmental imbalances caused by human activity: extinction of resources, extinction of animal and plant (p. 131)".
4°	"Know and apply standards of:… importance of drinking water (p. 107)"; "recognize the importance and necessity of basic sanitation and water supply (p. 130)"; "recognize the importance of reserves and natural parks for preserving the balance between nature and society (p. 131)".

Table 2. Framing in the curricular area of "Environmental Studies" within the content explored in theoretical-demonstrative session.

6. Data analysis and discussion

The instruments used to collect data in this research were: observation (direct and participant), the analysis of the itineraries of the outdoor learning activity and reflections in written records.

The analysis of results was conducted applying the categories: didactic transformation of the field content, environmental literacy and articulation science-child-environment. These categories were applied in the itineraries of the outdoor learning activity. They were means to verify the passage of a complex scientific language of the water field content to a simplified scientific language. The resulting didactic form fosters the interdisciplinary and articulated environmental literacy. The learning goal is the development of critical attitudes and participatory environmental citizenship. At the same time, the articulation science-child-environment was achieved. The environment should appear as one of the natural-humanized dimensions and the activity should be student-centered active learning environment. In short, the outdoor learning activity should be understood as a teaching-learning methodology in which scientific concepts are approached and articulated according to the couple scientific literacy-environmental literacy. In this context, the environmental literacy category was analysed in the scripts according to the development of decision-making capacities directed to the resolution of environmental issues/problems, based on ecocentric values and critical analysis of scientific knowledge.

We chose to analyse the results by triangulating the three categories of analysis.

Analysing the itineraries, we verified that all the groups chose to explore parks of urban leisure (natural-humanized environment) existing in the margins of a river that was object of requalification: river cleaning, tree planting, restoration of existing trees, training equipment equipping with, construction of recreational equipment (tables, wooden benches and children's playground) and catering infrastructures. It is concluded that these teachers responded positively to the challenge of discovering and valuing the natural/humanized environment near the place. They explored what was next to the school where they use to teach. Through the analysis of the resulting didactic scripts we realize that they prioritize the importance of developing the following skills: to observe, to describe, to register, to interpret and to evaluate.

All the scripts showed a common characteristic: they did not emphasize the scientific content already examined in the theoretical-demonstrative session with regard to the properties and function of water. Only one script included a song to be sung by the children at the end of the activity and the lyrics read: "Come often and do not forget to snack/It is not only lunch and dinner time/water is essential and must be drunk/It is so important that without it there is no life". Perhaps the group of teachers had difficulty in the didactic transformation of the concepts explored in the theoretical-demonstrative dialogue session. According to Ref. [28], there are few teachers at this level of education who have had a good education in science, which will translate into their teaching practices. Then the tendency is to avoid these subjects. However, their preference and consequent adequate didactic transformation were evident in topics related to ecology (ecosystem-living beings, water quality, pollution). Here some examples of the messages in the didactic scripts: (a) "The little river/again you will cross/if you notice running water/do you know what animal to pass? These amphibians are indicators of river water quality. Know why? We must all preserve the environment! How can you contribute to the preservation of this park? "; (b) " We need to preserve the environment by saving water and avoiding waste. Write four ways to save water"; (c) "This site reminds me of the forests that existed on our planet, already dead. What do you think? ". It was identified the conviction of this group that activities of outdoor learning are preferred methodologies for the promotion of environmental literacy, since in all scripts there are messages that points this purpose. Examples: "You are in a public space/That you must preserve/Treat it with respect/For all of us to use it"; "Would this Park exist without this natural resource?/We should therefore keep the space always clean"; "On our right side we find a waste basket. What is written there? Let's read and copy". Under the point of view of Bogner and Wiseman [22], this type of activity aims to promote conservation and environmental protection. The diversity of ecocentric messages demonstrated that the concepts we deal with in this study constitute the foundation of attitudes of environmental citizenship. There is also a concern for interdisciplinarity with the mother tongue (there is a constant call of attention to messages in the park to be transcribed in the script, and the existence of elements that appeal to the registers). The concern of interdisciplinarity with mathematics was evident in all didactic scripts. Here some examples: "It was about 2160 m/That you just walked/If you do it twice/How many Km would you walk?"; "If the volume of this lake/You could determine/Which unit to survey is the best?/Which would you use?"

All didactic itineraries of the outdoor learning activity contain messages of leisure and encouragement of the practice of physical activity. For example: "When the teacher says/Let's

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all play/In the playground/And to finish/In the grass you should sit/To rest/And the activity to evaluate"; "You find on your left/A green space to play/It's what we ask of you/Jump to the axis, without the colleague hurt".

It is observed in the messages that appear in all the scripts, a prevalence of situations/questions that promote the achievement of social, relational and affective goals.

We conclude that this pedagogical-didactic experiment mobilized the participation, raised the motivation and valorised outdoor learning activities. It was evident in the written reflections that the teachers presented like this: "… can and should be used as a resource as a teaching-learning element proper to the current requirements of the syllabus, since it allows a contextualized learning through which children can be formed Citizens capable of participating consciously and responsibly in society"; "These activities promote (…) the development of attitudes and values towards others individuals and the surrounding environment, they also promote motivation, interest and empathy for these subjects, stimulating the cooperation, the decision making and the spirit of leadership"; "It was good, we felt it would be a good thing to continue this line of training".

We found that the outdoor learning activity was considered by all stakeholders as a valuable strategy for the development of pro-environment skills. According to Ref. [22], *"There is also strong evidence that young children respond more positively to experiences in the outdoors than adults as they have not yet adapted to unnatural, manmade, indoor environments"*. Teachers concluded that children exposed to these activities can learn in a non-formal direct way, outside the classroom and free from the pressure associated with it. This is similar to Ref. [30]: *"When the child goes abroad, it is precisely the World, in its reality, that offers itself to his eyes. Instead of fabricating objects that represent ideas, and closing them in a closet, let the child out, showing them things in their authenticity"*. According to Ref. [31] *"Children in situations to act cooperatively are to lay the foundations for their better insertion in future society"*.

The group of teachers was very participative, committed and dedicated. They expressed their satisfaction for the pedagogical-didactic practices carried on. They were sensitized and interested in continuing to deepen their knowledge about the benefits of outdoor learning activities because in this regard they said: "for us, this active methodology of teaching-learning effectively promotes learning, critical awareness and civic attitudes".

It was demonstrated that this pedagogical-didactic practice contributed to the appreciation, on the part of these participants, of teaching and learning methodology to develop children's environmental literacy. It is concluded, from the observations made throughout this study, that the approach taken in the theoretical-demonstrative session about the water field motivated this group of teachers to the challenge of implementing outdoor learning activities as teaching practices. They look for promoting attitudes of critical and participant environmental citizenship (environmental literacy). It was evident that there was an interdisciplinary relationship with the mother tongue and the field of mathematics. However, it was not evident in the pedagogical-didactic scripts the concern in articulation of science-child-environment, that is, the interconnection of the content of sciences – in this case the topic of "Water" – with the promotion of children's environmental literacy.

7. Concluding remarks

The analysis of the results showed that this pedagogical-didactic practice of outdoor learning contributed with these teachers: (i) to (re) construct their conceptions about the pedagogical-didactic potentialities of outdoor learning activities; (ii) to promote the predisposition to open the conventional classroom to Nature classroom, demonstrating the intention to implement this pedagogical teaching practices in the curricular area of "Environmental Studies"; (iii) to verified the valorisation of the local natural-humanized environment when transforming scientific concepts of sciences (only those of the area of ecology), in the theoretical-demonstrative session, according to the perspective of articulation scientific literacy-environmental literacy with critical attitude. This training course highlighted the acquisition by this group of skills that are fundamental to the development of a teaching and learning process that promotes a participatory, responsible and critical environmental citizenship through the discovery of the surrounding natural environment.

It is concluded that the activities of outdoor learning, which are part of study field curricular area of "Environmental Studies", considers *"the local environment as a lived space, and it should be the privileged object of a systematic and methodical first learning of the child since, at these ages, the thinking is directed towards concrete learning"* [11]. It is also considered, based on the analysis made to this pedagogical-didactic activity, that it should be applied to other study field contents of primary education sciences, in order to be able to identify limitations and potentials to make it more effective. It will contribute to the construction of scripts and didactic sequences of learning where the student-centred active learning environment is valued. Also, the articulation between the curricular contents of sciences (in a perspective of interdisciplinarity) and the development of attitudes of critical participation is operationalized. Besides the aspects already analysed in this article in relation to outdoor learning activities, there are other considerations that could jeopardize the implementation feasibility, specifically time factor. Time could be an obstacle for implementation of this type of activities (duration of the outdoor activity to explore the natural/humanized site and the subsequent exploration of the didactic routes after the activity) is a factor. In the Portuguese teaching-learning process, at the level of primary education, the management of the duration of the learner activities by study field is not flexible. This is the reason why this factor is considered a limitation if we admit that these teachers will apply the script that they have built and will replicate the outdoor learning activity to other curricular contents, as they also mentioned in their reflections. However, from our experience, since this line of research has been carried out for several years, we are convinced that there are obstacles to implement radical changes in the teaching-learning process. Pedagogical-didactic activities such as this will certainly contribute to changes, no matter its magnitude. They constitute pedagogical paths that give important contributions to an integrated scientific education based on values of respect, appreciation of natural/humanized resources and its interaction (behaviours). They foster critical and responsible citizenship with a view to the preservation and resolution of environmental issues.

Professional development is an on-going process in which the learning-teaching path is done throughout the professional life, and where the training courses constitute means of

consolidation, evolution and construction of professional skills. According to Refs. [32, 33] teacher training must be demanding and continuous, *"capable of leading to changes in perspective and, later, to new practices to innovative practices, by the attitude and values they introduce, to create another culture of scientific education"*.

It is hoped that this research developed as part of an ongoing course for primary teachers will contribute to the improvement of effective pedagogical practices in children's environmental literacy developed in the context of science education.

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Section 2

E-Learning and New Methods of Teaching and Learning

Chapter 7

Exploring the Pedagogy of Online Feedback in Supporting Distance Learners

Christine Savvidou

Additional information is available at the end of the chapter

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Abstract

While feedback is recognized as an important part of the pedagogical process in supporting student learning, it is a relatively a new area of online education research. The purpose of this mixed-methods study was to examine online feedback processes from the vantage points of the course instructor and a cohort of students. Based on data collected from the online forums and student interviews, the researcher/instructor sets out to determine what feedback was given and how it was perceived by students. Evidence suggests that the feedback given was largely aligned with research definitions of "best practice" in terms of being timely, accessible and substantial. In terms feedback type, it was informative, supportive, corrective, and, to a lesser extent, reflective. However, evidence suggests that the scope of students' perceptions of effective feedback was broader than suggested in the research literature with feedback viewed in relation to specific pedagogical, contextual, and relational dimensions. It is suggested that analysis of feedback from these two vantage points is important for instructors wishing to enhance their online teaching. It is also suggested that a frame for understanding the effect of online feedback on student learning should be broadened to consider its wider pedagogical, contextual, and relational dimensions.

Keywords: feedback, online education, distance learning, pedagogy, perceptions

1. Introduction

Giving and receiving feedback represent a type of dialog between educators and learners that supports learners in modifying their academic performance going forward. As such, the value of this pedagogical practice is well recognized in the literature (for example, see [1–6]). As a formative process, feedback does not attempt to formally evaluate the standard of work, rather it is designed to point students in the right direction through commenting,

questioning, scaffolding, reminding, and offering models and examples. However, in contrast to the more summative process of formal assessment, it is claimed [7] that theory of feedback, in general, is lacking; moreover, research into online feedback is still in its infancy (for example, see [8–13]). However, it is more important than ever to research this area, as increasing numbers of students enroll in online courses [14] and, with this increase, faculty are required to spend more time responding to distance learners and adopting new skills and practices [15–18]. Indeed, the literature shows that for many faculty, the transition from providing immediate verbal feedback in a classroom to delayed written feedback in an online forum is not a seamless one [19]. This is compounded when institutional service goals specifying the roles and responsibilities of the instructor are not explicit [20]. Overcoming these challenges is critical, since it is shown that effective feedback is not only linked to higher university ratings [13], but more specifically, it is linked to student satisfaction with online learning [4, 9, 21–24]. Considering the attrition rate of online and distance learning students is considerably higher than on-site courses [12, 25], the need to improve the quality on online feedback cannot be underestimated. Thus, the aim of this paper is to explore the interrelational nature of online feedback by examining what and how feedback was given to distance learners by their instructor and how it was perceived by the students. This dual perspective attempts to redress traditional hierarchies by making the 'evaluator' the 'evaluated' and, in so doing, offer insights into established feedback practices and suggestions for how they might be improved.

2. Background

2.1. Terminology

At its most general level, feedback can be defined as the means by which learners are able to determine their progress towards an end goal [6]. However, there appears no widely accepted definition [5] with most definitions reflecting various cognitive, social, and affective perspectives. At a cognitive level, feedback has been defined as a means of controlling learning through the use of reinforcement, i.e. punishment or reward [26]. Such a behaviorist approach has been replaced by more constructivist thinking in which 'knowledge of results' (p. 310) emerges from an ongoing process of forming and testing hypotheses rather than a memorization of results [27]. Added to this is the recognition of social interaction in the formation of feedback as instructors respond to learners and check if the information is appropriate to a given task [28, 29]. The affective features of feedback are also recognized with feedback defined as any message which praises, encourages, and supports learners in reaching a specific learning goal [30]. It is also noteworthy that the term "feedback" has often been used synonymously with "formative assessment" and "formative feedback" to imply information about a student's progress as distinct from formal results-based summative assessment [4]. Within the present study, online feedback is used to denote any messages intended to support students so that they can monitor their own performance in terms of learning goals and strategies. It also refers to any collective, personalized, detailed, written, and/or oral messages provided to distance learners in order to guide and support their learning.

2.2. Feedback types

The two most rudimentary types of feedback are "verification," an evaluation of the learner's work, and "elaboration," the guided instructional cues given to direct the learner [31]. Additionally, feedback can be "norm-referenced" comparing the learner's answers to others, as in comments such as "this is below average," or it may be "criterion-referenced," indicating what has been done and how the answer might be improved [32]. Other feedback typologies include "corrective," "informative," and "Socratic," of which the latter involves asking questions to direct the learner [33]. Yet, other models identify feedback along a continuum ranging from "no feedback," "error-flagging," involving highlighting errors without correction and "informative tutoring," involving providing elaborate feedback with strategies for revision [34].

2.3. Delivering online feedback

Apart from being online, there are several other considerations to take into account when delivering online feedback. In one study [35], weekly podcasts delivered to a whole class were rated positively by learners who also used the additional examples and advice as a supplementary resource for revision. This method was also perceived positively by instructors as a time-efficient way to provide feedback to all students at one time. However, this one-way method of communication fails to address individual learning needs, and other research [9] indicates that students who receive personalized feedback have higher levels of course satisfaction and perform academically better that those students who receive only collective feedback.

In addition, another issue regarding delivery of online feedback focuses on who initiates the feedback. One study [36] suggests that in most cases, learners are unwilling to participate in giving feedback to their peers, and that the reason most students give for logging-on is to read the contributions of other students and any accompanying feedback from the instructor. Even when learners do offer feedback, it tends to be in the form of "verification", as in "*I agree*" rather than the more elaborative feedback offered by lectures regarding learning content, task, and social participation [37]. There is also evidence about online learning preferences that suggests that some students do not rate social interaction with peers as important or contributing to their learning [38].

This is not to say that learner engagement in the feedback process cannot be increased. One study [8] showed how teaching explicit metacognitive strategies such as offering support, eliciting information, asking questions, establishing a situation, offering a possible solution, etc., as well as monitoring and evaluating student participation, all have a positive impact on the feedback process. It is also shown that student interaction and feedback are also enhanced when participating in online discussion forums becomes mandatory [36, 39].

2.4. Characteristics of effective online feedback

What makes online feedback effective is determined by both educators and learners. According to educators, effective online feedback is time-consuming requiring detailed and

"substantive" comments rather than "basic" ones such as "*good answer*" [40, 41]. It should promote higher order thinking skills and ask learners to reflect on their learning by asking questions which require learners to clarify, summarize, hypothesize, and link ideas to other areas of course content [42]. Ongoing analysis of online dialog suggests that effective online feedback requires instructor and students to play equal roles in the "assessment of process" [39]. Moreover, educators recognize that in the design of Web-based learning tools, specific principles are more effective, e.g., feedback should summarize learners' performance, motivate, be relevant to assessment criteria, and be manageable and timely [11]. Added to this, it is recognized that effective online feedback should be clear and comprehensible, leaving no room for confusion or doubt [43].

Such characteristics of best practice are hardly contentious; however, research suggests that these criteria can be perceived differently by learners than by instructors. For instance, in one study [44] on feedback in general, instructors consider their feedback to be more useful than their students; they also believe their students are less interested in feedback than final grades; they also perceive their grading to be fairer in contrast to students who perceive bias toward more active class members. However, both students and instructors acknowledge difficulties for students in decoding feedback, and both groups acknowledge the emotional impact of feedback on student motivation. Similarly, in another study of feedback [13], feedback is linked to students' individual learning styles with students identified as "deep" learners preferring feedback that encourages reflection, and students identified as "surface" learners preferring positive feedback that verifies an answer and does not require further participation [13]. Another study [23], comparing student satisfaction with distance learning and on-site learning, shows that distance learning students are less satisfied with feedback in relation to comprehensibility, emotional impact, and fairness. It is also been shown that similar to educators [39], online graduate students perceive effective feedback as mutually constructed with their instructors, and that it should also allow space for students to negotiate learning goals and mutually agreeable deadlines [10].

2.5. Challenges and concerns

The literature also highlights several areas of concern and challenge. Conceptually, feedback is considered an under-theorized area that focuses on informal and dialogic processes that are difficult to measure [7]. Moreover, it is claimed that the turn to constructivist pedagogy remains a challenge for online education, in general, and feedback, in particular [45]. On a practical level, multiple taxonomies and models of feedback indicate that it is generally not a well-understood area of online teaching, and, as such, it may possibly be delivered ineffectively, e.g., too little, too late, incomprehensible, demotivating, etc. [46]. This is supported by research which suggests that students cite feedback containing complaint or dissatisfaction as reasons for low participation [47]. This too is in line with research that indicates that instructors new to online teaching often underestimate the need for consistent support and presence in encouraging, motivating, and keeping students focused [20]. A final concern relates the contextual setting that either supports or discourages effective online teaching. Factors such as institutional recognition, promotion, compensation, technical support, and overall work-load are shown to directly

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influence the quality and quantity of faculty participation [48]. Overall, the extant literature highlights the complexities of the topic and the related challenges involved in delivering feedback in an online setting.

3. Methodology

3.1. Purposes of study and research questions

The study was based on data collected over the course of one academic year (2015/2016). This descriptive study uses a mixed method approach to describe educational phenomenon, as it exists and compares it to what is desired [49]. Such research allows for description, explanation, and improvement of educational practices and does not attempt to draw conclusions based on cause and effect. Rather, the overall aim of this study is to uncover data that may not have previously been encountered using other research approaches. Thus, the research questions guiding this study are (1) what feedback was given to distance learning students?, and (2) how was it perceived by these students?

Emerging from these questions, the use of a mixed methods approach allowed for creative data collection, the collection of thick, rich data [50], and the possibility of uncovering contradictions [51]. Indeed, the use of content analysis in phase 1 of the study (see Section 3.2.1) allowed for a systematic and descriptive investigation of the types and frequency of feedback offered by the lecturer to her DL students. The coding of the textual features of this feedback provided inferences about the types of feedback provided, to whom and how often. Moreover, in phase 2 of the study (see Section 3.2.2), semistructured interviews provided opportunities for the researcher/instructor to uncover students' beliefs, attitudes, and perceptions about the feedback they received, as well as follow themes and issues that may not have been previously considered [52].

3.2. Context

This study took place at a higher education institution in Cyprus, where degree programs are offered in a variety of modes, face-to-face, online, and distance learning courses, for undergraduate and graduate students. While online courses are an option for face-to-face students, distance learning students are geographically distant from the institution with most of them resident in other European countries. Most instructors in this institution have recently added online and distance learning courses to their teaching loads and, as such, are responsible for the design, management, and delivery of these courses. Against this background, the researcher/instructor sets out to explore the feedback given to distance learning (DL) students studying for a postgraduate degree Teaching English to Speakers of Other Languages (TESOL). The degree offers a combination of nine courses, each of which is delivered to students over the period of a 12 week semester. Course content consists of weekly prerecorded video lectures, audio presentations, and recommended readings and students are required to reflect on and discuss this material, critique ideas, ask questions, express

opinions, and collaborate on individual and group tasks such as creating lessons and activities. Feedback is then provided in response to these tasks and any other specific academic, administrative, and technical issues that might arise.

3.3. Participants

At the time of the study, the researcher/instructor had more than 26 years teaching experience, of which only 2 years included teaching DL courses. Data were also collected from interviews with five DL students after completion of the course. The students, four female and one male, were all aged between 24 and 45 years. They were all English language teachers with teaching experience ranging from 5 and 22 years. They were based in different three European countries: Greece, Cyprus, and Germany. Before agreeing to participate in the study, all participants signed a consent form expressing their willingness to participate.

3.4. Procedures

3.4.1. Phase 1

After completion of the course, all messages written and posted to distance learning students over the duration of one semester (Fall 2015) were collected from course forums. The total data set comprises 93 messages posted by the course leader in response to students' questions, online tasks, and discussions. Content analysis was then conducted based on an established taxonomy of feedback: corrective, informative, and Socratic feedback [33]. The analytic tool was adapted to include corrective, affective, informative, and reflective feedback (**Table 1**).

Category	Indicator	Definition	Example
Affective	Salutations, phatics	Greetings & expressions purely for social purposes	*Dear students, good morning* *wishing you all a great week*
	Vocatives	Addressing participants by name	*Thanks* [student name]
	Complimenting, expressing appreciation	Complimenting contents of messages	*I really enjoy reading your thoughts and ideas about …*
	Empathetic	Shows empathy	*As we draw towards Christmas, there are more and more things to do and I understand that it is difficult to find time*
	Supportive	Offers support	*Good luck and please get in touch with me immediately if you have any questions.*
	Self-disclosure	Reveals details of life outside the course	*I am from …and I have been teaching for …*
Corrective	Knowledge-of-response (with or without elaboration)	Positively or negatively evaluates the content of a student's answer	*You have encapsulated Borg's ideas very nicely* *Great answer*

Category	Indicator	Definition	Example
Informative	Content	Comments on the content of the course and may include references to theory	*Savignon defines this as communicative competence.* *Humanist theories give prominence to the affective (emotional) aspects of language learning*
	Procedural	Gives procedural details of the course (technical, dates, assignments) and directs the learners to do something specific	*Please use this forum to ask questions, make comments and answer questions from your colleagues* *You can find the book at www. library…*
Reflective	Direct and indirect questions	Asks students to reflect on their understanding of various elements of the course and relates their learning to their professional experience	*Do any of these ideas resonate with your own experience of language teaching?* *Could it be used effectively in combination with other methods—what do you think?*

Table 1. Analytic model of online teacher feedback.

The software package, NVivo, was used to highlight coded segments of text and produce summaries of findings. Because of the elaborate nature of feedback, single messages may contain multiple codes, so to ensure reliability, an independent rater also coded 10% of the data. A Cohen's Kappa established interrater reliability as 0.6, which indicates a good possibility of agreement occurring other than by chance. In addition, the percentage of agreement between the two raters was shown to be 91.63%.

3.4.2. Phase 2

In the following semester (Spring 2016), semi-structured interviews lasting between 60 and 80 min were conducted with five students who had completed the course the previous semester. All interviews were recorded, and full orthographic and verbatim transcripts were produced. NVivo was used again to identify and code segments of text. Themes and subthemes were then identified and aggregated into hierarchies. This phase of analysis focused on identifying "thick rich descriptions" rather than descriptive statistics.

4. Findings

The following sections consider what feedback was given by the researcher/instructor and how it was perceived by the distance learning students.

4.1. Feedback given

Findings show that the researcher/instructor posted 93 messages in response to 108 messages posted by students, which equates to a response rate of 86.1%. Of these 93 messages posted by the course leader, 27 messages (29%) were addressed to the whole group as collective feedback, while 66 messages (71%) were addressed to individual students. The quantity of feedback given by the course leader amounted to 10.150 words, which is an average of 109 words per message. Moreover, the response time between students posting their messages and the course leader responding ranged from 0 to 15 days with a mean average response time of 1.7 days. So what type of feedback was given by the course leader (**Table 2**)? Content analysis shows that the most frequent type of feedback given was informative feedback that focused on content (23%), followed by procedural content addressing administrative and technical details related to the course (17%). Affective feedback dealing with the social, emotional, and motivational aspects of learning was the next most common type of feedback (11%) followed by corrective feedback (7%). The least common feedback was reflective feedback (asking questions that encourage students to reflect on their answers) (4%).

4.2. Feedback received

Findings show that distance learning students' perceptions of feedback revolve around three main themes: the pedagogical, contextual, and relational dimensions of their learning.

4.2.1. Pedagogical dimensions

In relation to the pedagogical dimensions of learning, students identified three subthemes. The first subtheme highlights the positive aspects of feedback as being accessible to all, focused, motivating, personalized, and timely (**Table 3**).

Conversely, DL students also identified the negative aspects of feedback on their learning as the following: being critical in tone, inconsistent, inconvenient, lacking, and vague and confusing (**Table 4**).

In the third subtheme, students identify and distinguish between the different functions of feedback in relation to their learning. These functions include affective, corrective, informative, and reflective feedback (**Table 5**).

Node	Density by % coverage	Density by word number
Informative-content	23.25	2347
Informative-procedural	16.62	1804
Affective	11.21	1248
Corrective	07.28	737
Reflective	04.01	425

Table 2. Content analysis of feedback.

Theme	Subtheme	Student comments: examples
Positive	Accessible	T: before the exams and during the study period I am trying to read all the messages because I want to see if I am on the right path or not
	Focused	M: I liked the fact that she always highlighted the part where she had to make comments and she explained very clearly what she expected of me in this particular part
	Motivating	A: to me, feedback is the motivation, I get really motivated even with bad feedback, you know what I mean by bad…it helps me understand what I did and what I was supposed to do, it's like a clear guidance… I can closely relate it to achievement, yes it also adds to confidence obviously
	Personalized	S: but for me you know, maybe this is because I don't have the face-to-face opportunity… but for me it's very important for you to know who I am… you know when I write (student's name) you know it's me (student's name) talking
	Timely	C: I think a couple of days is reasonable because when I ask something I need to have the answer to that in order to move on with my studying
	Useful	T: of course and since I have started this master's programme I now give my own students the same opportunity to contact me every Saturday at specific hours on the phone, in email or Viber messages to ask and talk about any thoughts they have…

Table 3. Pedagogical dimensions of feedback: positive features.

Theme	Subthemes	Student comments: examples
Negative	Critical	T: for instance, when I ask about references, how to cite something, I am asking because I really don't know, I have a slight idea but I am not sure if it's the correct way…so an answer like "you have to do it like masters students do" is not the kind of answer I have been waiting for…
	Inconsistent	A: the more the students, the less the feedback or the lateness of the feedback but no this has not proven so, like for example as I told you previously in the independent course there were 2 people and I didn't get any feedback, either in the forums or the assignments, just nothing, whereas in other courses I got feedback right away and quite detailed…
	Inconvenient	A: all WebEx sessions are at times that I have work so I have never been to a WebEx session, so this is my first one actually, so come on guys please talk to us
	Lack of	M: but well I kept posting on the forum and no reply, no nothing, even when I said "Hello, this is (student's name) at the beginning of the course, I didn't even receive an "ok, welcome" so it was a bit strange like you don't want me around, yes I got no feedback, I felt like I was in the dark…
	Vague & confusing	E: for this course I am trying to finish today, it's basically, try and answer this question give your own views and I am a bit confused …like, what do you mean, give my own views? A couple of other students did ask the lecturer but to be honest I was still not sure so I'm just kind of giving support by what I find in the readings and giving a little bit about my own views

Table 4. Pedagogical dimensions of feedback: negative features.

Subthemes		Student comments: examples
Functions	Affective	A: … and it was after midnight and I thought oh my god, she is not sleeping, honestly, so that was amazing really because when I asked for an extension I was really stressed, but it's nice to have somebody saying 'alright, calm down, I am there, let's see what we can do'.
	Corrective	T: and also as a student I need to know why you are giving me this specific feedback, to explain to me why that was wrong and where can I find the correct answer…
	Informative	M: The lecturer also referred us to other links for extra information.
	Reflective	T: I like the comments "well done" or "nice thoughts but I also like it when lecturers ask us questions like "how about this?"

Table 5. Pedagogical dimensions of feedback: different functions.

4.2.2. Contextual dimensions

In relation to the contextual dimensions of learning, students identified how the cultural context, teaching context, and their work and home life contexts played a role in their perception of feedback given (**Table 6**).

4.2.3. Relational dimensions

The third theme identified in the data, focuses on the relational dimensions of feedback. Within this theme, two subthemes emerge, showing the intrapersonal dimensions of feedback based on how students relate it to their personal experiences (**Table 7**).

Theme	Sub-themes	Student comments: examples
Context	Cultural	A: maybe it's a Greek thing but I wouldn't expect a student of mine to say alright I have 99% what went wrong? I would say what the hell are you talking about, this is magnificent but yes, I wanted more explanation and not just a grade but obviously it's not the lecturer's problem, its mine…
	Teaching	M: I don't know if we can expect quick feedback if there are like 50 students and one professor…
		E: the response was kind of vague and I guess because I had been a teacher at a university before I was kind of timid about following up on my confusion and not wanting to be annoying so I kind of just plodded on because I know how it is to get bugged by students when I am expecting them to understand and they're not understanding…
	Work/home life	C: I sent a message, and I got no reply, saying that because of a family situation, I need a big extension because I am many hours in the clinic, I'm outside the home and I have everything going on in my head
		E: I mean people have got their jobs and family obligations, whatever, and so forth, and professors will say they're giving them plenty of time but they don't understand what's going on.

Table 6. Contextual dimensions of feedback.

Subthemes	Student comments
Intrapersonal	A: anyway when I was 24 I needed a lot of guidance not that I don't need it now but I feel more confident about stuff that I have worked on extensively.
	E: I guess because I had been a teacher at a university before I was kind of timid about following up on my confusion and not wanting to be annoying so I kind of just plodded on because I know how it is to get bugged by students when I am expecting them to understand and they're not understanding and you know, you know what I mean…its challenging but it's my fault in a way, maybe I should be interacting with the professor more and asking questions and even for extensions

Table 7. Intrapersonal dimensions of feedback.

Subthemes	Student comments	
Interpersonal	Instructor	M: To be honest my expectations were kind of different. I thought that I would not feel the presence of the lecturer and that she wouldn't comment on my work. However, I was wrong. … during the course I had the feeling that the lecturer was not distant but someone who was eager to support the students
		E: I can see how too much involvement can create less motivation in students and less self-responsibility. So yeah, it would be good to have umm bit of involvement but then students should know… should be understanding that this is a matter of self-responsibility
		E: but I think for the first two or three weeks things are not very clear about the course and about how we ought to study, about the assignments and all the online activities which are our main worry, I think, so yes, I think we should have more interaction I think in the first couple of weeks
	Peers	A: I really adore reading to work out what others have written because it opens a new door to things I haven't thought before or things I have thought differently which is the thing I like and then I can see the feedback and see if that was a good direction I should have taken, yes I do so, very often
		E: but I just sense that from the students they are just a bit uneasy about criticizing, there's more of a sense on the forum of trying to support each other instead of critiquing what they are writing.
		T: I have been in contact with only two people but we have really, really interesting conversations about the lectures and about our experiences … other students do not answer the questions, even though the question is not addressed to the lecturer, it's not to "dear lecturer" its addressed to "dear everyone", well I think it was to do with showing respect to the lecturer and not commenting on what they are about to say

Table 8. Interpersonal dimensions of feedback.

The other subtheme highlights the interpersonal dimension of feedback which shows how students construct knowledge through their interactions with their peers and the researcher/instructor (**Table 8**).

5. Discussion

This study sets out to explore two research questions on the inter-relational nature of online feedback by examining what feedback was given by a course leader during a DL course and how this feedback was perceived by students.

5.1. What feedback was given?

The first part of this study offers a descriptive insight into the online feedback practices in this specific distance learning course in terms of 'what happened'. The amount of feedback given was fairly extensive, with students receiving feedback to over 86% of all their online postings. Moreover, this feedback was mostly personalized (71%), and based on length of messages, it was substantive, with the average length of a message over 100 words. Findings also show that feedback was timely with most students receiving a response within 2 days. In relation to the types of feedback given, it was overwhelmingly informative, focused on providing information about course content and procedures (40%). Other types of feedback were also evident to a lesser extent including affective feedback that focused on motivating and supporting students (11%), corrective feedback (7%), and reflective feedback that asked questions (4%). Finally, it is also noteworthy that the flow of feedback was unidirectional originating from the researcher/instructor to the students. The data show little evidence of student participation in the feedback process other than superficial and infrequent instances of "I *agree with …*" or "[name] *makes a good point*." Although students were encouraged to interact with each other and ask and answer questions addressed to each other, this did not occur in the public space of the course forum, although interview data suggest that students did message and support each other privately: "*through the whole Master's programme I have been in contact with two people but we have really, really interesting conversations about the lectures and about our experiences, I think it would be helpful if we had a way to connect to each other."* Many aspects of these findings are supported by the literature which advocates that effective online feedback is personalized [13], substantive [41], and timely [37, 40]. However, findings also show that the limited amount of reflective feedback—asking students questions about their learning—challenges the notion of best practice. Indeed, the importance of building reflection into a distance learning course is important in helping learners develop metacognitive skills that encourage self and peer evaluation [42]. Another finding that challenges best practice relates to the unidirectional flow of feedback from researcher/instructor to students and lack of mutually constructed feedback between students. This lack of participation may be due to numerous factors reported in the literature, such as course design not based on constructivist pedagogy [45] and lack of incentive and/or knowledge of feedback strategies [37]. In addition, DL students' perceptions of who should give feedback, discussed below, may also offer insights into their lack of participation.

5.2. How was feedback received?

The second part of this study offers insights into students' perceptions of online feedback practices and the extent to which it influenced their learning. Analysis of these findings shows how these students interpret feedback according to specific pedagogical, contextual, and relational dimensions of learning.

In relation to the pedagogical dimensions of feedback, students' positive perceptions of this feedback are very much in line with concepts of best practice described in the literature. In line with the literature [36], students perceived feedback as being accessible, in that they could read their own and other students' feedback at any point throughout the course: "*before the exams and during the study period I am trying to read all the messages because I want to see if I am on the right path or not*."

Similarly, as reported in the literature, students comment that feedback was focused [11], motivating [23, 43, 47], personalized [9], timely [37, 40], and useful [44] (see **Table 3**). Students' more negative perceptions (see **Table 4**) are also documented in the literature with students making particular references to some of the feedback they received as being critical in tone [23, 43, 47], inconsistent, inconvenient, lacking [37, 40], and vague and confusing [44]. In addition, these DL students were aware of the different pedagogical functions of feedback and identified the value of affective, corrective, informative, and reflective feedback on their learning (see **Table 5**). This is also supported by the literature of best practice in asynchronous learning environments [33].

Next, in relation to the contextual dimensions of feedback (see **Table 6**), students perceived online feedback through the lens of their own cultural expectations with one student commenting that despite achieving a top grade "*…maybe it's a Greek thing but* […] *I wanted more explanation not just a grade*." The disappointment with the lack of feedback suggested by this comment is reinforced by findings in the literature which suggest that online learning can be a lonely place for learners whose cultural experiences and expectations may differ from the dominant educational culture [53]. Also, in relation to context, students perceived that the quality and quantity of feedback were dependent of class size and the perceived work load of their instructor with one student commenting "*I don't know if we can expect quick feedback if there are like 50 students and one professor*." While student numbers in this particular course may be low, one student perceived a demanding work load for instructors with another student commenting "*because I had been a teacher at a university before* […] *I kind of just plodded on because I know how it is to get bugged by students*." The perception of overworked and unavailable faculty is echoed by research that reports that the massification of online education and the increasing workload means they are more likely to sacrifice formative feedback as part of their online teaching [48, 54]. Finally, some DL students perceive that the feedback they received lacked understanding of their particular work/home life situations with one student commenting "*I sent a message, and I got no reply, saying that because of a family situation, I need a big extension because I am many hours in the clinic, I'm outside the home and I have everything going on in my head*," while another students said "*I mean people have got their jobs and family obligations, whatever, and so forth, and professors will say they're giving them plenty of time but they don't understand what's going on*." This lack of understanding for students' lives outside their studies is cited in the literature as reasons for high student attrition and low online course completion [25, 55].

Finally, the findings also highlight students' perceptions of feedback as constructed through their relationships with self and others. In the first instance, students comment on their intrapersonal dimensions of knowledge construction and the awareness of autonomous learning (see **Table 7**). One student comments on her growing confidence and the need for less guidance, as she gets older: "*anyway when I was 24 I needed a lot of guidance, not that I don't need it now, but I feel more confident about stuff that I have worked on extensively*," while another student turns to self-reliance rather than inconvenience the course leader: "*I kind of just plodded on because I know how it is to get bugged by students*." A greater understanding of how students perceive their own learning in relation to guidance and support is important, since such perceptions are strongly associated their learning outcomes [13].

In relation to students' perceptions of feedback as constructed interpersonally with their peers and course leader (see **Table 8**), findings suggest that feedback is an indication of

teaching presence "*To be honest my expectations were kind of different. I thought that I would not feel the presence of the lecturer and that she wouldn't comment on my work. However, I was wrong, during the course I had the feeling that the lecturer was not distant but someone who was eager to support the students*." The implications of this are highlighted in the literature, which indicates that teaching presence is strongly associated with course satisfaction and learning outcomes [56, 57]. However within the research [58, 59], there is also a caveat that too much teaching presence may deter autonomous leaning and self-reliance, and this is echoed in this study: "*I can see how too much involvement can create less motivation in students and less self-responsibility*."

The interpersonal dimension of feedback also includes students' engagement with their peers. Findings indicate that although students value reading work posted by their peers, "*I really adore… reading to work out what others have written because it opens a new door to things I haven't thought before or things I have thought differently which is the thing I like and then I can see the feedback and see if that was a good direction I should have taken*," they did not participate in the feedback process. Indeed, this also borne out in research which suggests that most students enrolled in online or distance learning courses are lurking; with the main reason given for logging on is to look at questions and tasks, as well as read other students' posts and instructor feedback. The same research suggests that only one in four are willing to contribute to discussion [36]. These findings are contrary to other research which suggests that students identify effective feedback as a mutual process [10], and it indicates an inconsistency between students' perceptions and their actual practices. Indeed, findings suggest that these students perceive feedback as a top-down process with distinct roles assigned to students and educators. One student comments "*but I just sense that from the students they are just a bit uneasy about criticizing, there's more of a sense on the forum of trying to support each other instead of critiquing what they are writing*." While another student adds "*when we write a question to a lecturer, other students do not answer the question, they are waiting for the lecturer to answer that even though the question is not addressed to the lecturer … its not to "dear lecturer" its addressed to "dear everyone", well I think it was to do with showing respect to the lecturer and not commenting on what they are about to say*." It might also be that lack of collaborative learning in the feedback process is part of students' preferred learning style, and there is evidence to suggest that successful online learners often exhibit a preference for an independent over a collaborative learning style [38].

6. Conclusions

This study set out to explore the practices and perceptions of feedback given during a DL course for postgraduate students with the aim of offering insights and making suggestions for improving teaching. There are several conclusions which can be drawn from this study.

First, from an evaluative perspective, findings show that in terms of the frequency, length, and types of feedback given, it is largely in line with notions of best practice as outlined in the literature. However, findings also reveal some shortcomings in the type of feedback given, namely that there was limited reflective feedback that asked students direct and indirect questions so as to reflect on their understandings of the course. It should be stressed, however, that the main purpose of this study was not to evaluate the performance of the researcher/instructor but rather to offer a professional development perspective. By making explicit the

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nature of the feedback given, the course leader has the opportunity to reflect on her feedback practices, which are typically intuitive and spontaneous.

Second, this study also shows the extent to which students' perceptions of feedback align with notions of best practice. These perceptions offer a variety of experiences and understandings of feedback that express both positive and negative points. In themselves, these perceptions cannot offer a complete and unbiased picture of the quality of feedback; however, they offer valuable insights into how feedback is perceived by students and why it is perceived in such a way. This is especially important in DL Education courses, when some students may be practicing teachers with their own feedback practices and beliefs. In such cases, it is important for course leaders to be aware of how these practices and beliefs align or differ from their own.

Third, the use of an analytic frame to consider the pedagogical, contextual, and relational dimensions of feedback broadens the scope by which feedback is typically discussed. Findings show how these three dimensions act as a lens through which students are able to mediate and understand their feedback experience. Such a frame can also be used as a developmental tool to help educators consider how their online feedback practices may support or inhibit student learning. Questions such as the following can guide educators to examine their own online feedback practices:

1. Pedagogically: Is online feedback accessible to all, focused, motivating, personalized, timely, and useful? What type of feedback is offered and how does it support student learning? E.g., To what extent does it provide information about course content and/or procedures? To what extent does it emotionally support and motivate students? To what extent does it positively and/or negatively evaluate student work? To what extent does it ask questions and encourage students to reflect on their learning?
2. Contextually: To what extent does the online feedback reflect the values of a specific educational culture? Does feedback take into account the experiences and expectations of learners from other educational cultures? To what extent is the quality and quantity of feedback shaped by the specific demands of teaching context? To what extent does feedback consider the external work/home life pressures face DL students?
3. Relationally: How do students feel about the online feedback they receive? To what extent is your teaching presence established through feedback? What kind of presence is it? What is the role of other students in the feedback process? Is feedback mutually constructed by instructor and students and between students? Why/why not?

It is important to acknowledge some of the limitations of this study, so that they may encourage further research. First, the role of the instructor as researcher and instructor may raise concerns about objectivity of data. However, efforts made to minimize bias ensure a standard of rigor with the use of retrospective data collection and an independent rater. Interviews were also held with participants after course completion, when students would have no further contact with the particular instructor. Second, the focus on perceptions can only represent the views of a small sample of DL students. Similarly, findings can only represent the feedback practices of one particular instructor on one particular DL course. As such, the idiosyncratic nature of the data does not provide a basis for transferability and generalizability to other courses or other instructors teaching on the same or a similar program. In spite of these concerns, this choice of

research methods offered the researcher/instructor the opportunity to analyze her own online teaching and gain insights into the practices and processes of giving feedback and how these might be perceived by DL students to support or inhibit their learning.

In educational institutions around the world, the challenges of online teaching have become a reality for many instructors, and as such, it is hoped that by sharing these results, other instructors will take the opportunity to inquire into their online feedback practices. It is also hoped that the issues raised in this study will also pose questions for further research in this area to enhance online teaching.

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Chapter 8

Practical Usage of OER Material in the EFL Classroom

Maria Haas, Martin Ebner and Sandra Schön

Additional information is available at the end of the chapter

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Abstract

In this research work, we want to follow the idea of using open educational resources (OER) in a classroom to gather practical experiences. The topic of our choice is English as a foreign language (EFL), because in our opinion a lot of teaching content should be available. The preparation of the lectures, as well as the final lecturing, is described to understand how OER can be used in the EFL classroom. The feedback of the pupils and the lessons learned point out that there are more obstacles than expected, mainly because of the strict copyright law in German-speaking Europe.

Keywords: EFL, language learning, open education, open educational resources

1. Introduction

Despite the fact that open educational resources (OER) movement has been around for 15 years, little attention has been paid with regard to practical usage in secondary education. Instead, the focus has been on tertiary education as well as education for developing countries. Geser [1] points out his benefits of using open educational resources in education (p. 21):

- OER offer a broader range of subjects and topics to choose from and allow for more flexibility in choosing material for teaching and learning.
- OER leverage the educational value of resources through providing teacher's personal feedback, lessons learned, and suggestions for improvements.
- OER provide learning communities, such as groups of teachers and learners, with easy-to-use tools to set up collaborative learning environments.
- OER promote user-centered approaches in education and lifelong learning. Users are not only consumers of educational content but also create own materials, develop e-portfolios, and share study results and experiences with peers.

Since those early days of the OER movement, different publications have pointed out why OER are highly relevant for higher education [2–4] as well. For example, the necessity of an own OER strategy is carried out by Schaffert [5] and executed for the first time at Graz University of Technology [6] in Austria. Despite these initiatives OER is less represented in secondary education right now, although open educational resources allow teachers to adapt teaching material in order to suit the needs of their students. Rather than having to worry about copyright-related issues, more time can be spent on creating quality material.

The author had a personal interest in determining how OER material can be used in secondary education in a subject such as English as a foreign language (EFL) where schoolbooks are said to be the primary material used [7]. Therefore, a study was conducted in an Austrian middle school with students in their second year of English study. Over the course of 2 weeks, students were taught using OER material only.

During the study, influencing factors, such as the time needed to create the material, complexity of licensing, as well as students' age and feedback, were evaluated.

The goal of this study was to determine how English as a foreign language (EFL) lessons would look like if exclusively OER material rather than traditional schoolbooks would be used.

2. Research design

The term open educational resources (OER) was first introduced in 2002 during the UNESCO Forum on the Impact of Open Courseware for Higher Education in Developing Countries [8]. According to the UNESCO websites, OER refer to "teaching, learning or research materials that are in the public domain or that can be used under an intellectual property license that allows re-use or adaptation (e.g., Creative Commons)" [9].

This means that OER material can freely be shared, remixed, and reused by both teachers and students in order to allow for the best learning experience possible. A term often associated with and seen as the "de facto standard" of OER is Creative Commons (CC) ([10], p. 7).

Creative Commons (CC) is a nonprofit organization that was founded in 2001 [11]. It allows users to release material under a license that is not "all rights reserved." It should be noted that Creative Commons licenses do not work against copyright but work together with it and can be seen as an extension of it [11, 12]. At the moment (July 2017), users are able to license their works under one of the six licenses as well as a special public domain license. These licenses are "open" to various degrees. However, on the most basic level, material licensed under a CC license is allowed to be freely shared, modified, and even sold without restrictions as long as credit to the original source is provided. Altogether, there are four different "modules" that can make up a Creative Commons license. For the purpose of the study, particular attention was paid to exclusively use the two most open licenses: BY and BY SA.

In November 2015, a 2-week long study was conducted in an Austrian middle school in order to determine how lessons using OER material would look like with regard to EFL classes.

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The middle school was selected because the staff, as well as the students, were open to trying out and using OER material in the future. A class with 30 students in their second year of English study participated in the study. The students were 11–12 years old, and the class consisted of 21 female and 9 male students.

As mentioned in the introduction, according to a study regarding schools in Germany, English is one of the subjects in which textbooks are most frequently used ([7], as cited [13], p. 36). Similar results can be assumed with regard to Austrian schools. All in all, over the course of 2 weeks, six lessons were taught focusing on the grammar topics which present perfect simple as well as comparative forms. The subject taught was English as a foreign language.

English as a foreign language (EFL) refers to English being taught in a country in which English is not the primary language and the teacher is a non-native English speaker. In most cases, both the teacher and students share a common mother tongue that can be used in order to overcome potential problems and misunderstandings. ESL, or English as a second language, on the other hand, refers to English being taught in a country in which English is the main language, and the lessons are taught by a native speaker of English. In this context, both students and teachers do not share a mother tongue, and therefore English needs to be used as a lingua franca. The above paragraph is based on information provided by LinguaServe Germany [14].

In February 2015, a preliminary study was conducted in the selected middle school. The preliminary study allowed for familiarization with the available equipment and setting of the classroom and school as well as the students. Each classroom was equipped with a desktop computer and projector. While the school had two computer labs available, English teachers do not frequently use these during their regular classes. Therefore, it was decided against using online material and instead focused on offline material in order to better simulate how OER material could be used by EFL teachers in Austria.

In order to increase reusability, the so-called free cultural licenses [15], i.e., BY and BY SA, were chosen for the material used and created over the course of the study. With the exception of one audio file that the students listened to, all the material followed the abovementioned principle [16].

As mentioned previously, 30 students participated in the study. During the course of the study, one of two English teachers was always present which allowed for consulting the teachers in order to receive feedback with regard to possible changes from students' regular behavior due to their familiarity with the said students. The students were in their second year of English study which according to the Austrian curriculum [17] means that their English level corresponds to the A1 level of the Common European Framework of Reference for Languages [18]. Due to the fact that the students were part of a special class called "English as a working language," other subjects such as mathematics, chemistry, and music were also taught in English. Therefore, it can be assumed that their level is slightly higher compared to other second year students of English in Austria.

It should be noted that OER is of particular interest for Austrian schools and teachers because, while Austrian copyright laws permit classroom usage of copyrighted material under certain restrictions, the law also states that this does not include material explicitly created for teaching purposes ([19], § 42/6]).

In order to evaluate the results found during the study, an evaluation plan was created. It consisted of the three criteria briefly discussed below:

1. The first criterion was preparation time. The potential time-saving aspect of using OER material has been noted on various occasions [20, 21]. In order to evaluate the time needed to create the material, a time sheet was kept throughout the research process. The time spent researching the topics and exercises as well as the time needed to adapt and properly cite pre-existing material was included.
2. The second criterion was feedback. At the end of the research period, students were asked to evaluate the OER lessons in a special 30-minute feedback session at the end of the study in order to determine if there were any differences with regard to course content and students' motivation. In addition to that, feedback was received from the two English teachers present in order to better determine how the students' behavior was compared to their regular English lessons and whether or not any differences could be noticed.
3. The final criterion that was evaluated was the target group. Due to the results of a previous project seminar regarding OER material for EFL students in Austria, the hypothesis derived that finding appropriate material for ESL/EFL learners with a relatively low level of English (A1) would prove to be problematic. Furthermore, due to the fact that OER is currently predominantly associated with the tertiary sector, and little research has been done with regard to secondary education, this is another aspect that needs to be considered if OER material is supposed to be used in lower-level EFL classes in the near future.

3. Field study

According to the CC website, the best practice for crediting CC material is TASL [22]. Due to the fact that the material was created to be used offline, difficulties arose due to the hyperlink length of some of the source material. Unlike material created for online usage which can simply link to the source, the hyperlink of the source material needed to be included in full. Therefore, it was decided against including the links to the source material on the actual worksheets. However, the teachers were provided with a separate document containing all the links to the source material. In addition to that, for a memory game created during one of the lessons, the title of the source images was omitted from the files provided to the students. This was done in order to avoid giving away the correct answers and thus defeating the purpose of the exercise.

One of the benefits of OER material is that teachers are able to mix and match various resources in order to create material best suitable for their students. One of the exercises used as a base

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for another exercise was released under a CC BY SA 4.0 version. SA stands for share alike and means that new material containing a SA license material needs to be released under the same license. The original exercise compared PDAs in order to practice the comparative and superlative forms. In order to make the exercise useful for students in 2015, it was updated to compare smartphones instead (**Figure 1**). While the base exercise as well as the pictures and texts used were all released under either BY or BY SA, the version numbers of the licensed material are different.

Therefore, some time was spent trying to evaluate what to do in a case like this. Due to the fact that this seems to be a common problem with SA licenses, the CC website provides a detailed explanation on how to deal with version numbers of SA licenses that do not match. In a case like this, the latest SA license included should be used as the license for the entire document [11].

During the study, in addition to being taught about the topics of shopping and vacation which included exercises for the grammar points present perfect simple and the comparative, students also received a brief introduction to OER and Creative Commons licenses. The reason for this is that the students are the future generation, and therefore it is important to make them aware of issues such as copyright infringements and possible solutions, e.g., material released under CC license.

Furthermore, in order to raise even more awareness for the topic of OER and CC licenses, the majority of the final lesson was used to create a class poster together with the students (**Figure 2**). For this purpose, the students were asked to bring pictures from their previous vacations, attach the said pictures to the poster, and write a short sentence about their experiences during the vacation using the present perfect simple which they had learned in one of the previous lessons. It should be noted that during the study the students were also introduced to the concept of "right to one's own picture"; therefore, the pictures included on the poster did not feature people but rather featured objects and landscapes [19].

In the second to the last lesson, the students were introduced to the concept of OER and CC licenses. During this lesson, the students heard about the various modules that make up CC licenses, and the benefits of OER material compared to copyrighted material were explained. This was done because the poster of the students created would be released under a CC licenses. Therefore, it was important to raise students' awareness.

Due to the fact that the students were underage, a written permission by the parents needed to be obtained before the poster could be released under a CC license. In order to protect the integrity of the students, the poster was not released under a BY or BY SA license but was instead released under a BY NC ND license. This means that the poster can be shared but cannot be modified or resold. Additionally, while explaining the various licensing modules to the students, it was discovered that they had difficulties with the SA concept; therefore, it was decided against using a license that contained the SA module.

For the future research with older students, it would be beneficial to include them in the license choosing process in order to get them more involved with OER as a whole and start a possible discussion regarding which license to use and why. However, due to the fact that

Smartphone Comparison

	 Title: BlackBerry Passport Author: Maurizio Pesce CC BY 2.0 http://creativecommons.org/licenses/by/2.0	 Title: Mockup/drawing of iPhone 6S Author: Rayukk at English Wikipedia CC BY SA 3.0 http://creativecommons.org/licenses/by-sa/3.0/	 Title: Samsung Galaxy Note Edge Author: GadgetsGuy CC BY 3.0 http://creativecommons.org/licenses/by/3.0/
Name	Blackberry Passport	Apple IPhone 6s	Samsung Galaxy Note Edge
Price	~ € 530	~ € 738	~ € 655
Memory	32 GB	16/64/128 GB	32/64 GB
Weight	194g	143g	174g
Battery	~ 30 hours	~ 20 hours	~ 25 hours
Display	1440×1440 pixel	750 x 1334 pixels	1600 x 2560 pixels
Easy to Use	☺☺☺☺☺	☺☺☺	☺☺☺
Features	13 MP Camera BlackBerry Assistant BlackBerry Keyboard	12 MP Camera 3D Touch 4K Video	16 MP Camera Fingerprint sensor TouchWiz Interface
Operating System	Blackberry OS 10	iOS 9	Android 4.4
	Text Source: BlackBerry Passport Wikipedia, the free encyclopedia CC BY SA 3.0 http://creativecommons.org/licenses/by-sa/3.0/	Text Source: iPhone 6S Wikipedia, the free encyclopedia CC BY SA 3.0 http://creativecommons.org/licenses/by-sa/3.0/	Text Source Samsung Galaxy Note Edge Wikipedia, the free encyclopedia CC BY SA 3.0 http://creativecommons.org/licenses/by-sa/3.0

True or False:

1. The BlackBerry is cheaper than the iPhone.
2. The Samsung Galaxy has a better camera than the iPhone.
3. The iPhone is easier to use than the Samsung Galaxy.
4. The BlackBerry has a larger memory than the Samsung Galaxy.
5. The Samsung Galaxy has a bigger display than the iPhone.
6. The BlackBerry is more expensive than the Samsung Galaxy.
7. The iPhone is lighter than the BlackBerry.
8. The battery of the iPhone is better than the battery of the Samsung Galaxy.
9. The BlackBerry is heavier than the Samsung Galaxy.

Which Smartphone:

1. is the easiest to use?
2. is the cheapest?
3. has the best features?
4. has the biggest display?
5. has the most buttons?

What do you think? Which one:

1. Is prettiest?
2. Is best for teenagers?
3. Is best for you?

Based on:
COMPARATIVES AND SUPERLATIVES
Walton Burns
http://www.englishadvantage.info/lesson/comparativesuperlatives/
http://creativecommons.org/licenses/by-sa/4.0/deed.en_US
CC BY SA 4.0

Maria Haas
http://creativecommons.org/licenses/by-sa/4.0/
CC BY SA 4.0

Figure 1. Worksheet: smartphone comparison.

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Figure 2. Class poster.

prior written permission needed to be obtained, the license was chosen beforehand. However, the students were involved in the naming process, that is to say that the class as a whole chooses the author name under which the poster was released.

4. Results and discussion

4.1. Preparation of the lecture

All in all, it took about 39 hours to prepare the lessons. Around 20 hours were spent trying to find suitable OER material online that could be used as a base for the lessons. The first 4 hours of the research period were spent comparing Austrian EFL schoolbooks as well as finding material relevant to the Austrian curriculum. This was done in order to get a better understanding of the students' prior English knowledge and to ensure that the created OER lessons would be useful and suitable for students in the future. This task would not be necessary for experienced secondary school teachers. The remaining 15 hours consisted of adjusting the exercises to suit the students' needs and licensing material under a CC license.

Throughout the research period, instances such as a website no longer hosting material under a CC license and a website releasing material under "a Creative Commons license" without any reference to a particular CC license led to an additional increase in preparation time.

It should be noted that the preparation time cannot be seen as representative for all teachers due to the limited prior teaching experience and the fact that certain material needed to be newly created due to the lack of available material for the target group.

Initially, it was believed that repositories with EFL and ESL material could easily be found. The reason for this was that OER material is predominantly produced in English or by institutions situated in either the USA or Europe [23]. However, as mentioned in the introduction, the OER movement is also mostly focused on the tertiary sector. Therefore, despite the fact that material is available in English, the students' level is assumed to be relatively high. While there are repositories available that provide users with suitable language learning activities, the beginner activities are mostly focused on Romance languages such as Spanish or French. Very little material with regard to EFL/ESL beginner students was found. While it would be possible to reuse language learning material for other languages, due to the lack of Romance language knowledge, this was not possible during this study [24].

Due to the fact that a relatively small number of repositories with material for secondary education as well as EFL material in a suitable level could be found, so-called little OER were frequently used throughout the study process [25].

Big OER refers to repositories often hosted by renowned universities that provide users with material for a variety of subject areas. Since these repositories are backed by abovementioned universities, users are more likely to trust the provided material [25].

According to Clements and Pawlowski [26], trust is one of the main reasons that determine whether or not a teacher decides to reuse the material.

Little OER, on the other hand, are websites that are hosted by individual users. Therefore, due to the fact that rating systems are often missing, the quality of the material cannot always be easily determined [25]. Throughout the research process, it was found that teachers often had their own blogs or websites where they offered material they had created themselves. In addition to providing the material, some of the websites also included information and ideas on how to incorporate the material in a classroom setting. Therefore, despite the fact that according to Weller [25] little OER are seen to be of lesser quality than big OER, this could not be confirmed during the study.

One of the reasons why so little suitable material for English beginner students was found might be due to the fact that teachers are not openly sharing their material online. This does not mean that no sharing takes place but rather that this sharing happens covertly, e.g., in password-protected forums or via email. Due to the fact that teachers are often unaware of copyright-related issues [27], sharing in this close-knit setting allows them to do so, seemingly without having to worry about possible copyright infringement. In turn, this means that OER material that could be shared and be useful for a larger group of people is hidden in password-protected networks ([28], p. 4). Therefore, it is important to make people as a whole and teachers in particular more aware of the OER movement and the benefits it entails.

OER allows teachers to draw from each other's experiences instead of having to reinvent the wheel. Due to the fact that material is allowed to be changed and adapted, students can highly benefit from OER material. One of the misconceptions found during Richter and Ehlers' [27] study with teachers in Germany was that the interviewed teachers thought that offering and putting material online were enough in order to ensure that the said material could be shared, remixed, and reused by their colleagues. Once again, this reinforces the fact that awareness

raising and educating about copyright as well as the OER movement is important in order for more people to benefit from material created by others.

One of the difficulties found during the research period of the study was that material marketed as OER did not necessarily only include material that was licensed under a Creative Commons license or material in the public domain. One of the examples was a shopping dialog. While the text was released under a BY license, the image credit was provided as "Google images." Due to the fact that no link to the source images was provided, it could not be determined whether or not the images were released under an appropriate license.

It should be noted that particularly with regard to pictures, proper credit was not always present. Therefore, instead of simply not using the exercises, the parts that were credited properly were used, while others were omitted. However, in order to be able to remove pictures without credit and for reuse to be feasible, it is important that the material is offered in an easily editable format [23, 29]. An example for this can be providing users with PDF files for easier printing as well as a Word document if the user wants to edit the provided material.

The pictures used for the exercises were almost always obtained from the Flickr website [30] which allows users to search for pictures with a varying degree of openness. As mentioned previously, suitable material for the students' level could not always be obtained; therefore, new material is needed to be created. It should be noted that pictures found on Flickr were also used as a base to create new material for the students.

4.2. Lecturing

The students' regular English class was predominantly teacher-centered, and the textbook provided by the teacher was primarily used throughout the lessons. Over the course of the study, particular attention was paid to use a more student-centered and interactive teaching approach.

During the first lesson, students were provided with a shopping dialog in order to act as an awareness-raising activity [31] for the comparative and superlative forms. They were asked to read the dialog together with a partner and form concepts about the new grammar point. This allowed students to actively contribute to the grammar explanation process rather than merely receiving information from the teacher. Additionally, the dialog provided students with a guideline for creating their own shopping dialog during the lesson.

The second lesson was used to reinforce the comparative and superlative forms. Students were asked to read a text about a raccoon trying to find the ideal car and highlight the appropriate comparative forms. The text was chosen because it was seen as an interesting read that still included grammar points from the last lesson. Afterward, a game was played in order to practice the grammar formation. For this purpose, the class was divided into two teams, and students had to race to the board and add the comparative and superlative forms to words provided on the board.

Lesson 3 was the last lesson to deal with comparisons. Prior to this lesson, students had never directly compared people or objects, e.g., "Lisa is taller than Tim." Therefore, as a warm-up

activity for the lesson, students were asked to compare the two English teachers present. The class enjoyed the exercise, and a few students even asked to volunteer when talking about criteria such as height, age, and hair length. Afterward, students were asked to find the best smartphone for one of the English teachers. They received a worksheet which included information about three different smartphones as well as comprehension questions. At the end of the lesson, the answers to the questions were compared, and students were asked to vote for their favorite smartphone.

In order to incorporate the upcoming Halloween holiday, students were asked to create and write about a "superpet" as their homework. The worksheet included images of superheroes as well as sentences and useful words and phrases. In addition to writing about their superpet, students were asked to draw a picture. This part was included to allow students to be more creative and to make their texts more visible.

The fourth lesson was created to give students an overview of the differences between British and American English. In Austrian schools, students are predominantly taught British English, and often times they are not aware of the differences between the two language variations. In addition to providing an overview of some of the main differences between British and American English, the lesson also acted as an introduction for the topic of vacation and traveling to other countries.

Pictures of various objects with different terms in British and American English were used as a stimulus for the students. The pictures were stuck to the chalkboard located in class, and index cards with the corresponding terms were randomly distributed on the teacher's desk. Students were then asked to come to the front of the class and work together in order to add the correct terms to the pictures. Other differences with regard to spelling and pronunciation were discussed in class. Later, students were provided with the pictures and terms located on the chalkboard. They were then asked to cut the worksheet in order to create their own memory game. This activity not only reinforced the vocabulary but also allowed students to create the material themselves, an activity that would not easily be possible with a textbook.

The last two lessons introduced the present perfect tense. As mentioned previously, the last lesson predominantly consisted of students creating a class poster using sentences with the present perfect alongside vacation pictures. Prior to that, a worksheet as well as a listening comprehension was used to familiarize the students with the present perfect tense.

4.3. Feedback

At the end of the study, a 30-minute feedback session was held with the students. Prior to the study, a preliminary study was conducted in which it was discovered that the students' feedback had mostly focused on the teacher rather than on the material itself. Therefore, the students were provided with some guiding questions during the feedback session in order to ensure that feedback regarding the OER material was received.

The students' feedback was overwhelmingly positive, with only 2 of 30 students noting that they did not like the OER material but preferred using the schoolbook. The others noted that the material was as good as or better than the material they used during their regular classes.

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Additionally, they positively mentioned the games and activities that were incorporated in the lessons. According to an email received by the two English teachers, the students were more engaged and motivated than usual, and one of the teachers noted that she thought that this was due to the fact that the material was created specifically for the students which made the exercises more "authentic" rather than, e.g., simply telling students to open the book on page 45.

One of the complaints the students frequently mentioned was the number of worksheets they received. In order to decrease the amount of paper used for student copies, as well as to speed up the communication process, email was supposed to be used. However, during the preliminary study, only about one-third of the students made use of the email feature. This is why it was decided against using it for the main study. Additionally, the school website had recently been restructured, and students were not allowed to use mobile devices in class. Therefore, the material was provided only in hardcopy format.

Over the course of the six lessons, the students were provided with nine worksheets each. This means that all together over the course of 2 weeks or six lessons around 420 copies were produced. This not only meant a huge amount of paper usage but also led students feeling frustrated because they needed to hole punch each sheet and loose sheets could easily get lost. While it would have been possible to decrease the number of copies by printing double sided, it was decided against it in order to increase flexibility.

5. Conclusion

Open educational resources are a great opportunity for teachers to increase the quality and enjoyment of students. As could be seen throughout the study, the students enjoyed working with the material and were eager to learn. This suggests that students would not be opposed to using OER material in class instead of using their schoolbooks.

However, the study also showed that while it is possible to exclusively use OER material in an EFL setting in an Austrian school, at the moment there are certain challenges encountered when doing so. Therefore, in order for OER material to be used on a regular basis in an EFL classroom in Austria, certain changes need to occur.

While it is possible to use OER material in an offline setting, there are certain drawbacks associated with it. In addition to the paper used to create hardcopies, citing Creative Commons material became more difficult and confusing due to the offline setting. Further research needs to be conducted in order to determine if measurements such as providing material online could decrease the time needed to prepare the lessons.

Furthermore, it is important to spread awareness of the OER movement as a whole in order to make teachers aware of its benefits. Doing so will stop teachers from sharing material in a private setting and allow a larger audience to benefit from the material created by others. Therefore, the author suggests implementing a course with regard to OER usage as a requirement in the curriculum for teacher training in order to allow the future generation of teachers to learn about the benefits associated with using OER material and provide an introduction to OER usage.

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Chapter 9

Making as Pedagogy: Engaging Technology in Design Teaching

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Additional information is available at the end of the chapter

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Abstract

With the wide spread adaptation of digital technology in the design discipline, there is a need to understand the role of technology in design teaching. In this chapter, we will examine the role of technology as probes, prototype, and toolkits and ask how this facilitates a more holistic learning process. "Design problem" is by its nature multi-facetted and open ended. The difficulty faced by most educators in the design discipline is that of encouraging students to develop critical thinking and approach the open-ended nature of their subject. We will explore making as a critical investigation of the design problem with two projects taught in an architectural design studio environment, at both undergraduate and graduate levels as case studies. By reviewing experiential learning through making, we can develop a more integrated means of teaching technology within a broader trans-disciplinary design context.

Keywords: technology, design teaching, collaborative design, pedagogy, digital fabrication

1. Introduction

Learning through making is a critical pedagogy in the discipline of design. This mode of teaching places emphasis on learning experiences, rather than on the "banking" concept of education [1]. As designers are form givers and bringing ideas into the material world is part of their business [2, 3], the process of learning and working through design as an open-ended "wicked" problem [4] requires the integration of both mind and hand, where students construct individual learning experiences through embodied interactions with reality. As Kolb [5] pointed out, in an experiential and integrated model, learning is based on the conflict between concrete experiences and abstract concepts and the conflict between observation and action.

This mode of teaching has recently being advocated in other curriculum areas such as science, technology, engineering and mathematics (STEM), as a means of integrating trans-disciplinary knowledge [6].

Like most disciplines, architecture and design have been significantly affected by recent disruptive technologies, from computer-aided design (CAD) to computer-aided manufacturing (CAM). In this chapter, the discussion will be situated in the context of the wide spread adoption of digital fabrication technology in the design discipline through the use of computer numerically controlled (CNC) machinery such as 3D printers, laser cutters, and CNC routers and robotics in manufacturing. In addition, recent advancements in open- source electronic prototyping platforms, which enable a more amateur engagement with electric prototyping, have led to a burst of Do-It-Yourself (DIY) experimentation; this is evidenced by the global rise of FabLab, Maker Faire, and Hackathon. The challenge in understanding the impact of disruptive technology on design studio teaching is not so much about the range of emerging skill sets acquired by students but rather about whether we as educators should be focused on understanding how these technologies change the way in which we teach design thinking. I use the word "we" because in this open-ended learning environment, the knowledge development process is a collaborative effort between the tutor and the students; the tutor becomes a co-designer of the project instead of being a source of knowledge [3]. This teaching model is underlined by the notion of the design studio as a teaching environment; in most contemporary higher education settings, it typically consists of 1 tutor with a group of 12–16 students at both undergraduate and graduate levels.

Typically, the tacit or embodied knowledge [2, 7] acquired through making and the knowledge of design strategy and analysis, are separated in the way they are taught in a design studio [8, 9]. Thus, it is often difficult to integrate these within the same coursework assignment. This often results in students using digital software and fabrication tools as problem-solving devices. In this chapter, we will examine how the integration of technologies in design teaching and learning can encourage the exploration of design thinking in which students grapple with the different aspects of knowledge, and we will consider how these could be restructured to formulate new knowledge and personalised learning experiences.

We will examine the learning experiences of two sets of projects from different architectural design studios led by the author at the University of Melbourne. The first set of projects involved a group of second-year undergraduate students working on a selection of 1:1 wearable artefacts generated using digital fabrication techniques to explore the idea of personal space boundary. The second project examined the use of electronic prototyping platforms in design where students at the Master's level created operable machines and sensory devices to advance their design knowledge. In these projects, we will explore the role of technology as a probe for design thinking, as means to develop and test ideas through prototyping, and as a toolkit with agentive capacity to explore creative solutions to the design problem.

In the last part of the chapter, we will look at the results of an on-going questionnaires administered to the students of these design studios to understand the role of technology from their perspective. We will discuss how technology affected their design process and evaluate the impact of integrating technology in design teaching; the steep learning curve associated with

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technology teaching in design is often seen as a primary drawback [6, 7, 9]. We will review experiential learning through making and examine how tacit knowledge allows students to develop a multi-dimensional appreciation of the design problem.

Making in this context is not just an act of reproduction but a creative act of gaining knowledge in design, which involves the construction and transformation of meaning [3]. In the process of making, technologies play a vital role in the formulation of tacit knowledge precisely because as toolkits and probes, they act as what Ratto called transitional objects [10]. They have an agency to deliver knowledge and facilitate critical thinking processes, Ratto termed this critical making. Through this strategy of engaging technology in design teaching, we can develop a better understanding of the role of technology in teaching. It can also be applied to our understanding of how future emerging technologies can be integrated in design teaching and learning.

2. Theoretical background

In his book on experiential learning, Kolb outlined three historical models of experiential learning proposed by Lewin, Dewey and Piaget [5]. He noted that all models share a baseline relationship between "concrete experience", "reflections and observations", "abstract conceptualization", and "active experimentation" or "testing". These four categories are set up as feedback to enable a continuous learning experience. Kolb identified the process of learning as "the resolution of conflict between didactically opposed modes of adaptation to the world" – those of "observation" and "testing of active experiments", "concrete experience", and "abstract conceptualization"; both constructionism and critical making have experiential learning as part of the thinking and are thus relevant to our discussion [10].

2.1. Constructionist approach to learning

Constructionism in education advocates the construction of knowledge through real life or real life-like experiments that foster learning [11]. It emphasises the importance of actively making things and, pairing abstract concepts with concrete experiences to make sense of knowledge.

Schank pointed out that the key to enhance learning is "doing". While his writing does not cover architecture design studio teaching, many of the scenarios he has discussed are applicable and comparable to studio teaching, e.g. how to teach students practical or tacit knowledge [12]. Schank discussed the mechanism behind learning through doing; there are two key concepts relevant to our discussion.

The first concept is "experience". Schank described learning by doing as an opportunity for students to acquire experiences. Through doing, the experience extends beyond the abstract scholarly reading of the subject. The students start formulating judgements by naming the experience, something he called "indexing". According to Schank, learning is the accumulation and indexing of experiences. The more the experience the larger the index vocabulary and, hence, the better the ability to make judgements, thereby triggering associated memory, building related skills, and connecting tasks with learning outcomes. We will further discuss how technology enabled indexing of experience in the case study projects.

Secondly, learning by doing requires "doing devices", which facilitate the learning process. Traditionally, in architectural and design education, the use of representational drawings and models, be it digital or hand-made one, act as the key deliverable media. These media in most creative practices are already an active ground for interrogating ideas and hypotheses; what is typically missing is the requirement to test, interrogate, and implement these ideas in reality. In architecture design, the making process is perhaps the most direct means of testing a hypothesis as a prototype. This is where technology plays a critical role given that we can now streamline the workflow from digital drawing and modelling (as an abstract hypothesis) to physical testing and prototyping using CNC technology.

Apart from prototypes, there are two other types of "doing devices": toolkits and probes. Sanders & Stappers define probes as "materials that have been designed to provoke or elicit response" and toolkits as components to "make artefacts about or for the future" that are "specifically confirmed for each project/domain" [3]. The author suggests that prototypes, probes, and toolkits as "doing devices" are critical in scaffolding the experience feedback cycle mentioned in Kolb's analysis. Here, the role of the prototype sits between the conflict of observation and testing, while probes and toolkits negotiate the ground between concrete experience and abstract conceptualisation (see **Figure 1**).

2.2. Critical making: technology as design agency

Papert discussed the need of "messing about" with materials to construct active learning through incremental building of knowledge [13]. The use of "computer as material" removed the black box mentality towards technology. Instead, its programming language and software are seen as materials integral to the construction of artefacts and capable of solving real-life

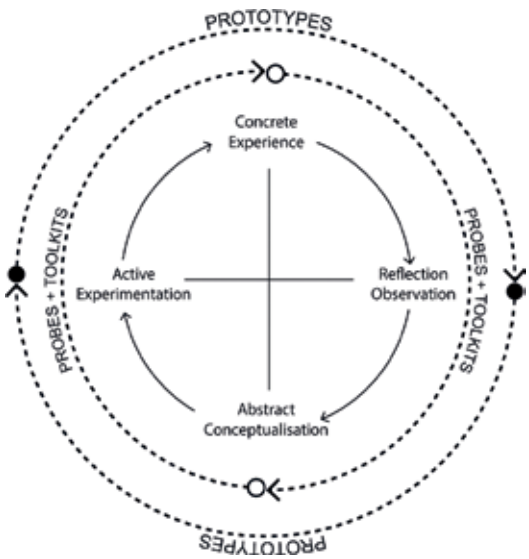

Figure 1. Prototypes, toolkits, and probes as "doing devices" overlaying the experiential learning model of Kolb [image by Paul Loh].

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problems, like wood or metal. Recent software and hardware advancements have further allowed designers to engage design directly with technology. Open-source electronic prototyping has allowed designers to tinker with electronics and build reasonably stable and complex mechatronic systems without prior training as engineers. Through open-source codes, designers can implement and modify the logic of a device using software coding instead of messing around with the hardware, which traditionally was designed for specific applications [14]. This inversion of workflow flattens the knowledge structure of electronics and essentially democratises physical prototyping of technology [15], thus allowing designers to invent bespoke machinery or tools to expand their design repertoire [16].

In order to understand technology as an operative design agent, there is a need to position technology, not simply as a tool that is a means to an end but also as a component to carry certain conceptual thought processes that enable designs to emerge. Ratto [10] refers to this notion as critical making; where he situated the hacker culture within scholarly activities that examined making as a social technological engagement. He suggested that through making, the maker not only "writes" with material to construct the logic of a system but also makes sense of the relationships between the user and technology; the process of making sense of these relationships is the critical process of enquiry. Ratto makes a distinction between critical making and constructionism [17], suggesting that while constructionism focuses on how reflexive practice can improve the quality of the material world, critical making extends beyond this to explore how engagement with material production can improve the conceptualisation of our world. The ability to intervene and have an impact on social life is a key aspect of critical making. In architectural design, this aspect of learning is often excluded from the teaching of technology for a number of reasons. The predominant reason is the need to see technology as a separate silo to social engagement. Ratto pointed out, "there remained a strong disconnect between these more material forms of engagement and the conceptual work being done on technology, the built environment, and society" [17].

As Papert pointed out, technology can be used as "material" that has a role as a transitional object. The "transition" refers to the exploration of ideas through making, where the design knowledge generated is carried through to the making process. Here, technology as a toolkit is seen as having an agentive capacity to be able to enhance social communication [10]; it has the capacity to carry and deliver knowledge.

The word "agent" and "agentive" should be differentiated to make the argument more precise. An agent is defined as "any element which … makes other elements dependent upon itself and translates their will into a language of its own" [18]. According to Malafouris, an agent is not exclusively a human activity but could be satisfied by a material, in so far as the material (tools and technology included) can become an extension of the person [19]. He highlighted the role of the material agent through the making of an axe head, using the knapping technique on flint. The act of knapping, he argued, is an exercise of multiple agents at work; for example, the hand of the maker, the knapping stone, and the stone being knapped. Each subsequent strike of the flint determines the angle of the next strike. He suggested that the making of the axe head is not a preconceived image of the axe head within the flint but rather an iterative negotiation of materials.

Agency or agentive capacity is the capacity of an agent to deliver or carry knowledge, meaning it, therefore, has the capacity to be useful in design. As Nafus & Beckwith point out, "knowledge comes not just in the planning, but in the doing" [20]. Referencing back to Malafouris's example, the agency of the flint carries the know-how of making, so each agent has the capacity to deliver specific pieces of knowledge that facilitate the making process. The word agent, therefore, refers to the "what", while agency refers to the "how" of the activities.

3. Case study projects

In this section, we will look at the role of technology in two sets of projects. All the projects were led by a design studio or coordinated by the author at the University of Melbourne. The projects were conducted as group work and completed in a 12-week teaching period. In the first project, titled "The Second Skin", we will discuss the role of probes and prototypes in the design process. In the second project, titled "Machining Aesthetics v4.0", we will examine the role of toolkits and how they have an agentive capacity to deliver knowledge.

3.1. Second skin: imbedding computational thinking in making

The Second Skin project is the result of a second-year architectural design subject "Digital Design and Fabrication". As the name of the subject implies, the subject aims to teach students a set of digital design skills ranging from 3D modelling through to using CNC tools such as laser cutter and 3D printer. Instead of delivering the content as a series of theoretical lectures with a practical class in software application, the subject explores the content through a design studio format guided by a series of lectures. It is worth noting that most students encounter digital design and modelling software for the first time in this subject and the learning curve is typically very steep; we will examine this in detail under 3.3.

The objective of the subject is to utilise an open-ended design task to encourage students to explore the premise of digital design and develop software application skills through physical making of their project as a prototype. The brief given to the students is to design a "Second Skin" using the body as a social and cultural site for intervention. The outcome is a 1:1 wearable physical prototype made from various materials that are digitally fabricated, meaning the 3D modelling has to be output as physical and makeable objects, using a range of CNC tools namely, 3D-printer, CNC paper cutter, and laser cutter. This last phase is perhaps the most challenging one for the students as digital models tend to confront the reality of the physical property of materials.

3.1.1. Method and strategy

Two key probes were used to jump-start the design process: a given object as material strategy and a reading by Robert Sommer on personal space [21].

The aim of the given object was to provide a material strategy to the students. We identified three material strategies: skin and bone, panel and fold, and section and profile; each team had

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to choose and develop one of these strategies using a given digital toolset. These material strategies are common strategies utilised in architectural design and can be feasibly implemented using CNC tools. To introduce the task of making to the students, we devised a 1-h workshop where students implemented a pre-set exercise on the body. The exercise shown in **Figure 2**-left is a panel-and-fold exercise that took a known geometric logic of a Buckminsterfullerene, which resembles the geometry of a soccer ball, to encourage students to produce a 3D surface using flat pieces of paper. The purpose of this exercise was to help the students understand a complex set of rules or algorithms in the panelling and folding process without making them feel overwhelmed by complex descriptive mathematics. Through making and exploring the material and geometry, the students developed their first index with their material system. This included how and where to fold the paper, how to glue the panels together, what is the scale of the Second Skin, and how to work around a complex shape like the human body. The algorithmic mode of thinking needs to be imbedded at an early stage as it allows students to take the rule-based thinking into their digital design process.

The early phase of the subject focused on the tooling of the students with a digital skillset. In parallel with 3D modelling skills, the students applied the material strategy as probes to explore their design. Coupled with the reading on personal space boundary, the design took on cultural and social dimensions (see **Figure 2**-right).

3.1.2. Result

We encouraged the students to document and physically measure their own personal space to gain an understanding of scale, dimension, and area of focus; an ambitious interpretation of the brief of the Second Skin project is illustrated in **Figure 3**. This Second Skin project by Brydie Singleton, Matthew Tibballs, and Stephen Yoannidis explored the ambiguity of gender-specific personal spaces resulting in a literal blurring of the body. The initial digital manipulation of the body (**Figure 3**-bottom) acted as a probe for the ideation process. By exploring the pixilation of the images, the design team explored the permeable effects of the skin, leading to the creation of openings or apertures within the panelised surface.

Figure 2. Left – Developing index of making experience through making. Right - Personal space as probes for design [images by Galimova].

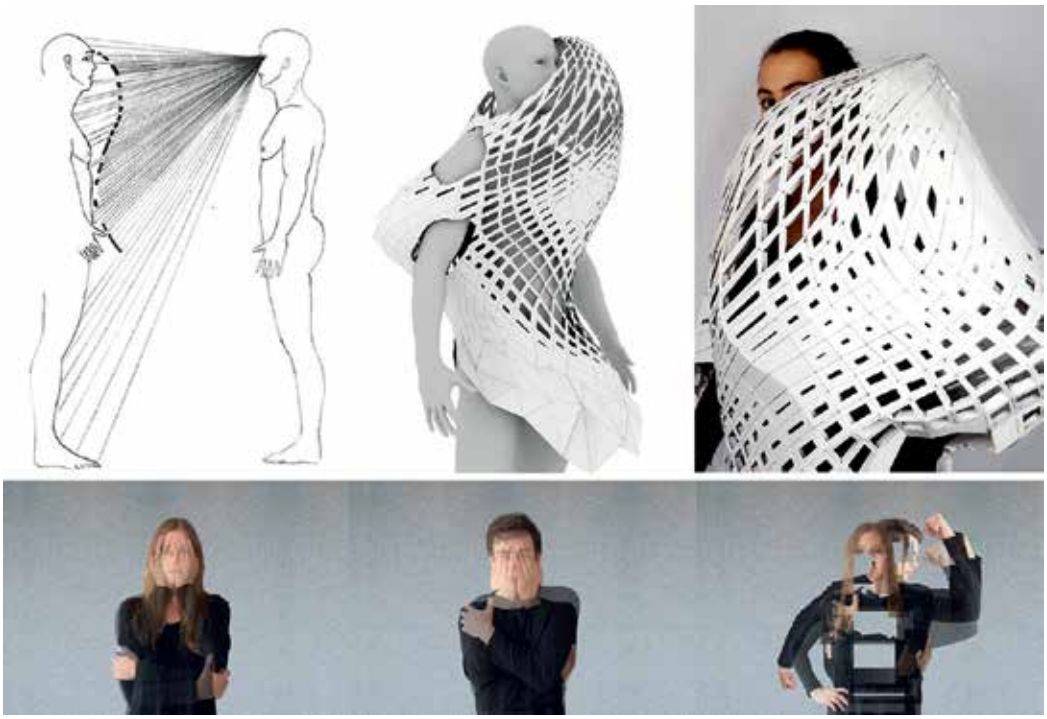

Figure 3. Top left – The ideation process probed by digitised images of the bodies (bottom). Top right – 1:1 wearable prototype [images by Singleton, Tibballs and Yoannidis].

Another Second Skin project by Diana Galimova and Daniel Parker used section and profile as the material strategy. They integrated the physical prototype in the interrogation of the design. **Figure 4** shows the prototype fragments made from cardboard constructed using the template from the digital model. Here, the function of the prototype was to test the hypothesis of their design – to create a Second Skin which allows the user to view his/her environment from different angles. The observation documented in the prototype informed the conceptual thinking and allowed the design to be refined. The iteration of prototypes can be considered physical evidence of the index of experience.

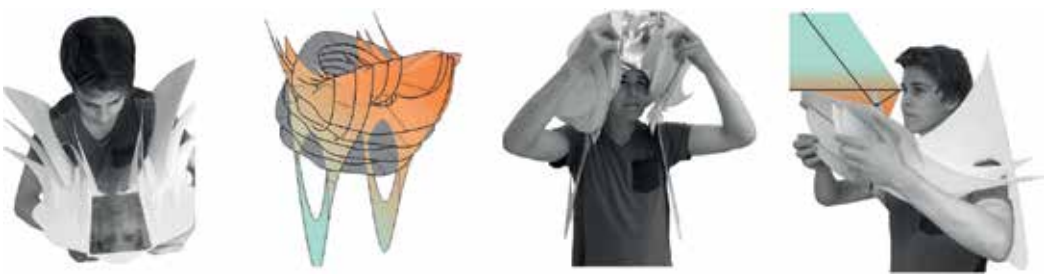

Figure 4. Testing of prototypes against hypothesis [images by Galimova and Parker].

3.1.3. Discussion

These two projects demonstrated how material strategy in the design process allows making to become part of the design strategy; the material strategy is intricately linked to the making process. Here, making is not only about putting things together but also about facilitating design thinking to be formulated and tested against the initial design brief. The design brief of the Second Skin was an open-ended design problem probed by the material strategies and textual reading. The author found this balance useful in the articulation of the design studio brief as it defined a clear boundary of the problem and, at the same time, allowed for multitude interpretations with varied outcomes.

Owing to the specific technical skills required in software application, technology only acts as a probe in the later phase of the design process. We find its real value in delivering the prototype for the testing of ideas. As Sanders & Stappers pointed out, probes are useful at the pre-design and early phases of the generative design process [3]. Here, constrains and opportunities of the CNC tool form part of the design outcome and aesthetics as evidenced by the physical outcomes of the projects. **Figure 5** shows a series of panelised and cut cardboards with pre-cut "tabs" used for gluing a series of panels together. Through the use of panelling software, the students learned to craft their digital model to suit the material property of the cardboard. This in turn speeded up the making process with the aid of a laser cutter, which delivers a more precise physical model. Without the aid of technology, this model would have taken a lot longer to work out geometrically and would have been too laborious if cut by hand.

Given the prevalence of digital fabrication technology in the design discipline, Özkar suggested that the means for teaching design should be altered in parallel to the tools [22]. This demands a different approach to teaching which integrates design thinking with techniques of digital fabrication technology [23]. However, in practice, this may not always be possible. Often, the tacit knowledge applied and acquired through the making process and the knowledge of design strategy and analysis are separated in the way they are taught [8, 9]. From an educator's point of view, it can be difficult to integrate these within the same coursework owing to time constraints. It tends to overwhelm students with a large amount of information. The learning of digital fabrication techniques in a studio setting consumes more time than

Figure 5. Laser-cut panels made with dexterity and craftsmanship using digital technology [images by Singleton, Tibballs and Yoannidis].

other subjects because without the technical knowledge, it is difficult to explore the potential of a design [6, 11]. Unfortunately, in some instances, students tend to use digital software and fabrication tools as problem-solving devices instead of active probes in designing [7].

3.2. Machining aesthetics: agency of tool

Machining Aesthetics v4.0 was led by the author and teaching partner, David Leggett. The objective was to investigate the role of tools in the design process. The brief was to design a "machine" that can make architecture at a pavilion scale. Each project team consisted of three students working collaboratively throughout the 12-week period, the same time frame as the previously discussed project.

The aim of the studio was to introduce tool making as the starting point of an architectural design project. The objective was twofold. Firstly, while there was a clear programmatic and simple design brief, the approach to the brief was purely from a making perspective – a "wicked" problem where the solution can only be discovered through making. The boundary of making was defined by the authors on the basis of precedent studies and specific making techniques as probes. Secondly, we wanted to encourage the students to escape the pre-set conditions of existing tools in order to discover novel making techniques and design potentials.

3.2.1. Method and strategy

Introducing tool making in the design studio had its own limitations, primarily owing to time constraints and the depth and breadth of knowledge that the students needed to acquire to complete the design and fabrication of their system. Unlike the previous projects, the students had to utilise and work across a greater range of software and physical toolkits such as Arduino Microprocessor, Arduino Integrated Development Environment (IDE), electronic prototyping platform (including jumper leads, breadboards, resistors, relays and servos), and other CNC equipment. At the start of the studio, all participating students had some prior parametric design skills in terms of visual scripting but had little or no electronic knowledge and making skills. To make the hardware more accessible, we introduced the students at an early stage, to a plug-in for parametric software and programming language of Arduino IDE, based on C/C++. Arduino IDE is an open-source platform and its programming language has been widely used. More importantly, the code library is shared and therefore, accessible to students. The studio saw this as an opportunity to allow students to tap into the shared online code and build up technical know-how in a reasonable time frame. In this case, the students only needed to understand the basic structure and language to access and understand most codes.

3.2.2. Result

We will now discuss the two projects that were developed out of the studio. The first project is called Re-configure Edge Mould (REM) and the second, Pneuma.

REM (**Figure 9**) is an adjustable mould that works with an industrial thermal-forming machine to allow for continuous production of different shaped panels made from high-impact polystyrene sheets (HIPS). The aim of the project was to produce variation in panel shape using

one mould design; the design team came up with a mould that can be computer numerically controlled and adjusted to produce variation in the panel. The objective of the machine was to create a set of geometrically different panels that could be accumulated together to form a visual screen to provide privacy in an urban setting.

The making process acts as a probe for the design. Through a series of initial making experiments and precedent studies, the team highlighted a few issues with the traditional vacuum thermoforming technique. Firstly, to produce panels with variable geometries, a unique mould has to be made for each shape. In this case, the mould was made using laser cut plywood. This technique generates a large amount of material waste. Secondly, through making, the team discovered the minimal surface formed by the vacuum former when they introduced a so-called "shaping object"; the shaping object pushed onto the HIPS and allowed it to be pushed into the desired form. Thirdly, the team identified the clamping edges of the vacuum-forming machine as a key parameter in the operation of the technique. These issues and parameters outlined through the making process posed a design problem to the team: How to make a single mould that is adjustable so it can eliminate waste and utilised the parameter observed through the thermoforming process?

The design of the final mould was tested and prototyped numerous times before reasonably successful panels were fabricated (**Figure 6**). The struggle of the prototyping process was accompanied by physical problems and made visible the potential of the system for design to the design team [3].

Pneuma (**Figure 10**) is a pneumatic device that regulates airflow in order to inflate or deflate a double-skin polyvinyl chloride (PVC) inflatable structure. The aim of the project was to use air to control sunlight and view penetration through the inflatable structure. Our discussion will focus mainly on the making of the air control unit. Like REM, this project was developed through a series of experiments in the making of an inflatable structure. The team of students reflected on the system and questioned how such a structure can be used to regulate daylight and view as a soft façade or building cladding system. To make the project more ambitious, we prompted the students to look into adding light sensors to their system to regulate the inflation in order to limit the amount of sunlight. Up to this moment, all the information that the students received was researched from various sources of literatures, precedent studies, and making instructions from Instructable™; no new knowledge was generated but a great deal is learnt in a short period of time.

Figure 6. REM for thermoforming plastic panel [images by Frances White, Alex Morse & Maryam Bennani].

Innovation happened when the team started to imbed a secondary opaque layer through the construction of the inflatable structure, which could be deployed to block out daylight. From this moment onwards, they were in bespoke territory. They had to design the control device from scratch, whilst prototyping it and struggling with air leakage and moving parts. Imbedding electronic required another layer of learning, which thanks to the open-source nature of the code, meant that once the basic principle was understood, the code could be modified to suit their purpose. The hardware design was reasonably simple, with the use of servos to adjust the rotation angle to open and close multiple air paths as "gates". The tinkling process with the electronics provided a useful learning experience, mostly trial and error, including burning out the servos and the usual mess of ensuring the circuits are connected in a logical manner. It took the team six iterations of hardware and software configuration and reconfiguration to incrementally modify and improve the system. **Figure 7** shows the final prototype, which maintained a 10 minutes inflation and deflation cycle.

3.2.3. Discussion

In REM, when the design problem was clarified, the electronic prototyping component was used as the primary toolkit to prototype the adjustable mould in order to test the hypothesis. In this project, the "definition" of the design problem came from a series of observations and practice of existing making techniques with the aim of developing a more efficient and less wasteful fabrication procedure. The solution came from the isolation of key parameters in the making process and how these parameters were used to generate different aggregation logics of the panels.

Figure 8 show a diagram illustrating the logic of the tool-making process. In order to design and create REM, the design team had to first learn the technique of thermoforming. We called this the computational history of the making technique [A], referring to the knowledge of

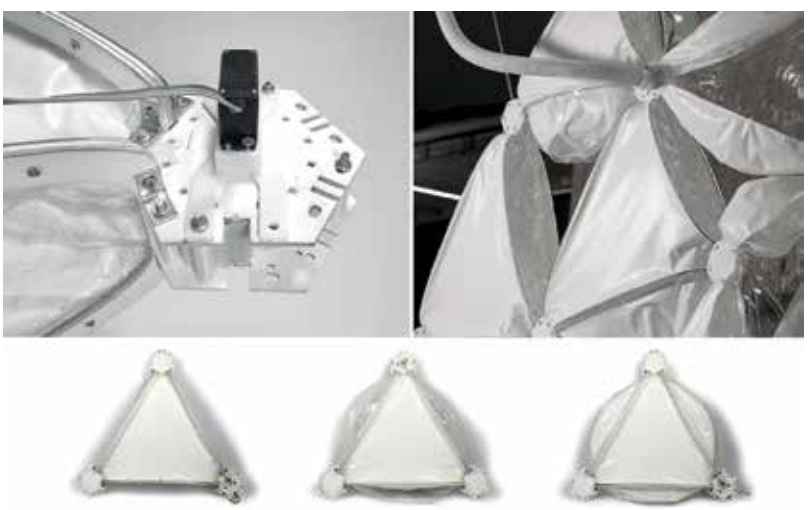

Figure 7. Top left – Servo-controlled air gate. Top right – Final prototype of Pneuma. Bottom – Prototype showing secondary opaque layer in inflatable structure [images by Ryan Huang, Daniel Parker and Suyi Zha].

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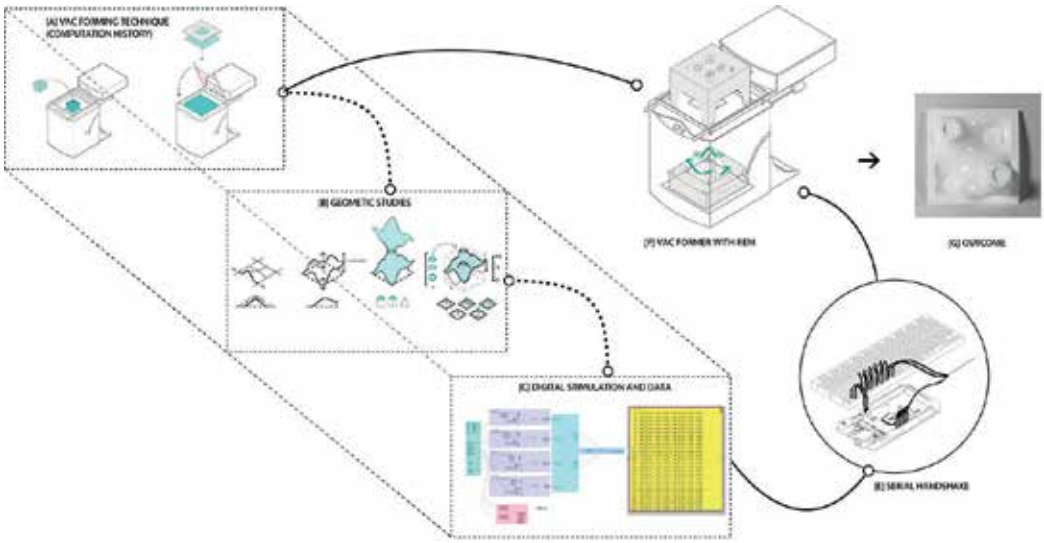

Figure 8. Knowledge structure of tool design process [images by Loh].

how to use various tools to perform certain techniques. Computational history is a term borrowed from computing that refers to the storage of memory for machine learning. This is similar to Schank's index of experience. Probably, these sets of indexes were more complex and in this case study were "stored" or transcribed in the design of the technology. The second aspect was to understand the mathematical description of the output panel called geometric studies [B]. Finally, through visual scripting [C], the digital information aligned the computational history with geometric studies, allowing the electronic prototyping platform [E] to act as serial handshake between the panel geometry and physical mould [F & G]. Here, electronic prototyping facilitates this collapse by drawing on the data simulated in the script and the know-how of the making process. This was translated into linear motion through the servo which, in turn, drove the gearing system in the mould design.

This diagram reveals the agentive capacity of the toolkit in so far as having the capacity to collapse the various layers of knowledge together into a coherent piece of novel technology. Through designing and making of this piece of technology, the traditional top-down approach to design is inverted. While working on the mould design, the students started to question the design potential of this new tool. They speculated that it could be used as an urban play device to allow the public to make and accumulate the panel to form public enclosures (see **Figure 9**).

While in REM, the electronic prototyping toolkits enabled a collapse of the index of experiences into the made object (the mould design), in Pneuma, they facilitated a design workflow, bridging digital code and physical object. In this project, the electronic prototyping toolkit was used to work through the logic of "gates" for the air path in order to control the sequence of inflation (see **Figure 10**). The flexibility of the toolkit allowed the students to modify the configuration before settling on a suitable prototype. The visual scripting was modified in parallel as the electronic toolkit was reconfigured, allowing a dialogue between the script and the physical toolkit

Figure 9. Urban aggregation of panels to form public enclosure. Right – 1:1 prototypes [images by White, Morse & Bennani].

(see **Figure 10**). Here, physical and digital toolkits worked in tangent to stimulate the goal of the task and, at the same time, to allow the students to test out different scenarios. The toolkit has an agentive capacity to deliver and construct new design knowledge during the process of testing.

Both projects utilised electronics as toolkits to prototype a reasonably feasible working system that attempted to solve real-world issues either as environmental controls or as means for reducing manufacturing waste. The making in these instances involved a critical engagement of social and environmental issues through technological means, thus allowing the students to embody the act of making with meaning and narrative.

3.3. General discussion

The case study projects demonstrated the use of probes, prototype, and toolkits to scaffold learning experiences. Technology, in these case studies, moved beyond the application of software

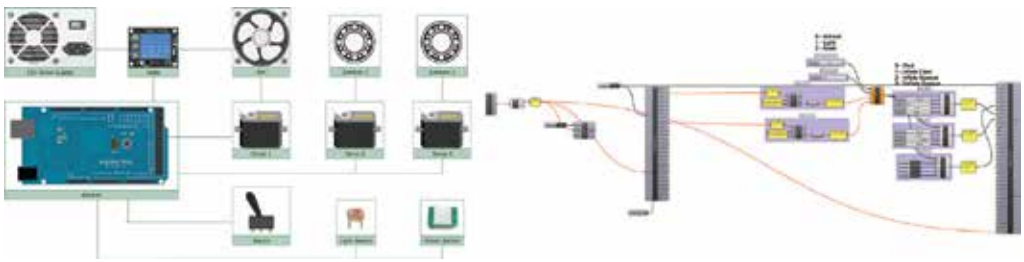

Figure 10. Left – Iteration of physical configuration of electronic prototype. Right – Visual scripting of code to operate the electronic configuration [images by Huang, Parker and Zha].

and hardware, but rather played an active role in stimulating, enhancing, and more importantly, becoming part of the creative agency in the design process. The ability to see technology as part of the design solution means that it is integrated into the knowledge structure of experiences. As Schwartz pointed out, "too rarely in an architectural curriculum are acts of making used, instead, to generate ideas and sometimes they are left out of the primary iterative loop of idea conception altogether" [6].

To conclude our discussion in this chapter, I would like to present the initial results from a questionnaire as part of my on-going research on the use of technology in teaching and learning. The questionnaires were answered by students from both design studios. The questionnaire aimed to capture the students' perspective of learning using technology and understand their views on tacit knowledge as part of their learning experience. The invitation to participate was sent between 2015 and 2017 to about 100 students, of which 34 responded (approximately 33% response rate). The questionnaire was anonymous and voluntary, conducted as an online exercise using SurveyMonkey™.

3.3.1. Technology in design learning

We asked the students how technology affected their design process, refer to **Figure 11**. As the participants could choose more than 1 answer, 97% of them stated that it opened up design opportunities and increased the sophistication of their project; 59% said that it expedited their process, 6% said that it slowed down their design process and restricted their creativity; and 15% provided alternative responses, one of which is given below:

> *"It takes time to grasp the way how technology works. Sometimes, it's hard to come up with a coherent way of designing through hands and through software. The balancing between the two can be time consuming. However, this balancing can be both beneficial and hindering. Beneficial: make a more precise design. Hindering: the translation between two worlds can be difficult".*

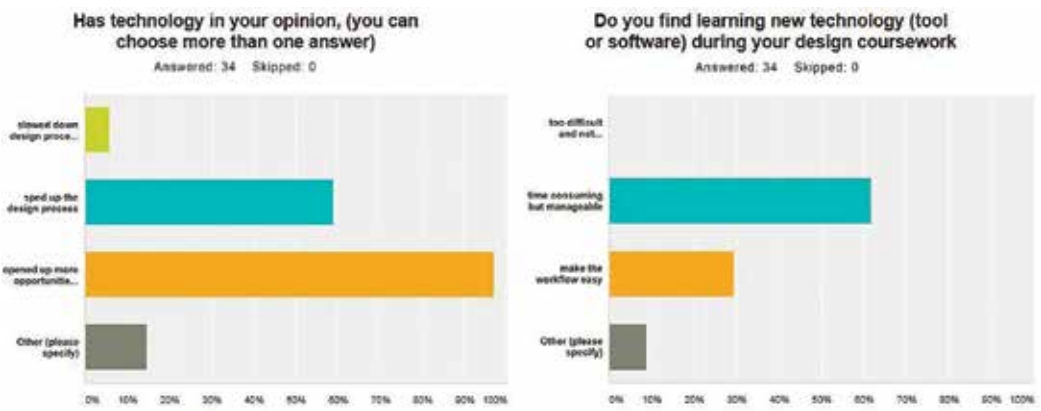

Figure 11. Survey results from questionnaire [images by Loh].

This is an interesting response as it highlights what the author believes is the typical struggle in learning and integrating technology in design teaching. This comment also highlighted that in technology teaching, there ought to be a more seamless workflow between the hand and technologically aided design process.

With regard to the question on learning new technology during the design studio, bearing in mind that all respondents attended it for 12 weeks, 62% said that while it was time consuming, it was also manageable, and 29% said that it made the workflow easy. What is surprising is that none of them said that it was too difficult and unmanageable. Three participants provided alternative responses; they suggested that the design period of 12 weeks should be extended. This suggests that the pick-up period for new technology is longer at the start of the design process, leaving the students with less time towards the end to complete the project to their satisfaction.

3.3.2. Tacit knowledge and critical making

Through physical making in the case studies, the students applied and enacted tacit or embodied knowledge. According to Schwartz, this embodied practice is where "the maker uses his or her body to generate a set of movements (known or unknown) in order to achieve the desired form or result of the made object" [6].

In the questionnaire, the students were asked to evaluate their understanding of tacit knowledge gained through their design project. The 33 responses collected (1 skipped) are outlined below:

- According to 18% (6 out of 33) of the responses, tacit knowledge can be applied to both digital skill and physical making skill.
- According to 57% (19 out of 33) of the responses, tacit knowledge includes an understanding of the practical application and limits of tools, materials, and techniques.
- According to 30% (10 out of 33) of the responses, tacit knowledge facilitates design opportunities and experimentation.

It is interesting to note that 18% of the responses highlighted digital skill set as part of tacit knowledge and almost half of the response saw evidence of their tacit knowledge in their prototype; included in this category are participants who understood tacit knowledge as a means to perfect their control over the CNC tools, materials, and techniques using phrases such as "limitation of the CNC machine", "tolerance for 3D printing or laser cutting", "more accurate making", and "manage the curvature and behaviour of the material".

The final category of response discussed both the practical application of tacit knowledge as well as how it enables and facilitates the design process through opportunities and experimentation. Two examples are listed below:

> *"I have without a doubt gained tacit knowledge throughout our design project. Such high- level skills in regards to computer technology and digital translation can only be learned through experience and implementation."*

> *"Tacit knowledge has been a definite part of the learning experience. Given that this was my first real project involving something of this scale to be constructed; many errors were made along the way that*

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could only be done so empirically. The process of craft-making enabled me as a designer to consider a multitude of factors that often times goes unnoticed when bound to the digital dimension, such as gravity, scale, and environment. For example, the final second skin, owing to the sheer number of panels that made up the final form, proved to be very fragile and prone to ripping. This was a side-effect of the material choice as well as the dependency of the design on the surface as a structure with no extra support. This was something that could only really be learned through the making process itself. "

What intrigues me about these responses is how students started to consider "multitude of factors" relating to their design and making. It highlighted that critical thinking around the design problem evolves out of the making experience which informed the students' judgement and evaluation. This model of teaching technology allows students to gain a more holistic picture of the design problem and juggle abstract concept with physical materials and technologies.

4. Conclusion

If education is to be transformative, then each piece of knowledge should contribute to the development of an individual. Through making, the experiential learning process allows for an integrated model of learning where tacit knowledge, whether digital or physical, plays a role in formulating judgement and critical thinking. When technology becomes part of the "material" strategy for students to construct and scaffold design thinking, it becomes an operative learning device in the form of probes, prototypes, or toolkits. The projects discussed in this chapter give us an understanding of the role of technology as "doing devices" that not only facilitate the process of making via sensory motor activities but also function as operative media to question the nature of the design problem. This writing highlights the integration of digital technology in learning where students grappled with different aspects of the bodies of knowledge and restructured them to formulate new knowledge and a personalised learning experience.

I see this teaching strategy as a useful means to tackle future emerging technologies. With the rise of virtual reality and other advanced modelling and visualisation software, educators need to develop more integrated and holistic means of teaching technology within a broader trans-disciplinary design context. Imbedding technology in the experiential learning process can help construct a better and more critical approach to design learning.

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Chapter 10

Pedagogical Techniques Employed by the Science Television Show *MythBusters*

Erik A. Zavrel

Additional information is available at the end of the chapter

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Abstract

The long-running Discovery Channel science television show MythBusters has proven itself to be far more than just a source of weekly entertainment. The popular cable program employs an array of sophisticated pedagogical techniques to communicate scientific concepts to its audience. These techniques include: achieving active learning, accommodating different learning styles, avoiding jargon, employing repetition to ensure comprehension, anthropomorphizing physical phenomena, using captivating demonstrations, cultivating an enthusiastic disposition, and increasing intrinsic motivation to learn. In this content analysis, episodes from the show's 10-year history were methodically examined for these instructional techniques. MythBusters represents an untapped source of pedagogical techniques educators at all levels may consider availing themselves of in their tireless effort to better reach their students. Science educators in particular may look to MythBusters for inspiration and guidance in how to incorporate these pedagogical techniques into their own teaching and help their students in the learning process.

Keywords: science education, television, science entertainment, educational programming, popular science, *MythBusters*, active learning, learning styles, demonstrations, intrinsic motivation

1. Introduction

MythBusters, the long-running Discovery Channel science television show, has proven itself to be far more than just a highly rated cable program [1–5]. While its focus is on entertainment, the show employs an array of sophisticated pedagogical techniques to communicate scientific concepts to its audience. These techniques include: achieving active learning, accommodating different learning styles, avoiding jargon, employing repetition to ensure comprehension, anthropomorphizing physical phenomena, using captivating demonstrations, cultivating an

enthusiastic disposition, and increasing intrinsic motivation to learn. In this content analysis, episodes from the show's 10-year history were methodically examined for these techniques. *MythBusters* represents an untapped source of pedagogical techniques science educators may consider availing themselves of in their tireless effort to better reach their students. Physics educators in particular may look to *MythBusters* for inspiration and guidance in how to incorporate these techniques into their own teaching and help their students in the learning process.

The premise of *MythBusters* involves the hosts (Adam Savage, Jamie Hyneman and build team members Tory Belleci, Kari Byron, and Grant Imahara) testing the validity of various urban legends, folk tales, common idioms, historical accounts, and internet viral videos using thinking and processes that are grounded in the scientific method [6]. A myth can be deemed "confirmed," "busted," or "plausible," if possible though highly improbable.

2. Methodology

Complete seasons of *MythBusters* were downloaded from Apple's iTunes Store and the episodes systematically analyzed in chronological order. The most commonly employed pedagogical techniques quickly became evident, and examples illustrating those techniques were sought in the content analysis of the remaining episodes. Narration and dialogue were transcribed and in cases of ambiguity, subtitles were consulted. The examples contained in this treatment should not be taken as exhaustive nor necessarily the most compelling, i.e., cherry-picked. For the sake of brevity, many equally illustrative examples could not be included. Examples were taken from across the show's decade-long span. Episode content varied, with episodes employing a different number of pedagogical techniques and to varying effect. Some techniques, such as achieving active learning, feature prominently in nearly every episode. Other techniques, such as anthropomorphizing scientific phenomena, are employed only when certain topics, e.g., inertia, are discussed. The analysis conducted was qualitative (descriptive) in nature [7–9]. Further work would be needed to treat the show in a quantitative manner (such as determining the frequency of certain techniques per episode and season) and was beyond the intended scope of this text, which was to acquaint educators at all levels with *MythBusters* as a valuable pedagogical resource.

3. Achieving active learning

First, *MythBusters* gets audience members learning in an active manner. Learning styles are broadly classified as either active or passive: "Passive learning takes place when students take on the role of 'receptacles of knowledge' … Active learning is more likely to take place when students are doing something besides listening" [10]. The lecture is the quintessential passive learning technique: "The lecture … is passive learning, with very low student involvement … Students are expected, and even encouraged, to sit quietly, listen, and perhaps take notes" [11]. The lecture is a "one-way mode of communication, giving the student little or no control over the nature, rate, and flow of information" [12]. Indeed, the lecture's "prioritization of facts and memorization over critical analysis, synthesis, and discussion" has been implicated in deterring otherwise bright and competent students from careers in science [13].

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Conventional wisdom holds that a television show is unable to encourage active learning among viewers: "The flood of uncontrollable images onto the TV screen … tends to generate a passivity … that suffocates the questioning and examination necessary for education" [14]. Traditional thought also holds that watching a television show is as passive an experience as attending a lecture: "When used as a platform for delivering content, visual-based instruction has not yet been shown to be significantly better than lecturing – perhaps because simply viewing a 50-minute film … does not actively involve students any more than listening to a 50-minute lecture" [15].

However, *MythBusters* cleverly complements its passive learning narration with several techniques designed to get the audience involved in meaningful ways. Indeed, *MythBusters* is unique among science television shows for the two-way, responsive, give-and-take relationship that exists between the hosts and the viewers.

First, the MythBusters break the fourth wall, speaking directly to the audience. They routinely anticipate questions and objections that those watching at home may have: "I know what you're saying. You're saying, 'Adam, your see-through manhole cover doesn't weigh near as much as a cast-iron manhole cover. How can this be an accurate test?' And you're right, except that we've already thought of it" ["Indy Car Special" – Original Air Date (OAD): 5/22/2013].

The MythBusters routinely solicit suggestions for myths to test from the viewers. Nearly every episode concludes with the hosts inviting fans to visit the Discovery Channel website and contribute their suggestions: "[P]lease keep your good ideas flowing toward us and we'll take the best ones, we'll test them out, and we'll put them on the air" ["Viewer Special 2" – OAD: 2/13/2008]. When introducing the "Gorn Cannon" myth ["Mini Myth Mayhem" – OAD: 12/28/09], Grant notes the overwhelming online response it elicited: "Fans have been requesting it for years and when I announced that we were doing this on the internet, the reaction was massive." The outpouring of ideas and suggestions from fans has been so great in fact, that the MythBusters have produced nearly a dozen episodes devoted exclusively to viewer-suggested myths ["Viewer Special 1" – OAD: 8/15/2007, "Viewer Special 2" – OAD: 2/13/2008, "Viewer's Special Threequel" – OAD: 11/19/2008, "Mini Myth Mayhem" – OAD: 12/28/09, "Mini Myth Madness" – OAD: 11/10/2010, "Wheel of Mythfortune" – OAD: 11/23/2011, "Mailbag Special" – OAD: 5/20/2012, "Mini Myth Medley" – OAD: 11/4/2012]. The response from fans was so astounding in fact, that it prompted Adam to remark, "I am so overwhelmed. We have so many responses to our request for ideas from viewers" [Viewer Special 2: OAD: 2/13/08].

In addition, fans routinely take issue with the results of an experiment or critique the methodology employed in testing a myth. They vociferously voice their objections by inundating the hosts with their observations, complaints, and suggestions, as Adam observes, "Every time we air a new episode of *MythBusters*, hundreds, thousands of fans write to us to comment on that episode … Some of them want to say things we screwed up, others want to suggest other tests we missed, and some of them just want us to go down different tangents of stories we've already done because they have other ideas about things we could explore" ["Myth Evolution" – OAD: 11/18/2009]. In response, the hosts are obliged to re-open or revisit these seemingly closed myths ["Myths Revisited" – OAD: 6/8/2004, "MythBusters Revisited" – OAD: 10/12/2005, "Myths Reopened" – OAD: 4/26/2006, "More Myths Revisited" – OAD: 10/25/2006, "More Myths Reopened" – 3/21/2007, "Myth Revolution: OAD – 9/5/2007, "Myth Evolution" – OAD: 11/18/2009, "Revenge of the Myth" – OAD: 5/6/2012, "Failure Is Not an

Option!" – OAD: 2/13/2016] in an attempt to mollify meticulous fans. For example, in "Salami Rocket" ["More Myths Revisited" – OAD: 10/25/2006], fans objected to an earlier result the MythBusters had obtained, claiming that the thrust evolved by a particular rocket motor was solely from escaping oxidizer gas and not from the actual combustion of fuel (**Table 1** Entry 1). The MythBusters examined this claim but showed that the thrust was indeed from combustion. **Table 1** provides a brief summary of all myths discussed herein for convenient reference.

Moreover, the MythBusters have actually invited fans onto the show to engage in testing myths firsthand. Most notably, in the first revisit of Archimedes' fabled weapon ["Archimedes' Death Ray" – OAD: 1/25/2006], several fans were invited to participate in a series of competitions that pitted their contraptions against one another (**Table 1** Entry 2). In the second revisit of Archimedes' death ray ["President's Challenge" – OAD: 12/8/2010], the Discovery Channel sponsored a Science, Technology, Engineering, and Math (STEM) academy in which 500 local middle and high school students were involved in retesting the myth, helping to aim mirrors and focus the sun's rays on a target (**Table 1** Entry 3). When testing various everyday household items for bacteria, Adam and Jamie employed microbiology students at UC Berkeley to help collect samples ["Hidden Nasties" – OAD: 12/28/2009]. Fans of the show have been recruited as volunteers to help test everything from gender stereotypes ["Battle of the Sexes" – OAD: 4/22/2012, "Battle of the Sexes: Round 2" – OAD: 5/29/2013, "Laws of Attraction" – OAD: 8/7/2014] to the most efficient airplane boarding strategies ["Plane Boarding" – OAD: 8/21/2014] to zombie survival techniques ["Zombie Special" – OAD: 10/17/2013]. Educators seeking to promote active learning in their classrooms should note that, "No teaching approach has greater potential for student involvement and engagement than student-directed investigation" [16].

The hosts routinely encourage fans to visit the *MythBusters* website to view bonus footage or material that did not make it into the episode due to editing or time constraints. As Jamie explains, "*MythBusters* is all about experimentation but that means that there are a lot of things that don't make it on air so if you want to see some of that stuff, log onto Discovery.com/MythBusters" ["Bug Special" – OAD: 12/1/2010]. In addition, immediately after a new episode airs, fans can visit the website to chat in real-time with each other and with the cast members themselves about the very episode they just watched. As Grant entices, "[D]o you want to know why we did what we did and didn't do what we didn't do? Well go to Discovery.com/MythBustersaftershow and watch our aftershow" ["Bubble Trouble" – OAD: 4/27/2011].

Until recently, the Discovery Channel website featured a *MythBusters* forum where fans could create a profile, post comments, and share messages with fellow fans. This message board had well over half a million postings before its format was overhauled. The message board was organized into several categories where fans could discuss recent episodes and post ideas for myths. These postings often involved fans utilizing physics and chemistry – or their understanding (sometimes flawed) of physics and chemistry – in an attempt to justify what they thought would be the result of myths yet to be tested or of extensions of myths that had already been tested. Even if the postings betrayed incomplete or flawed understanding of scientific principles, these "prior concepts" need to be elicited before being supplanted with correct understanding of scientific phenomena [17]. In addition, defending a position or viewpoint

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Myth	Episode Title	OAD	Description	Result
1. Salami Rocket	More Myths Revisited	10/25/2006	A hybrid rocket motor can use salami deli meat as the fuel source	Re-Confirmed
2. Archimedes Death Ray Burn-Off	Mailbag Special	1/25/2006	The famed Greek inventor Archimedes set fire to invading Roman ships using reflected sunlight	Re-Busted
3. Archimedes Solar Ray 3.0	President's Challenge	12/8/2010	The famed Greek inventor Archimedes set fire to invading Roman ships using reflected sunlight	Re-Busted
4. 22,000 Foot Fall	22,000 Foot Fall	12/13/2006	A pilot jumps out of his plane, has his parachute malfunction, but survives by having his fall cushioned by an explosion on the ground	Busted
5. Underwater Blow Dart	Ninjas 2	8/29/2008	A medieval Japanese warrior could launch a blow dart from underwater with the blow gun doubling as a breathing tube	Plausible
6. Does Alcohol Warm You Up	Viewer's Special Threequel	11/19/2008	Hypothermia can be staved off by imbibing alcohol	Busted
7. Toothbrush Surprise	Breakstep Bridge	1/25/2004	Bacteria can be deposited onto a toothbrush if placed in proximity to a toilet	Confirmed
8. Down with the Titanic	Goldfish Memory	1/25/2004	A sinking ship generates a vortex powerful enough to suck people in the surrounding water down with it	Busted
9. Which is Better for You: Breakfast Cereal or the Box?	Steam Cannon	7/19/2006	A cereal box can be as nutritious as the cereal itself	Busted
10. Gas Room Boom	Inverted Underwater Car	11/24/2010	In a room filled with flammable gas, firing a gun through a milk carton will prevent the muzzle flash from igniting the gas	Busted
11. Cell Phone Destroys Gas Station	Cell Phone Destroys Gas Station	10/3/2003	An electrical discharge from a cell phone can ignite gasoline vapor present in the air around a gas pump	Busted
12. Lead Plunge	Mini Myth Mayhem	12/28/2009	A person can briefly dip his hand into molten lead without injury if his hand is wet	Confirmed
13. Motorcycle Flip	Motorcycle Flip	10/29/2008	Thrusting a stick into the spokes of a motorcycle's front wheel will cause it to launch into the air end over end	Busted

Myth	Episode Title	OAD	Description	Result
14. Phonebook Friction	Phonebook Friction	9/10/2008	It is impossible to separate two phonebooks that have their pages interleaved	Partly-Busted
15. Underwater Car Escape	Underwater Car	1/24/2007	If a car becomes submerged in water, the door cannot be opened until the interior is flooded	Confirmed
16. The Squeeze	Dumpster Diving	11/25/2009	If the line to the surface air compressor breaks, a diver in an old-style suit can be crushed into his helmet	Confirmed
17. 7 Paper Fold	Underwater Car	1/24/2007	It is impossible to fold a piece of paper in half more than seven times	Partly-Busted
18. Rat Pee Soda	Hidden Nasties	12/28/2009	Drinking from soda cans contaminated with rat urine can be fatal	Busted
19. Bottle Bash	Bottle Bash	4/14/2010	An empty beer bottle will cause more damage than a full one when used as a weapon	Busted
20. Swinging Pirates	Swinging Pirates	4/15/2012	When trapped in a freely suspended cage, a group of people can swing themselves over to the cliff wall	Busted

Note: Myths appear in the order in which they are discussed.

Table 1. Synopsis of myths discussed herein to be consulted by the reader for clarification.

with logical reasoning fosters an internalization of scientific concepts: "One of the best ways to develop confidence and comprehension of issues is to convince others your ideas warrant consideration" [18]. In this way, involvement well beyond the one hour a week the show is on the air was achieved: "While classroom discussion typically take one or two hours, [electronic] threaded discussions can last an entire semester because the Internet allows the interactions to transcend the time-and-place restrictions of meeting in a classroom" [19].

MythBusters has shown that a science television show can achieve a high degree of active learning among its viewers. It does so by breaking the fourth wall and utilizing the unique communication means provided by the Internet.

4. Accommodating different learning styles

MythBusters also accommodates different learning styles in its attempt to communicate scientific concepts to viewers. *MythBusters* realizes that its viewers have different preferred ways of absorbing information: "[S]ome students prefer to learn through visual means … Other students may have auditory strengths and perform better when something is presented to them orally" [20].

In the "22,000 Foot Fall" myth ["22,000 Foot Fall" – OAD: 12/13/2006], the consideration of different learning styles is well demonstrated. The myth involves a pilot who jumps out of his plane at an altitude of 22,000 feet, has his parachute malfunction, but amazingly survives by having his fall cushioned by a fortuitous explosion on the ground (**Table 1** Entry 4). Testing of the myth hinges upon the pilot's terminal velocity. Following Adam's mention of terminal velocity, the narrator gives a precise definition: "The key to this myth is terminal velocity: the maximum speed at which an object can fall. It's reached when gravity is matched by the force of wind resistance." Synchronized with the narrator's explanation, an animation of a falling person depicts the opposing forces of gravity and wind resistance as vectors. These vectors become equal in magnitude but are directed in opposite directions, resulting in zero net force and hence zero acceleration. For those who are auditory learners, the narrator's description might suffice but for those who are visual learners, the animation solidifies their understanding of terminal velocity: "[D]ifferent people receive and create information using different physical modalities" [21].

In the "Archimedes Death Ray" myth, ["Archimedes' Death Ray"– OAD: 1/25/2006], the MythBusters attempt to determine whether the famed Greek inventor Archimedes could have set fire to invading Roman ships using reflected sunlight. In the myth, a polished parabolic surface concentrates sunlight to such intensity that the ignition temperature of wood is reached. "A parabola is hottest only where all the light meets – the fixed focal point. If the target moves slightly in front or just behind this, the death ray is rendered useless," explains the narrator. Accompanying this verbal description is an animation depicting a thermometer sliding back and forth along the focal axis of the mirror, from in front of the focal point (where the mercury drops) to the focal point (where the mercury rises), to behind the focal point (where the mercury drops again). Synchronizing the animation with explanatory dialogue serves to appeal to both visual and aural learners.

In the "Underwater Blow Dart" myth ["Ninjas 2" – OAD: 8/29/2008], different learning styles are again accommodated. The myth centers on whether medieval Japanese warriors were able to shoot blow darts from underwater (**Table 1** Entry 5). The build team members quickly realize that they will have to account for refraction, the bending of light as it passes between media of different densities. As the narrator explains, "Light travels at different speeds through water and air, getting bent out of shape as it passes from one to the other," an animation provides a visual understanding of refraction by showing how the apparent position of an object changes when viewed from underwater.

In the "Does Alcohol Warm You Up?" myth ["Viewer's Special Threequel" – OAD: 11/19/2008], the MythBusters test whether hypothermia can be staved off by imbibing alcohol (**Table 1** Entry 6). This myth was particularly good at accommodating different learning styles. As Adam intones, "The superficial blood vessels constrict, preventing heat loss through the skin and directing blood to critical internal organs," an animation is shown depicting the response of the vascular system to cold. This animation shows an internal view of the human body. The extremities – legs and arms – are shown blue to indicate lack of blood flow and resulting drop in peripheral body temperature, while the chest cavity is shown bright red to indicate blood surging to the organs and core body temperature being maintained. This animation is synchronized with the dialogue perfectly: "Link visual objects with classroom narrative" [22]. Later, the narrator concludes, "In summary, alcohol dilates your vascular system, which

sends blood to your extremities, where it loses its warmth and as a result your core body temperature quickly cools." This dialogue is synchronized with appropriate footage from the thermal imaging camera.

MythBusters regularly appeals to viewers' dissimilar styles of learning. In doing so, it increases the viewers' understanding of the science involved in a myth: "When we take advantage of these multiple intelligences, we increase the learning potentials of our students, and open up the possibilities and potentials that are in them all" [23].

5. Avoiding jargon

In addition to getting viewers learning in an active manner and accommodating different learning modalities, the MythBusters are also careful to only use words that the audience will understand; that is, they avoid using obfuscating jargon. When they do incorporate unfamiliar technical terms, they define them immediately.

In the "Toothbrush Surprise" myth ["Breakstep Bridge" – OAD: 1/25/2004], the MythBusters test whether bacteria can be deposited on a toothbrush placed in proximity to a toilet (**Table 1** Entry 7). The following excerpt of dialogue demonstrates the way in which a new term is typically introduced:

> *Jamie: "We should do a simple test to see whether the toilet actually produces an aerosol."*
>
> *Adam: "You mean like when it's flushing it actually makes little droplets and vapor that go everywhere."*
>
> *Jamie: "Exactly."*

In the "Down with the Titanic" myth ["Goldfish Memory" – OAD: 1/25/2004], the MythBusters test whether a sinking ship generates a vortex powerful enough to suck people in the surrounding water down with it (**Table 1** Entry 8). Before launching into a full-scale test by scuttling a boat, they carry out a small-scale test using a hydrometer in a swimming pool. For those unfamiliar with the term, the narrator enlightens: "They've made a hydrometer: a simple floatation device that measures the specific gravity, or density, of a liquid."

In the myth "Which is Better for You: Breakfast Cereal or the Box?" ["Steam Cannon" – OAD: 7/19/2006], Adam employs a calorimeter to determine the energy content of cereal and of the box it comes in (**Table 1** Entry 9). He explains the operation of the device to the audience: "I burn it underneath a pot full of water. If I know exactly how much water I have and what temperature it was when I began burning the food, by the time it's all done burning, I measure the temperature and that tells me with an equation, what the caloric content of that food was."

When testing the myth that the muzzle flash from a gun can lead to an explosion in a methane-filled room in "Gas Room Boom" ["Inverted Underwater Car" – OAD: 11/24/2010], the MythBusters first try to find the ideal ratio of air to natural gas (**Table 1** Entry 10). As the narrator explains, "The numerical balance of different substances to cause a reaction is called stoichiometry."

Using unfamiliar terms will make meaningful communication impossible: "[U]se vocabulary that students understand. That is, don't talk over your students' heads" [24]. *MythBusters* excels at communicating at a level its viewers can understand without being patronizing.

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6. Employing repetition to ensure comprehension

MythBusters also employs the pedagogical technique of repetition. After returning from a commercial break, it is common for the narrator or hosts to provide a quick summary of what has transpired and what results have been obtained, as Adam demonstrates, "Welcome back. Let me walk you through our setup" ["Paper Armor" – OAD: 6/29/2011]. In another episode, Tori brings viewers up to speed: "Just to recap, we are testing the myth from the James Bond movie where if a car is upside down and you use the ejector seat, you can flip that car back on its wheels" ["Bubble Pack Plunge" – OAD: 6/3/2012]. This recap is obviously an attempt to hook those just tuning in or flipping through the channels, yet it also serves the desirable end of ingraining certain concepts into the minds of viewers tuned in from the start: "If students are not following, then you need to revisit the content" [25].

MythBusters also intentionally uses repetition to clarify and ensure full understanding of arcane ideas. This is skillfully demonstrated in "Cell Phone Destroys Gas Station" ["Cell Phone Destruction" – OAD: 10/3/2003]. The myth centers upon the idea that an electrical discharge from static buildup can ignite gasoline vapor present in the air around a gas pump (**Table 1** Entry 11). To create this electric spark, Adam constructs a Leyden jar. He describes his creation for the audience: "This is called a Leyden jar and it's actually just Tupperware with foil on the inside and foil on the outside and it's an early capacitor, which is basically an energy storage device." Following Adam's introduction, the narrator elaborates: "Around 1750, in the Dutch city of Leyden, scientists discovered that two conductors, separated by an insulator, could store an electrical charge." The narrator provides a more technical description of the device as well as a historical context. The same message is conveyed but in slightly different ways.

This repetition is again demonstrated in the "Lead Plunge" myth ["Mini Myth Mayhem" – OAD: 12/28/09] (**Table 1** Entry 12). After heating a steel ball until it is red hot, Jamie plunges it into a tank of water and explains: "What you're seeing in this demonstration is known as the Leidenfrost Effect. It's interesting because the steam that's created when you expose a hot surface to water is actually insulating that surface and it makes sense because steam – being a gas – conducts heat less rapidly than the water itself does." Immediately after Jamie's description, the narrator gives a more detailed technical description of the phenomenon: "When cool water is exposed to an extremely hot surface, a layer of water vapor – which is a relatively poor heat conductor – provides a thin protective barrier." This repetition promotes viewer comprehension.

7. Anthropomorphizing physical phenomena

The MythBusters routinely utilize the instructional technique of anthropomorphizing physical phenomena. This technique is routinely employed in chemistry: atoms are spoken of as *wanting* a full octet of electrons. Alkali metals are spoken of as *wanting* to give up an electron while halogens *want* to gain an electron. Indeed, it is not at all uncommon in a chemistry lecture or recitation to hear subatomic particles, atoms, and molecules referred to as "guys" when their behavior is being described. When these phenomena are spoken of in terms of "wanting," it gives the impression that the phenomena are somehow internally directed or acting in a deliberate, thoughtful manner. While this is, of course, untrue, the anthropomorphized

wording facilitates understanding: it is easier to accept electron transfer as occurring as a result of desire for stability rather than as just the result of the immutable laws of nature.

In physics, this anthropomorphized terminology is commonly used when the topic of inertia is encountered. In the "Motorcycle Flip" myth ["Motorcycle Flip" – OAD: 10/29/2008], the MythBusters test the physics of a stunt from the movie *Indiana Jones and the Last Crusade* in which Indiana Jones thrusts a flagpole into the spokes of a pursuing motorcycle, causing the motorcycle to launch upward into the air and flip end over end (**Table 1** Entry 13). The validity (or lack of as it turns out) of the myth rests with inertia, an object's resistance to changes in its motion. When testing reveals that thrusting a pole into the spokes of a rotating wheel results in the motorcycle continuing forward rather than hurtling skyward, Jamie offers an anthropomorphized explanation: "There are hundreds of pounds in this bike plus the rider that *want to keep on going*" (emphasis mine). Inertia was anthropomorphized again in the "Chain Reaction" myth in which an internet viral video shows a chrome ball chain seemingly violating the laws of physics, leaping up and over the lip of a container in a gravity-defying arc after being given a starting tug ["Do Try This at Home" – OAD: 2/1/2014]. Using an anthropomorphized description, Jamie explains that this curious effect has a natural explanation: "It's clear from our testing that there are two key forces that are causing this effect. And the first is that mass moving in a particular direction *wants to continue moving in that direction*, so when we're yanking on the chain up out of the pot, it *wants to continue moving upward*, but shortly after, gravity starts to pull it down, and so that's where we get this arc" (emphasis mine). Using terms normally reserved to describe human thoughts and actions is a useful strategy to help convey difficult concepts.

8. Using captivating demonstrations

Good educators know not to underestimate the lasting impression of a spectacular demonstration [26]. The MythBusters utilize visually compelling demonstrations to communicate scientific concepts. In the "Phonebook Friction" myth ["Phonebook Friction" – OAD: 9/10/2008], the MythBusters test whether it is impossible to pull apart two phonebooks that have their pages interlaced (**Table 1** Entry 14). They attempt to separate two interleaved phonebooks first using teams of shop assistants in a tug of war competition, before moving onto using two sedans pulling in opposite directions, and finally onto using two tanks pulling in opposite directions. Of course, they could have just employed some drab industrial machine bolted to the floor, but this would not have been nearly as dramatic.

This demonstration bears a striking similarity to one particularly compelling demonstration of atmospheric pressure from the annals of history: "[I]n 1650, the German physicist Otto von Guericke invented a mechanical device that little by little sucked air out of a container. This enabled him to form a vacuum at will and to demonstrate the effects of an unbalanced air pressure. Such air pressure would hold two metal hemispheres together against the determined efforts of two eight-horse teams of horses (whipped into straining in opposite directions) to pull them apart. When the air was allowed to enter the hemispheres once more, they fell apart of their own weight" [27].

Several of the most arresting demonstrations from the show have also involved the awesome power of differential pressure. In the "Underwater Car Escape" ["Underwater Car" – OAD:

1/24/2007], Adam simulates the pressure differential that exists when a car is submerged under just two feet of water by stacking weights atop a car door window (**Table 1** Entry 15). Standing before a car door with a massive 350 pound stack of weights atop the window, Adam speaks directly to the camera: "I do not know of a more visual way to make clear how much pressure you're dealing with when you put things underwater."

In "The Squeeze" ["Dumpster Diving" – OAD: 11/25/2009], the MythBusters test a diving myth that holds that if the air line connecting an older style dive suit to the surface air compressor were severed, the diver would to be squeezed into the helmet owing to the extreme pressure differential (**Table 1** Entry 16). In one of the most vivid demonstrations from the show's ten year history, the MythBusters place an analog for a human body – "meat man" – in a dive suit and submerge it 300 feet before cutting the line to the surface. Instantly, "meat man" is crushed into his dive helmet, gruesomely demonstrating the power of differential pressure.

In the myth of the "7 Paper Fold" ["Underwater Car" – OAD: 1/24/2007], the MythBusters give a compelling demonstration of exponential growth. In testing the myth that it is impossible to fold a piece of paper in half more than 7 times, they join together several rolls of paper inside a hanger at NASA Ames Research Center, creating a sheet so enormous that it takes the combined effort of 10 people and a steamroller to help fold it (**Table 1** Entry 17). With each fold, the number of layers doubles, and the stack becomes twice as thick.

The experimental setups from the show are quite singular and create indelible memories for viewers. When testing whether it's possible for aluminum soda cans to become contaminated with rat urine and infect unsuspecting consumers with various pathogens ["Hidden Nasties" – OAD: 12/28/2009], the MythBusters devise a very memorable setup (**Table 1** Entry 18). As Jamie quips, "This is one of those sounds that you'll only hear on *MythBusters*: the sound of forty rats on a thousand cans."

Sometimes an experiment that returns qualitative results is far more memorable than one that returns quantitative values. When measuring the bodily harm that results from smashing a bottle over a person's head in the "Bottle Bash" myth ["Bottle Bash" – OAD: 4/14/2010], Adam and Jamie opt for a rig consisting of a gelatin brain mold (with red dye added for realism) placed within a transparent jar (**Table 1** Entry 19). They could have instead gone with an accelerometer, but the demonstration was made much more compelling and visceral through being able to see the concussion-generating lateral movement of a gelatin brain as it sloshed from side-to-side.

Not only do exciting demonstrations help motivate students, but they promote long-term retention of the underlying concepts: "Students can remember many of their science class demonstrations for countless years … This is a good testimony to the emotional impact of demonstrations" [28].

9. Cultivating an enthusiastic disposition

The hosts of *MythBusters* also have enthusiastic dispositions, essential for effective teaching: "The teacher's enthusiasm for teaching, learning, and for the subject matter has been shown to be an important part of effective teaching" [29]. The cast members routinely crack

jokes, engage in good-natured ribbing, and maintain a feeling of levity throughout the show despite strict deadlines and demanding builds. Adam Savage is portrayed as the perennial jokester and humorist, the polar opposite of the reserved and aloof Jamie Hyneman. But even Jamie is occasionally reduced to uncontrollable bouts of giggling at the sight of a particularly astonishing outcome. The friendly and enthusiastic personalities of the hosts are no small part of the reason why the show has proven so popular: "If teachers have warmth … enthusiasm, and humor, they are much more likely to be successful than if they lack these characteristics" [30]. Moreover, incorporating aspects of humor can improve learning, with studies finding an increase in retention of course content when exposed to relevant humor as compared to those who received the same course content without humor.

At the conclusion of a myth, cast members are often filmed walking into the sunset excitedly discussing possible extensions to the myth they just tested. In this way, viewers take away the impression that the cast members have a genuine passion for what they are doing, treating it as much more than just a job.

The cast members also maintain their enthusiastic dispositions in the face of adversity or unexpected results. Indeed, one of the defining hallmarks of the show is how it conveys the notion that it is alright to be wrong and that unexpected results need not be feared or dreaded. A running line on the show is that, "Failure is always an option." Such an accepting attitude helps students regard unexpected or counterintuitive results as having the potential to usher in scientific discoveries and breakthroughs. When testing a scene from *Pirates of the Caribbean 2* ["Swinging Pirates" – OAD: 4/15/2012] and finding it possible to ascend a cliff face while confined inside a cage (**Table 1** Entry 20), Adam irrepressibly remarks, "How about that? We were totally able to climb. I love being wrong!" In a similarly exuberant manner, Tory exclaims in another episode, "I love those moments on *MythBusters* when you think one thing is going to happen and then the exact opposite happens" ["Mailbag Special" – OAD: 5/20/2012].

10. Increasing intrinsic motivation to learn

In addition to the multitude of ways they have of conveying science to the audience, perhaps no pedagogical technique is more valuable than the way in which the MythBusters increase viewers' intrinsic motivation to learn. Motivation is classified as either intrinsic or extrinsic. Whereas extrinsic motivation relies on external inducements such as grades, rewards, and penalties, "Intrinsic motivation refers to motivation to engage in an activity because of the satisfaction derived from the activity itself. Students who are intrinsically motivated … genuinely want to understand the content" [31]. Of the two, intrinsic motivation is much more esteemed among educators: "Intrinsic motivation … leads to a deep approach and conceptual understanding and produces learning outcomes that are flexible and transferable" [32].

The MythBusters test myths from sources that are likely to excite the viewers, especially younger viewers. Over the years, the MythBusters have tested myths from a dizzying number of Hollywood movies including: *Austin Powers*, *Body of Lies*, *The Bourne Supremacy*, *Caddy Shack*, *Cliffhanger*, *The Green Hornet*, *The Grey*, *Hellboy*, *Indiana Jones*, *Jaws*, *Lethal Weapon 2*, *The Matrix*, *The Mummy*, *Pirates of the Caribbean*, *Point Blank*, *Robin Hood*, *Speed*, *Shrek*, *Star Wars*, *Titanic*, *Wanted*, *The*

Wizard of Oz, innumerable James Bond movies, among many others. In addition, the MythBusters have tested myths from popular television series, including gadgets and stunts from *MacGyver* and *Knight Rider*, chemistry exploits from *Breaking Bad,* and even zombie survival techniques from *The Walking Dead*. Given that many of the myths involve high speed collisions, explosions, and gooey liquids ("Swimming in Syrup" – OAD: 5/6/2009, "Walking on Water" – OAD: 4/25/2007), it is little wonder why the show has such a dedicated following among young people: "The intensity of the want to learn depends [on] students' interest in the particular topic being learned" [33]. Or more tersely: "Students learn what they care about" [34].

Taking myths from pop culture provides the much needed hook to draw viewers in long enough that they learn the underlying science [35–39]. Viewers are more likely to be interested in the science if it relates to some stunt or gadget from their favorite movie or television show than if introduced without any context: "The use of film clips to explore science is one of the more effective pedagogical tools to build interest in science, awareness of real science, and students' understanding of scientific principles through the identification of illustrations and violations of scientific principles depicted in film clips" [40].

In recent years, there has been a profusion of books examining popular movies and television shows for their scientific content: Lawrence Krauss' *The Physics of Star Trek* (1995), Anne Simon's *The Real Science Behind the X-Files* (1999), Jeanne Cavelos's *The Science of Star Wars* (2000), Philip Plait's *Bad Astronomy: Misconceptions and Misuses Revealed* (2002), William Shatner's *I'm Working on That: A Trek From Science Fiction to Science Fact* (2002), James Kakalios's *The Physics of Superheroes* (2006), Tom Rogers' *Insultingly Stupid Movie Physics* (2007), and Adam Weiner's *Don't Try This At Home!: The Physics of Hollywood Movies* (2007). These books help inspire fans to learn the fundamentals of biology, chemistry, and physics so that they can better understand their favorite movies and shows: "Science and physics education have long recognized science fiction films' intrinsic value for teaching basic principles … films can create lasting mental images that are correlated to the underlying scientific theory. This can help students better understand many of the abstract concepts that are covered in the sciences."

Motivating students is not an optional luxury to be indulged if time permits [41]. By relating to what students find personally meaningful, instructors are more likely to gain and hold their attention [42]. *MythBusters* is so successful at communicating scientific concepts due largely to the source of the myths it tests and the ability to spark the curiosity of its viewers [43].

11. Summary

MythBusters has proven itself to be far more than a source of weekly entertainment. Its lasting success is in no small part due to the use of an array of pedagogical techniques to adeptly communicate scientific concepts to its viewers. These strategies include achieving active learning and accommodating different learning styles. In addition, the MythBusters avoid using jargon, employ repetition to ensure comprehension, anthropomorphize physical phenomena, incorporate provocative demonstrations, and cultivate enthusiastic dispositions. Lastly, the MythBusters increase intrinsic motivation to learn by choosing topics that appeal to their viewers. Educators are encouraged to familiarize themselves with the show, starting

with the episodes mentioned herein. These episodes can be purchased on DVD from the Discovery Channel website. They can also be downloaded individually or by season from Apple's iTunes Store for immediate streaming. Science educators in particular may look to *MythBusters* for inspiration and guidance in how to incorporate these pedagogical techniques into their own teaching and further their classroom goals [44].

12. Postscript

After a run of 14 seasons and 282 episodes, the *MythBusters* finale aired in spring 2016; however, reruns continue to air on Discovery's sister network The Science Channel. In addition, The Science Channel has announced it is relaunching the show with new hosts to be determined through its new reality show *Search for the Next MythBusters*. Also, build team members Tory, Kari, and Grant will be investigating unusual events from pop culture, science, and history in the Netflix original *White Rabbit Project*. Lastly, a hands-on exhibition with artifacts from the show, interactive exhibits, and live demos called "MythBusters: The Explosive Exhibition" was installed at the Mall of America in Minneapolis, MN in 2016 and at the Liberty Science Center in Jersey City, NJ in 2017. With reruns, a reboot, a spin-off, and a touring exhibition, the final pedagogical legacy of *MythBusters* is not yet written.

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Chapter 11

How the Science Entertainment Television Show *MythBusters* Teaches the Scientific Method

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Additional information is available at the end of the chapter

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Abstract

All too often, high school—and even university—students graduate with only a partial or oversimplified understanding of what the scientific method is and how to employ it. The long-running Discovery Channel television show *MythBusters* has attracted the attention of political leaders and prominent universities for having the potential to address this problem and help young people learn to think critically. *MythBusters* communicates many aspects of the scientific method not usually covered in the classroom: the use of experimental controls, the use of logical reasoning, the importance of objectivity, the operational definitions, the small-scale testing, the interpretation of results, and the importance of repeatability of results. In this content analysis, episodes from the show's 10-year history were methodically examined for aspects of the scientific method.

Keywords: science education, television, science entertainment, popular science, *MythBusters* scientific method, repeatability, objectivity, experimental design

1. Introduction

The importance of understanding and internalizing the scientific method can hardly be exaggerated: "The future of man depends upon his skill in solving problems … Recent successes in problem solving have brought about enormous changes in agriculture, industry, transport, medicine, and communications, which have considerably changed the pattern of human life and death" [1]. Unfortunately, it is all too common for high school—and even university—students to graduate with only a partial or oversimplified understanding of what the scientific method is and how to employ it.

Help in remedying this situation may come from an unlikely source: television. While most educational pundits bemoan the hours children spend transfixed by television, a few select

programs are teaching the scientific method and how it is applied. One television show that is conspicuously good at teaching the scientific method in an easy-to-understand, pedantic-free, entertaining manner is the Discovery Channel's *MythBusters*, which began airing in 2003. Indeed, *MythBusters* has attracted the attention of political leaders and prominent universities for having the potential to help young people learn to think critically.

For those unfamiliar with the show, its premise involves the hosts (Adam Savage, Jamie Hyneman, and build team members Tory Belleci, Kari Byron, and Grant Imahara) testing the validity of various urban legends, folk tales, common idioms, historical accounts, and internet viral videos using the scientific method: "Mr. Hyneman and Mr. Savage employ thinking and processes that are grounded in scientific method … They come up with a hypothesis and test it methodically" [2]. A myth can be deemed "confirmed," "busted," or "plausible," if possible though highly improbable.

While the focus of the show is on entertainment, the hosts rigorously adhere to the scientific method: "The show's genius is that beneath the kinetics and risky stunts – spectacular car crashes, explosions and other dangerous merriment – is a cleverly veiled science show that instructs as it entertains, which any teacher will tell you, is a real feat" [3].

MythBusters provides such a wealth of insight into the process of scientific discovery, in fact, that recently Stanford University created an entire course based on the show [4]. In the freshman course, "The Science of *MythBusters*," students learn the scientific method and how to think critically using excerpts from the show [5].

Indeed, *MythBusters* is so effective at communicating the scientific method that President Barack Obama has appeared on the show commending the hosts and stressing the importance of the show's contributions to the society: "[N]othing is more important to our country's future than getting young people engaged in math and science. A lot of the challenges that we face as a country are going to depend on how engaged young people are in science and so I'm just thrilled that you guys do such a great job making it fun ["President's Challenge" [Original Air Date (OAD): 12/8/2010].

The scientific method is far richer and more nuanced than the abridged "five-step" system commonly disseminated in classrooms (define the problem, make observations, formulate a hypothesis, test the hypothesis by experiment, and draw a conclusion—confirm, abandon, or modify the initial hypothesis) [6]. The scientific method is "the method by which … knowledge is … won … an intellectual tool … a probe for exploring the unknown" [1]. *MythBusters* teaches many aspects of the scientific method not usually covered in the classroom: the use of experimental controls, the use of logical reasoning, the importance of objectivity, the operational definitions, the small-scale testing, the interpretation of results, and the importance of the repeatability of results.

2. Methodology

Complete seasons of *MythBusters* were downloaded from Apple's iTunes Store, and the episodes were systematically analyzed in chronological order for aspects of the scientific method. The most common aspects quickly became evident, and examples illustrating those were sought in the content analysis of the remaining episodes. Narration and dialog were transcribed, and in

cases of ambiguity, subtitles were consulted. The examples contained in this treatment should not be taken as exhaustive nor necessarily the most compelling, i.e., cherry-picked. For the sake of brevity, many equally illustrative examples could not be included. The analysis conducted was qualitative (descriptive) in nature [7–9]. Further work would be needed to treat the show in a quantitative manner (such as determining the frequency of certain aspects of the scientific method per episode and season) and was beyond the intended scope of this text.

Additionally, we designed and implemented a classroom activity to introduce the scientific method with a particular emphasis on experimental controls that utilized myths from the show. We did this with two sections (10 and 12 students) of the twelfth grade Regents Physics (designed to prepare students for statewide standardized examinations) at Onondaga High School near Syracuse, New York. The time commitment was approximately 90 min (1.5 days on an A/B schedule of alternating short and long classes). Complete activity details and materials are available online [10]. Because the format of each episode is to feature several different myths and to jump back and forth between them, we found that it is highly useful to make a note beforehand of the times of the specific segments we wanted to show, allowing us to present a myth in an uninterrupted manner, improving coherence and saving time.

3. Proposing a hypothesis

Before conducting an experiment, the *MythBusters* offer their opinion on what they think will happen; that is, they formulate a hypothesis: "Hypotheses can be considered as possible answers to problems … hypotheses do not as yet constitute real knowledge … [they] are … 'candidates for truth'" [11].

In the "Anti-gravity" myth ["X-mas Lights and Anti-Gravity Device"—OAD: 12/19/2007], Tory, Kari, and Grant test internet-bought gadgets that purportedly employ antigravity in their operation (**Table 1** Entry 1). **Table 1** provides a brief summary of all myths discussed

Myth	Episode Title	OAD	Description	Result
1. Anti-Gravity	X-mass Lights and Anti-Gravity Device	12/19/2007	Various internet-bought gadgets employ anti-gravity in their operation	Busted (for now)
2 Depth Charge Disaster	Paper Armor	6/29/2011	A person can increase the chances of surviving an underwater explosion by floating on his back at the surface rather than diving or treading water	Confirmed
3. Brain Drain	Tablecloth Chaos	10/27/2010	People only use 10% of their total brain capacity	Busted
4. Diet Coke and Mentos	Diet Coke and Mentos	8/9/2006	Why does dropping a Mentos point into a bottle of Diet Coke create a geever effect	N/A
5. Cockroach Survival	Airplane on a Conveyor Belt	1/31/2008	Cockroaches on the only organisms able to survive the radiation exposure from the fallout of a nuclear war	Busted

Myth	Episode Title	OAD	Description	Result
6. Red Flag to a Bull	Red Flag to a Bull	8/22/2007	The color red provokes bulls to change	Busted
7. Eye Patch	Pirate Special	1/17/2007	Pirates wore eye patches to preserve night vision	Plausible
8. Talking to Plants	Exploding House	11/14/2004	Talking to Plants or playing music can help them grew	Plausible
9. Animal Magnetism	Shark Week Special	7/27/2008	Magnets can repel sharks	Busted
10. Play Dead	Shark Week Special	7/27/2008	In shark-infested waters, it is better to 'play dead' than to thrash about	Confirmed
11. No pain, No Gain	No pain, No Gain	4/28/2010	A person's threshold to pain can be increased by cursing	Confirmed
12. Request Fest	Mini Myth Madness	11/10/2010	Underinflated tires can significantly reduce fuel economy	Confirmed
13, Eye Block	Viewer Special2	2/13/2008	Base players wear black makeup under their eyes to reduce glare from the sun	Plausible
14. Vodka Myths: Top Shelf Filtration	Bullets Fired Up	4/19/2006	One can turn cheap low-quality vodka into high-quality vodka by filtering it repeatedly through a chargoal filter	Busted
15. Battle of the Sexes	Battle of the Sexes	4/22/2012	Tested whether men or women are better at various tasks including reading facial expressions driving and cooling	Mixed
16. The Smell of Fear	Fright Night	10/28/2012	Humens give off a detectable scent when scared	Plausible
17. What is Bullet Proof?	Coffin Punch	11/5/2008	A sufficiently cloese person will have his internal organs protected from a bullet by the overlying layer of fat	Busted
18. Beer Goggles	Alcohol Myths	10/22/2008	Consumption of alcohol can make one perceive others as more physically attractive than while sober	Plausible
19. Taking Candy From a Baby	Mini Myth Madness	11/10/2010	It is easy to take condy from a baby	Busted
20. Square Wheels	Square Wheels	4/8/2012	Square wheels can provide a smooth ride if the vehicle is driven fast enough	Plausible
21. Driving Dangerously	Driving in Heels	4/29/2012	Certain types of shoe can seriously compromise a person's ability to drive car	Busted
22. Tryptophan Turkey	Surreal Gourmet Hour Food Fables	11/18/2012	Eating turkey makes people drowsy due to its tryptophan content	Busted
23. Water Heater Rocket	Exploding Water Heater	11/7/2007	A malfunctioning pressure release can cause a water heater to explode through the multiple floors of a house like missile	Confirmed

Myth	Episode Title	OAD	Description	Result
24. Bourne Magazine	Bule Ice	4/13/2011	A room filted with flammable gas can be made to explode by ignitting a magazine with a toaster	Busted
25. What is Bomp Proof?	Running on Water	4/20/2011	Various objects including tables, dumpsters, cars, and cinderblock walls will prodect a person from an explosion	Plausible
26. Let There be Light	Let There be Light	6/22/2011	A system of mirros can redirect sunlight to illuminate a tomb suffieciently to navigate safely through	Plausible
27. Down with the Titanic	Goldfish Memory	1/25/2004	A sinking ship generates a vortex powerful enough to suck people in the sorrounding water down with it	Busted
28. Bubble Trouble	Bubble Trouble	4/27/2011	It is impossible to swim in bubbly water	Plausible
29. Wrecking ball Baloney	Newton's Crane Cradle	10/27/2010	It is possible to construct a working Newton's cradle using wrecking balls	Busted
30. Tablecloth Chaos	Tablecloth Chaos	10/27/2010	It's possible to use a motorcycle to pull a tablecloth free of a banquet table without distubing a single place setting	Busted
31. Surfing with Dynamite	Lead Balban	1/23/2008	A person can surf on a wave generated by dropping a few pound of explosives in a body of water	Busted
32. Drain Disaster	Drain Disaster	11/2/2011	A methene explosion in a sewer can launch a manhole cover into the air	Confirmed
33. Vatkyrie Boom	Vatkyrie Boom	12/22/2010	An attempted assassination of Hitler failed because the explosion occurred in an aboveground room with windows and not in an enclosed bunker	Busted
34. Trench Torpedo	Trench Torpedo	10/14/2012	WWI trenches were built with right angle corners to limit the prooagation of shock waves	Plausible
35. The Haunted	Fright Night	10/28/2012	A 19 Hz inaudible tone may be responsible for peoples' perceptions of certain buildings as being haunted	Busted
36. Primary Perception	Deadly Straw	9/6/2006	Plants are conscious and capable of exhibiting emotions, such as fear and anger, detectable by polygraph	Busted

Note: Myths appear in the order in which they are discussed.

Table 1. Synopsis of myths discussed herein to be consulted by the reader for clarification.

herein for convenient reference. Grant explicitly states his hypothesis for the audience: "My suspicion about what's going on here is that the large DC voltage is ionizing the air around the lifter and it's creating a flow of ions, which is bringing air along with it, creating thrust. Now, what we can do to prove this, or disprove it, is to remove all of the air. If that's the case, then there should be no thrust." Inherent in all good hypotheses is testability. A hypothesis must be capable of being either supported or refuted, as Jamie explains, "That's science: you come up with a theory, you test it, either it works or it doesn't" ["Walk a Straight Line"—OAD: 10/12/2011].

No matter how eloquently formulated, a hypothesis must be empirically tested before gaining credibility. As the narrator notes, "[T]his is *MythBusters* and it's not a fact until you test it" ["Blue Ice"—OAD: 4/13/2011]. In the "Depth Charge Disaster" myth ["Paper Armor"—OAD: 6/29/2011], the *MythBusters* test whether it is safer to lie supine on the surface rather than diving or treading water in the event of an underwater explosion (**Table 1** Entry 2). Before getting underway, both Adam and Jamie voice their skepticism about the myth, but as the narrator cautions the audience, "So both *MythBusters* are skeptical, but science is an evidence-based discipline."

In addition, no matter how well accepted or long standing, a hypothesis is still subject to reevaluation and scrutiny, as demonstrated in this exchange among the build team members in the "Brain Drain" myth (**Table 1** Entry 3) ["Table Cloth Chaos"—OAD: 10/27/2010]:

> *Kari: "We are testing a myth that is so prevalent that it's just taken for granted that it's fact: humans only use 10% of their brain."*
>
> *Tory: "You hear that everywhere. It's like ingrained in our society."*
>
> *Grant: "Definitely. But that doesn't necessarily make it true."*

Occasionally, competing hypotheses to explain a phenomenon exist: "Rival hypotheses constitute alternative, incompatible or disjunct answers to some problem" [11]. This is vividly demonstrated in the "Diet Coke and Mentos" myth ["Diet Coke and Mentos"—OAD: 8/9/2006] when Adam and Jamie test different hypotheses for the vigorous reaction that ensues when Mentos mints are added to a bottle of Diet Coke (**Table 1** Entry 4). Various tendered explanations implicated the ingredients of the soda and the pitted surface of the mints. If dissolved CO_2 were the only factor, then a mint added to soda water should bring about the same reaction as a mint added to Diet Coke: "If CO_2 is the only factor, these two things should spurt the same height," explains Adam. When the reaction with the soda water proves anemic by comparison, the *MythBusters* conclude that some other component of the Diet Coke is responsible for the energetic nature of the reaction. They go on to test each possible culprit—aspartame, citric acid, phosphoric acid, caffeine, and potassium benzoate—by mixing with soda water and noting the intensity of the reaction with a Mentos mint. On the contribution of the mint to the violent reaction, Adam states "The most common theory about what's going on in this reaction between the candy and the soda is what's called nucleation. Basically, the idea is that the surface of the candy is covered with microscopic pits and more surface area than you can actually see and each little pit, each little corner, provides what's called a nucleation site or a place where a carbon dioxide bubble can form and escape." To test this hypothesis, the *MythBusters* compare the reaction intensity of Diet Coke with two

kinds of Mentos mints—one pitted and one covered in glaze—both made by the same company: "These two candies are made by the same manufacturer … using the same process but the colored version of this actually has a glazing over it – it's a wax coating or a sealer – that inhibits the nucleation process that the other one achieves quite readily," explains Jamie. If nucleation sites are what permit the CO_2 to rapidly bubble out of solution, then the reaction of the Diet Coke with the smooth mints should be much less vigorous than with the pitted mints. The *MythBusters* enumerate various competing hypotheses to account for an observed phenomenon and design experiments to systematically test each one.

4. Designing and carrying out an experiment

The *MythBusters* are thorough in their design of experiments, carefully noting to use controls and employing single-blind and double-blind techniques to avoid introducing bias and tainting the obtained results.

The use of controls in experiments is of paramount importance: anticipating and accounting for confounding variables are essential in the design of a good experiment. In "Cockroach Survival" ["Airplane on a Conveyor Belt"—OAD: 1/31/2008], Tory, Kari, and Grant test the commonly held belief that the only life forms to survive the radioactive fallout from a nuclear war would be cockroaches (**Table 1** Entry 5). They expose cockroaches and other insects to varying levels of radiation (1 kilorad, 10 kilorad, and 100 kilorad) and maintain a fourth set as a control with no exposure to radiation. This establishes a baseline for comparison. While none of the insects in the control receive any radiation exposure, they could die from other factors: "Scientific studies must adequately control for alternative explanations of observed data" [12].

In "Red Flag to a Bull" ["Red Flag to a Bull"—OAD: 8/22/2007], the build team tests the idea that bulls are angered by the sight of a red flag (**Table 1** Entry 6). In the design of the experiment, the build team tests not just the effect of different colors (red, blue, white flags) but the presence of motion and the presence of a person. They come up with an experimental checklist to determine whether it is color or some other variable that provokes a bull to charge:

1. Single static flag—red, white, and blue
2. Comparative static flag—all three flags
3. Moving flag compared to color
4. Human form with moving flags

In part 1, only one flag is present in the arena at any one time as it might not be color that angers a bull but the fact that it is the only salient object in an otherwise featureless pen. The result is that the bull charges all three flags. In part 2, all three flags—red, white, and blue—are hung in the arena to see if the bull prefers a certain color but charges all three. In part 3, the experiment tests the idea that it is a moving flag and not a red flag that infuriates a bull. This part of the experiment consists of a red stationary flag and a blue flag on a pulley being pulled

back and forth with the result that the bull only charges the moving blue flag, not the stationary red flag. Therefore, it is movement that triggers an aggressive charge response and not the color red. In part 4, foam dummies in human form with waving and flapping flags—red, white, and blue—add a human element to the experiment. The last flag left standing is the red one with the blue and white flags taken down first. In this way, the *MythBusters* account for factors other than color: "Any extraneous variable that could provide an alternative explanation for the observed statistical relationships should be accounted for to show that none of these alternative explanations are the real explanation for the findings" [12].

The use of controls also factors prominently in the "Eye Patch" myth (**Table 1** Entry 7) ["Pirate Special"—OAD: 1/17/2007]. The build team tests the myth that pirates did not wear eye patches to cover an eye gouged out in battle but rather to keep one eye constantly night vision ready. In this way, one eye would always be dark-adapted so that if the pirate had to go below deck or enter a battle at night, he could see without difficulty. The build team designs an obstacle course to test the myth. As the designers, they are not permitted to navigate the course themselves: "If we're building this obstacle course, we're not going to be able to test it," notes Tory. Instead, they have Adam and Jamie each navigate the obstacle course, first using the eye that was exposed to bright light (with the dark-adapted eye kept under the patch) and then using the dark-adapted eye. To prevent Adam and Jamie from clocking a faster time owing to familiarity with the course, the obstacle course is rearranged before the second run. As an additional control, Adam and Jamie are made to run the course a third time to prove that the faster times are due to enhanced night vision provided by the dark-adapted eye and not due to familiarity with the course by leaving the course unaltered from the second trial and having them run it without dark-adapted vision. As Kari explains, "We've left the course exactly the same as when they went through it with the adjusted night vision eye. This way we can totally, empirically prove that if they can get through this course and it takes them twice the time or any more time than it took them with their adjusted eye, we've … proved this myth … And as one last variable of final control, we sent them through that obstacle course one last time with their daylight vision, taking out the them knowing the course, and they still messed it up just as bad as the first time they went through."

While some of the myths tested on the show strain plausibility, a robust scientific methodology is still employed. This dichotomy between silly myth and sound science is no more evident than in the "Talking to Plants" myth (**Table 1** Entry 8) ["Exploding House"—OAD: 11/16/2004]. To test whether sound can influence the growth of plants, the build team set up several green houses with pea plants inside. Some houses are exposed to recorded dialog, some to music, while silence is maintained in others as a control. As the narrator explains, the only variable is to be the sound: "As far as possible, conditions will be identical for all the plants except, of course, the sound." When a timer that controls watering fails, all plants experience a lack of water and wither. However, as the narrator explains, "The only upside: every green house was affected in exactly the same way. So, although the plants aren't a picture of health, the experiment is still valid."

The *MythBusters* also incorporate the use of controls in their experiments for testing of "Animal Magnetism" (**Table 1** Entry 9) ["Shark Week Special"—OAD: 7/27/2008]. The essence of this myth is that sharks are repelled by magnetic fields, which interfere with their sensory apparatus. An initial test employs a control: "I'm putting a plastic card over the shark's eye so that we can be sure that he's reacting to the magnetism itself and not to

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the sight of the magnet being brought close to him," explains Adam. In a second test, the *MythBusters* place a line of magnets across a tank to see if a shark will cross the magnetic boundary. As a control, they put down a line of similar looking lead weights to make sure the shark is not responding to the visual cue. As Adam explains, "You're going to say, 'But the shark is just disturbed by seeing a big line of stuff in their tank.' Well, we've already thought of that, that's why we're going to start with a control. We're going to lay a line of these innocuous lead weights across the tank and hopefully we'll see the shark not care about these at all from a visual standpoint … For the control, we expect to see the shark swim up and down this track with no inhibitions. Then, we're going to place a line of magnets somewhere along that track and see if the shark either resists crossing that line of magnets or doesn't care that they're there at all." The *MythBusters* anticipate and account for possible alternative explanations of an observed phenomenon, just as students should be encouraged to use their imaginations to think of possible alternative explanations for the observed relationships between variables [12].

In the "Play Dead" myth ["Shark Week Special"—OAD: 7/27/2008], the build team tests whether sharks are attracted to erratic, jerky movements (**Table 1** Entry 10). In the experiment, Tory thrashes about in shark-infested waters, while Grant floats calmly nearby in the same waters. As a control, they reverse roles: Grant then thrashes about, while Tory plays dead. This is done to ensure that the sharks are attracted to movement and not something unique to the individual, as Kari explains, "They might have just been attracted to Tory; he might have been a bigger target."

In testing whether swearing helps increase one's threshold to pain ["No Pain, No Gain"—OAD: 4/28/2010], the *MythBusters* recognize that they must isolate the act of swearing from the act of speaking (**Table 1** Entry 11). To do so, Jamie and Adam have participants vocalize similar sounding non-swear words as a control while having their hands submerged in ice water.

When testing whether underinflated tires reduce fuel economy ["Mini Myth Madness"—OAD: 11/10/2010], the *MythBusters* stress the importance of accounting for other factors that may affect fuel economy (**Table 1** Entry 12). As Grant notes, "We have to have a very specific route. We'll have to drive the same route every time at the same speed in the exact same way … the weight of the car cannot change between tests. That's the only way we'll be able to compare our results."

In addition to accounting for other variables through the use of controls, the *MythBusters* also frequently employ single-blind and double-blind experimental procedures to avoid introducing bias into the obtained results.

In the "Eye Black" myth ["Viewer Special 2"—OAD: 2/13/2008], the *MythBusters* test whether applying black makeup to the skin beneath the eyes reduces glare in bright light (**Table 1** Entry 13). To ensure the validity of the results, the test subject is not told if he is wearing the black makeup. As a control, regular flesh-tone makeup is applied in one trial and the eye black in another trial. The test subject is not allowed to know if he has received the control or the variable under question as knowledge could influence the self-reported results.

In the "Top Shelf Filtration" myth ["Bullets Fired Up"—OAD: 4/19/2006], the *MythBusters* test whether it is possible to turn cheap, low-quality vodka into premium, high-quality vodka by filtering it repeatedly through a charcoal filter (**Table 1** Entry 14). Three participants are each given eight samples of vodka: one from each of six filtration stages, one shot of high-quality vodka, and one shot of unfiltered cheap vodka. They are asked to rank them in order of perceived quality. The experiment is conducted in a double-blind setup; participants and the administrator of the test are kept ignorant of the identity of each sample. As Grant elaborates, "These samples have been prepared and randomized. Even I won't know which is which until the very end."

In the "Battle of the Sexes" ["Battle of the Sexes"—OAD: 4/22/2012], the *MythBusters* test whether men or women are better at various activities, such as driving and cooking (**Table 1** Entry 15). In each of these experiments, they ensure that those conducting the assessments are kept unaware of the gender of the participants to prevent potential bias. As Adam explains, "[T]o eliminate bias we should make sure that the driving instructor does not know the gender of the person he's testing at any given moment." Later, Jamie reminds the audience of the need to avoid introducing potential bias: "The grilling will be assessed by a panel of judges. [T]his is a blind test, which means that the judges will not know the gender of the people that are preparing the food that they're tasting."

In the "The Smell of Fear" myth ["Fright Night"—OAD: 10/28/2012], the *MythBusters* test whether fear-induced perspiration noticeably differs from exertion-induced perspiration (**Table 1** Entry 16). To test this myth, they collect samples of sweat exuded during exercise and exuded while experiencing fear and see if volunteers can distinguish between them. To prevent the introduction of bias, a double-blind format is employed, as Grant explains, "So for our smell of fear experiment, it will be double-blind, meaning neither the volunteers nor Tory, who is administering the test, will know what sample is what."

In their design of experiments, the *MythBusters* are careful to incorporate controls and to employ a single-blind or double-blind format to prevent introducing bias.

5. Formal logic

MythBusters demonstrates the importance of logical reasoning in science. This syllogistic logic is best explained by way of a simple example:

> *"B = A.*
>
> *B = C.*
>
> *Hence A = C" [13].*

The use of formal logic is demonstrated in the "What is Bullet Proof?" myth (**Table 1** Entry 17) ["Coffin Punch"—OAD: 11/5/2008]. The myth centers on the idea that a sufficiently obese person will have his internal organs protected from a bullet by the overlying layers of fat. Two important examples of formal logic are used to legitimately simplify the experiment. First, containers of lard are placed in front of a human analogue dummy in an amount corresponding to the

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world's fattest person: if the amount of lard corresponding to the fat possessed by the world's most obese person is insufficient to stop a bullet, then no person's fat can stop a bullet. This logic is also used in choice of the firearms employed. If a round from a 45-caliber gun with the low muzzle velocity of 900 ft/s passes through unimpeded, it is futile to try larger caliber rounds as all have greater penetrating power: "If this makes it all the way through our fat and vital organs, every other kind of round we could fire would as well," succinctly explains Adam. While the syllogism example utilizes mathematical variables and symbols and the myth utilizes containers of fat and the penetrating power of bullets, the principles are the same: "The validity or invalidity of a deductive argument depends on its form, and not on its content" [12].

6. Objectivity

MythBusters effectively communicates the jurisdiction and constraints of science. Science deals with matters in an objective fashion, and it is important that "students develop an understanding of … what science can and cannot do" [14].

Oftentimes, the *MythBusters* are confronted with having to assess something for which there is no obvious way to measure. In the "Beer Goggles" myth ["Alcohol Myths"—OAD: 10/22/2008], the *MythBusters* test the commonly held belief that the consumption of alcohol makes people perceive others as being more physically attractive (**Table 1** Entry 18). Early on, Jamie points out that this myth will be especially difficult to test empirically: "This seems to be a really subjective thing. We need to be objective if we're going to be scientific." In an attempt to quantify an essentially qualitative, subjective choice, the *MythBusters* employ a large sample size and numerically rate dozens of photographs of people while sober and while intoxicated: "The researcher may turn to rating as a last resort, when any more precise and explicit convention for scoring cases is either impossible or is deemed too much trouble" [15].

In the myth of "Taking Candy From a Baby" ["Mini Myth Madness"—OAD: 11/10/2010], the *MythBusters* are confronted with having to devise a method to measure something seemingly subjective in testing the idiom that taking candy from a baby truly is the epitome of effortlessness (**Table 1** Entry 19). They decide to "reduce the myth to a single quantifiable measurement – grip strength" by measuring the amount of force required to take candy away from newborns and infants (consenting parents were present) using a mechanical gripper.

In the "Square Wheels" myth ["Square Wheels"—OAD: 4/8/2012], the *MythBusters* test whether if above a certain speed, square wheels can provide a smooth ride (**Table 1** Entry 20). Testing the "smoothness" of a ride seems like an inherently unquantifiable, unscientific proposition, as Adam notes, "If these [square wheels] have any chance at all of giving us a smooth ride, how are we going to know beyond our own subjective experience? We need an objective measuring system for telling us how smooth our ride is." The *MythBusters* decide to place vibration sensors on the suspension and steering column of their vehicle as well as on the passengers inside the vehicle. After reviewing the data from the vibration sensors, Adam concludes "[T]he data is pretty compelling and it actually seems to match what Jamie and I felt in the truck …"

Oftentimes, the *MythBusters* are confronted with having to assess something for which there is no obvious way to measure. In the "Driving Dangerously" myth ["Driving in Heels"—OAD: 4/29/2012], Adam and Jamie test whether certain types of footwear make driving dangerous (**Table 1** Entry 21):

> *Jamie: "[H]ow do you propose we test them?"*
>
> *Adam: "[W]e each wear a strange piece of footwear with our foot all the way down on the accelerator. Then we time how long it takes to get from the accelerator all the way to the brake."*

In the "Tryptophan Turkey" myth ["Surreal Gourmet Hour"/"Food Fables"—OAD: 11/18/2012], Tory, Kari, and Grant test whether eating turkey makes you sleepy (**Table 1** Entry 22). As sleepiness is inherently subjective, they decide to measure their reflexes by playing a game of Whac-A-Mole. They compare their scores obtained after consuming tryptophan capsules, a turkey-laden meal, and a meal without any turkey but containing the same number of calories.

7. Operational definitions

MythBusters demonstrates the importance of operational definitions in scientific experiments. Operational definitions involve comparison of phenomena of interest against a standard: "Operational definition means defining the phenomena under investigation in such a way that they can be observed and measured, at least indirectly, in terms of other phenomena that can also be observed and measured" [12].

In "Water Heater Rocket" ["Exploding Water Heater"—OAD: 11/7/07], the *MythBusters* test whether a malfunctioning pressure release can cause a water heater to explode through multiple floors of a house like a missile (**Table 1** Entry 23). To ensure the validity of their results, the scale house they create is built to California building code specifications. They rigorously adhere to uniform standards and codes so that they can apply the results they obtain to existing houses.

Many of the myths tested by the *MythBusters* involve explosives. Operational definitions feature heavily in these myths. In the "Bourne Magazine" myth ["Blue Ice"—OAD: 4/13/2011], the *MythBusters* explore the combustibility of different ratios of air and methane gas (**Table 1** Entry 24). In their initial testing, they make use of operational definitions when employing the concept of standard temperature and pressure (STP) in determining the exact stoichiometric ratio of fuel to air that is explosive.

In the "What is Bomb Proof?" myth ["Running on Water"—OAD: 4/20/2011], the *MythBusters* employ Oseco burst disks as a way of determining whether blasts are harmless or would have resulted in injury or death (**Table 1** Entry 25). As the narrator explains, "We've used burst disks before on the show to find out if various shock waves were survivable without actually resorting to a human sacrifice. So in this control blast, they're testing the outer limits of two differently calibrated disks: one set for certain death, the other for injury." Grant

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provides a more detailed description of how these metal foil membranes, calibrated to burst at certain pressures, can be used to infer whether an explosion would have inflicted serious bodily harm or caused death: "We're going to set up a number of radii from the epicenter of the blast. At each of these radii, we're going to put two burst disks: one that goes at 13 [PSI], which is the threshold of injury, and one that goes at 75 [PSI], which is the threshold of instant death."

Operational definitions again feature in the "Let There Be Light" myth ["Let There Be Light"—OAD: 6/22/2011], in which Adam and Jamie test a scene from the movie *The Mummy* that depicts an elaborate system of ancient Egyptian mirrors redirecting light from the sun to illuminate a dark tomb (**Table 1** Entry 26). The concept of operational definitions is introduced at the onset as this excerpt of dialog illustrates:

> *Adam: "[T]his myth is all about lighting up the darkness with the sun's rays reflected. We need to answer the question: What does it mean to light up the darkness?"*
>
> *Jamie: "We need to define that: What's the minimum amount of light necessary to move around in an unfamiliar space?"*

Later in the myth, Adam emphasizes the use of operational definitions yet again: "Before we start bouncing light around … with mirrors, we need to determine a couple of benchmarks that we'll be aiming for in these tests … What is the minimum amount of ambient light required to see?"

The *MythBusters* excel at finding ways inherently difficult to measure and quantify phenomena using operational definitions.

8. Small-scale testing

MythBusters demonstrates the importance of small-scale testing in scientific experiments. It often behooves researchers to experiment with a small-scale model before investing substantial amounts of capital and time in a full-scale version. Technical concerns caught at the small-scale experiment can be remedied before the full-scale experiment is implemented.

In "Down with the Titanic" ["Down with the Titanic"—OAD: 1/25/2004], the *MythBusters* test the idea that a sinking ship generates a vortex powerful enough to suck people in the surrounding water down with it (**Table 1** Entry 27). They start off not by scuttling a boat but rather with smaller proof-of-concept tests using an aerator (bubbler) and hydrometer in a swimming pool.

In "Bubble Trouble" ["Bubble Trouble"—OAD: 4/27/2011], the *MythBusters* test whether it is impossible to swim in bubbly water (**Table 1** Entry 28). They begin with a small-scale test involving an aquarium tank and aerator along with a hydrometer to measure the density of bubbly water. This small-scale test yields a surprising result, with the *MythBusters* finding that the decrease in water density is offset and counteracted by the upwelling current of bubbles.

In "Wrecking Ball Baloney" ["Newton's Crane Cradle"—OAD: 10/5/2011], Adam and Jamie test an internet viral video of a giant Newton's cradle (a classic tabletop demonstration of elastic collision and energy transfer) made from wrecking balls set in motion by a crane at a construction site (**Table 1** Entry 29). The *MythBusters* decide to approach the myth cautiously rather than rush headlong to replicate the viral video:

Adam: "How do you want to proceed?"

Jamie: "[S]ince this is all about scaling the Newton's cradle effect … why don't we do it gradually?"

Adam: "You mean incrementally bumping up the size of our Newton cradles?"

Jamie: "Exactly, and see if we can tease out any kind of problems dealing with the increase in scale."

Later, Adam reiterates the rationale for implementing a small-scale version of the experiment first: "Before we go to full-scale, we're going to try a scale experiment with the simplest arrangement possible … it … ought to give us a good guide as to the viability of our concept for the large-scale one."

In the "Square Wheels" myth (previously discussed), Adam and Jamie test whether it's possible for square wheels to provide a smooth ride to a vehicle. They conduct small-scale tests involving a model vehicle on a treadmill to elucidate which wheel configuration gives the smoothest ride. This setup serves to provide crucial data on which configurations lead to dangerous resonance effects that might shake a vehicle apart at the full scale. As Jamie explains, "Our small-scale tests showed that the best configuration was to have two opposing corners with their points down, the opposite two corners with their flats down. That balances things out the best and so that's what we're going to do full-scale."

In "Tablecloth Chaos" ["Tablecloth Chaos"—OAD: 10/27/2010], the *MythBusters* attempt to replicate another internet viral video that purports to show a quickly accelerating motorcycle being used to whisk a tablecloth free of a fully laden banquet table without disturbing a single place setting (**Table 1** Entry 30). Adam decides to start with small-scale testing for obvious reasons: "We're going to scale this up to a fairly impossible dimension and I suspect that a lot of factors – object heaviness, cloth type, table type – all of these things – might affect our success on that scale. Thus, in the small-scale, we need to learn what factors are critical to making it work."

The use of small-scale, proof-of-concept testing features prominently in myths involving explosives. In "Surfing with Dynamite" ["Lead Balloon"—OAD: 1/23/2008], the build team conducts a small-scale demonstration before detonating dynamite in a quarry lake (**Table 1** Entry 31). Using plastic bottles filled with subliming dry ice, they test wave generation at the surface of a pool while varying the depth of the explosion. This small-scale test tells them at which relative depth explosions create surface waves with the greatest amplitude. As the narrator explains, "So the guys have their proof of concept; an explosion will make waves and depth is a factor in the size and quality of those waves."

In "Drain Disaster" ["Drain Disaster"—OAD: 11/2/2011], Adam and Jamie test whether a methane gas buildup in a sewer system can ignite and launch manhole covers skyward (**Table 1** Entry 32). Again, the *MythBusters* choose to begin at the small scale. As Jamie explains, "[B]efore we lock in on a full-size plan, let's do a small-scale one first and see if we can learn anything."

In "Valkyrie Boom" ["Operation Valkyrie"—OAD: 12/22/2010], the *MythBusters* test whether a last-minute change of venue from an underground bunker to an aboveground conference room prevented an attempted assassination of Hitler from proving fatal (**Table 1** Entry 33). Adam decides to start with a small-scale test to illustrate the difference between an explosion in a closed space, such as a bunker, and in an open space, such as an aboveground room with windows. In his small-scale test, Adam visualizes the wave mechanics by dropping weights into a tank of water. From the behavior of the ripples in water, Adam is able to collect evidence in favor of the myth that allows him to confidently proceed to the full-scale experiment.

In "Trench Torpedo" ["Trench Torpedo"—OAD: 10/14/2012], the *MythBusters* test whether, in World War I, building trenches with abrupt, right-angle corners served to prevent shock waves from exploding artillery shells from propagating (**Table 1** Entry 34). Adam starts exploring this myth at the small scale with wave tanks of different geometries: straight with abrupt, right-angle corners and with gradual, rounded corners. From this small-scale test, Adam finds a definite reduction in the amplitude of ripples in the tank with right-angle bends, lending credence to the myth and supplying the evidence needed to proceed with the full-scale experiment.

9. Interpretation of results

The *MythBusters* convey the intrinsic conservatism of science by not making sweeping generalizations or unjustifiably extrapolating the results they obtain: "[S]cientists and educators must resist the urge to state the case of science in terms that are stronger than the data support" [16].

In the myth of "antigravity" (previously discussed), the build team arrives at a conclusion of busted: "So anti-gravity is busted," Kari summarizes. This prompts Tory to retort, "I don't know if we can bust anti-gravity. I mean we can bust our devices." To which Kari replies, "Alright. Revised. Anti-gravity busted … for now." This exchange demonstrates how scientific explanations are tentative and that the current understanding of a phenomenon may not be the final word on the matter [17, 18].

In "The Haunted Hum" myth ["Fright Night"—OAD: 10/28/2012], Adam and Jamie test whether an infrasonic hum may be responsible for peoples' perceptions of certain buildings as being haunted (**Table 1** Entry 35). In this experiment, the *MythBusters* select four identical cabins in the remote woods as an appropriate venue for the myth. They apply the auditory stimulus in only one of the four cabins. They have participants spend 2 minutes alone in each cabin and report which cabin they found to be most unsettling. Most participants in the experiment found the first cabin to be the most unnerving, while the infrasonic tone was applied in the third cabin. As Adam concludes, "Ten tests. Ten test subjects. And I think we can definitively state that cabin 3 – the sound we put through it – did not make it the spookiest cabin. If anything, cabin 1 was the spookiest cabin, cabin 4, the least spooky. Now this could be because of one of two reasons. Either, because we had everyone enter the cabins in numerical order, the newness of the experiment and the weirdness of sitting alone in a room for two minutes made them the most frightened at the beginning and the least frightened at the end. The other reason is that cabin 1 could actually be haunted. But I don't think so." In this

way, Adam masterfully demonstrates how scientists are cautious and conservative in drawing conclusions from their experimental data. The *MythBusters* excel at identifying alternative explanations to account for a finding: "Even a statistically significant relationship must not be taken as supporting a causal hypothesis unless all plausible alternative explanations for the observed statistical relationship have been eliminated" [12].

10. Repeatability of results

One central tenet of science that is often omitted from the classroom is the importance of repeatability. The essence of science is that any result should be able to be reproduced on demand: "We do not take even our own observations quite seriously, or accept them as scientific observations, until we have repeated and tested them … Only by such repetitions can we convince ourselves that we are not dealing with a mere isolated 'coincidence'" [19].

In science, one person or team publishes its findings, and other people or teams seek to recreate the results. If the same materials are used and the same conditions are observed, then the results should be the same regardless of who conducts the experiment or where it is conducted: "The essence of the scientific method lies in the repeatable result: if you perform an experiment in the same way, nature will do the same thing again. This is the heart of science and is the sign that an observable phenomenon in nature has been found" [20]. This is what sets the scientist apart from seer, shaman, and oracle who purport to have a unique ability unable to be taught or communicated to others.

Lack of repeatability is often the deciding factor in the collective rejection by the scientific community of a new claim.

In 1977, SETI (Search for Extraterrestrial Intelligence) astronomers at the Big Ear radio telescope at Ohio State University picked up an intensely strong, narrowband radio signal. The unique nature of what was dubbed the Wow! signal seemed to imply an artificial (intelligent) origin, but because the signal did not repeat, the existence of extraterrestrial intelligence could not be confirmed.

In 1989, scientists Stanley Pons and Martin Fleischmann claimed to have achieved cold fusion: the fusion of heavy hydrogen at room temperature. The claim caused a global sensation, promising to usher in an era of cheap, clean, limitless nuclear power. However, the inability of others to obtain the same results quickly led the scientific community to excoriate cold fusion proponents [21]. Indeed, the failure of other scientists to reproduce the results claimed by Pons and Fleischmann dealt a credibility blow so severe that the entire field has never recovered and is even today looked upon by the overwhelming majority of scientists as little more than alchemy.

The importance of repeatability is frequently emphasized on *MythBusters*. As the narrator reminds the audience, "Reliable results should be repeatable" ["Running on Water"—OAD: 4/20/2011]. This point is succinctly communicated in the "Primary Perception" myth (**Table 1** Entry 36) ["Deadly Straw"—OAD: 9/6/2006]. The build team tests the myth that plants are conscious and capable of exhibiting emotions, such as fear and anger, detectable

by polygraph. When subjecting plants connected to bioelectrical monitoring equipment to physical abuse, the build team initially obtains some startling results that seem to indicate that the myth has some validity. However, upon further testing, they are unable to duplicate the surprising results. This prompts the *MythBusters* to classify the myth as busted, with Tory concluding, "If you can't repeat it, it's not science."

11. Summary

Educators must use all tools at their disposal, including television, to improve their students' understanding of the scientific method and instill in them an appreciation of its wide-ranging versatility. Understanding the scientific method and how to use it is more widely applicable and transferrable than the accumulation of disparate facts that can be recalled on a whim [22–25]. While formal student assessment was not conducted, feedback (via informal conversation) showed increased student confidence in identifying experimental controls and greater appreciation of the importance of controls in experiment design following the classroom activity we designed to introduce the scientific method utilizing myths from the show. *MythBusters* communicates the scientific method (proposing a hypothesis, designing and carrying out an experiment, etc.) along with its lesser-known components of experimental controls; the importance of logical reasoning, objectivity, operational definitions, small-scale testing, and interpretation of results, and the importance of the repeatability of results: "If the decades ahead produce another Thomas Edison or Steve Jobs, odds are that he or she will have grown up watching *MythBusters*" [3]. Educators are encouraged to familiarize themselves with the show, starting with the episodes mentioned herein. These episodes can be purchased on DVD from the Discovery Channel website. They can also be downloaded individually or by season from Apple's iTunes Store for immediate streaming.

12. Postscript

After a run of 14 seasons and 282 episodes, the *MythBusters* finale was aired in spring 2016; however, reruns continue to air on Discovery Channel's sister network The Science Channel [26]. In addition, the Science Channel has announced that it is relaunching the show with new hosts to be determined through its new reality show *Search for the Next MythBusters*. Also, build team members Tory, Kari, and Grant will be investigating unusual events from pop culture, science, and history in the Netflix original *White Rabbit Project*. Lastly, a hands-on exhibition with artifacts from the show, interactive exhibits, and live demos called "*MythBusters*: The Explosive Exhibition" was installed at the Mall of America in Minneapolis, MN, in 2016 and at the Liberty Science Center in Jersey City, NJ, in 2017. With reruns, a reboot, a spin-off, and a touring exhibition, the final pedagogical legacy of *MythBusters* is not yet written.

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Section 3

Some Experiences of Success in Physical Education

Chapter 12

Scientific and Theoretical Prerequisites for Improvement of Modern Pedagogical Technologies

Alexander Bolotin and Vladislav Bakayev

Additional information is available at the end of the chapter

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Abstract

It is established that pedagogy performs the same functions as any other scientific discipline: description, explanation, and prediction of phenomena of that area of reality it studies. However, in the social and humanitarian sphere, it has its own characteristics. Pedagogical science cannot confine itself to objective reflection of what it is studying. Pedagogical science is required to influence the pedagogical reality and to transform and improve the pedagogical process. Therefore, it combines two functions: scientific-theoretical and constructive-technical. Scientific-theoretical function is a reflection of the pedagogical reality as it is. The constructive-technical one is a regulative function that reflects the pedagogical reality as it should be. The pedagogical process is closely connected with the application of teaching technologies. The application of teaching technologies presupposes organizational arrangement of all dependencies of the learning process, alignment of its stages, identification of conditions for their implementation, and correlation of methods, forms, measures, and means of training during conducting classes with capabilities of the teacher and students.

Keywords: pedagogy, pedagogical technologies, subject and object of pedagogy, types and features of building pedagogical technologies

1. Introduction

This chapter consists of seven sections: "Introduction," "Functions and tasks of pedagogy," "Categories of pedagogy," "The system of pedagogical sciences," "Connection of pedagogics with other sciences," "Connection of pedagogy with practice," and "Characteristics of pedagogical technologies." In each section, the basic definitions and concepts are related to pedagogy, as a science.

In the introduction and in Section 2, the definition of pedagogy as science. The functions and tasks of pedagogy in the modern world. In Section 3, the definitions of the main categories of pedagogy. What is the education, development, education, training of people, and also paid special attention to such categories as self-education, self-education, pedagogical process, and pedagogical interaction. Sections 4 and 5 show the differentiation of pedagogy by industry and its relationship with other sciences. Section 6 illustrates the relationship between pedagogy and practice and in the final Section 7, the characteristic of modern pedagogical technology.

Improving the modern pedagogical technologies is closely connected with development of pedagogy as a science. The word "pedagogy" (Greek *paidagógiké*) is understood in different ways. First, pedagogical science is called in such way. Second, according to a different opinion, the art of upbringing is called in such way. Sometimes, pedagogy is understood as a system of activity, which is designed in educational materials, methods, and recommendations [1–3].

The multi-meaning term "pedagogy" means:

- Various ideas, accounts, views on goals, contents, and technologies of upbringing, training, and education
- Area of scientific research related to upbringing, training, and education
- Specialty, qualifications of teachers, their practical activities in upbringing, training, and education
- Academic subject
- Art, virtuosity, and mastery of teachers in education and upbringing

Yet, despite different interpretations, pedagogy is, first of all, *pedagogical science*, the field of scientific disciplines on upbringing, training, and education of a person.

2. Functions and tasks of pedagogy

It is accepted to distinguish between the object and the subject of science.

The object of science is an area, a part of reality, which the given science studies, its cognitive field.

For pedagogy, such a cognitive field, the main *object*, is a person, from the point of view of its upbringing, formation, development, and education in the course of the pedagogical process. Pedagogy learns its object, a growing, developing person, in integral fusion of the natural, social, and individual, personal in it, in its essence, formation, abilities, and activities.

The subject of pedagogy is the essence and laws of the pedagogical process in general and constituents of its processes in particular, as well as formation and development of personality in them. Thus, this is a *pedagogical process* as a special kind of interaction between people [4–7].

Its modern content includes a whole system of interrelated processes: training upbringing, self-improvement, development, education, and psychological preparation [8, 9].

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The object of pedagogy as a practice in modern understanding is the interaction of participants in the pedagogical process, and its *subject* is goals, contents, and ways of interaction of pedagogical technologies.

Pedagogy is a science that studies the laws, principles, methods, means, forms, contents, and technologies of organization and implementation of the pedagogical process as a factor and means of a human development throughout its life.

Pedagogy carries out the same functions as any other scientific discipline: description, explanation, and prediction of phenomena of that area of reality it studies. However, in the social and humanitarian sphere, it has its own characteristics. Pedagogical science cannot confine itself to objective reflection of what it is studying. Pedagogical science is required to influence the pedagogical reality and to transform and improve the pedagogical process. Therefore, it combines two functions: scientific-theoretical and constructive-technical. Scientific-theoretical function is a reflection of the pedagogical reality as it is. The constructive-technical one is a regulative function that reflects the pedagogical reality as it should be.

Pedagogy studies the following *main problems*:

- Identification and analysis of the essence and laws of the pedagogical process, development, and formation of the personality and their impact on upbringing and education
- Definition of goals of upbringing, training, and education
- Development of the content of upbringing, training, and education
- Research and development of methods and technologies of upbringing and education

In pedagogical science, there are several bases for classifying its tasks. According to one of them, the permanent and temporary tasks of pedagogy are distinguished.

The *permanent* tasks are:

- Identification of laws in the field of upbringing, education, and training and management of educational and upbringing systems
- Study and generalization of practice and experience of pedagogical activity
- Analysis of positive and negative trends within the pedagogical process and its structure
- Introduction of modern pedagogical and information technologies into practice
- Development of new methods, forms, means, systems of education, upbringing, and management of educational structures
- Prediction of development of pedagogical theory and practice
- Introduction of results of pedagogical research into practice

The *temporary tasks* of pedagogy are dictated by needs of practice and science itself. In particular, it is the creation of electronic textbooks and their libraries, development of state educational standards and requirements, introduction of automated training systems and programs, analysis of typical conflicts in the "teacher-student" relationship, etc.

3. Categories of pedagogy

The main categories of pedagogy reflect its essence. They include upbringing, development, education, and training of people. Significant categories are self-education, self-improvement, pedagogical process, and pedagogical interaction.

Let us consider the essence of these categories.

Upbringing has two meanings in the pedagogical science. In the broad sense, it is the process of targeted influence on a person. The goal of education is accumulation by a human of a social experience necessary to live in society and formation of a certain system of values. In this case, upbringing is seen as a purposeful process of forming the intellect, spiritual, and physical forces of an individual, preparing it for life and active labor activity.

In the narrow sense, upbringing is a systematic, purposeful influence on people being educated in order to form certain specific qualities, views, beliefs, desired attitudes toward people, and phenomena of the surrounding world. Upbringing is also interpreted in the narrower concrete sense, as a solution to a certain educational task.

Self-improvement is the conscious and purposeful work of a person in shaping desired traits, personality qualities, and behaviors.

Training is a purposeful process of interaction between teachers and students in transfer and assimilation of social experience, formation of knowledge, skills, and abilities. In this case, activity of teachers is called teaching, and activity of students is learning [10, 11].

Training in a certain sense differs from upbringing by the degree of organization; the training process is defined more clearly and is characterized by the usage of special means of teaching.

Education is the process and result of mastering the levels of cultural heritage defined by society, mastering the system of knowledge, skills, and abilities, as well as forming a worldview, moral, and other qualities of the individual on their basis and development of creative forces and talents. Education is a pedagogically organized process aimed at the formation of a high level of individual development of a human.

Self-education is a purposeful and meaningful work of a person, connected with the search and mastering of knowledge.

Development is the process of becoming, formation, and improvement of a human's personality under the influence of external and internal, controlled and uncontrolled, and social and natural factors, among which purposeful education and upbringing play a leading role. In a narrower sense, development is understood as improvement of intellectual, physical, and other personal qualities.

The pedagogical process is a specially organized interaction of teachers and students in order to solve tasks of education, upbringing, education, and personal development. It is a chain of individual pedagogical interactions.

Pedagogical interactions are intentional mutual contacts of a teacher with a student, aimed at changes in behavior, activity, consciousness, psyche, and attitude of the student to the surrounding world.

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The concept of "pedagogical interaction" denotes the most significant specific feature of practical pedagogy and its *bilateral, subject-subject* nature. At the same time, a student is not simply present within the pedagogical process; he/she, like a teacher, acts as a participant or, more precisely, interacts, as he/she actively responds to actions of the teacher, and the latter builds further work taking into account the student's response to these actions. In the concept of "pedagogical interaction," the activity of the student and presence of interaction between its participants as subjects of the pedagogical process as a whole are emphasized. This is the specificity of the modern subject-subject approach to the pedagogical process.

4. The system of pedagogical sciences

Developing, every science enriches its theory, is filled with new content. At the same time, scientific differentiation of the most important research directions is carried out. The level of development of science as a whole is evaluated according to the degree of research differentiation.

At present, the term "pedagogy" refers to an entire *system of pedagogical sciences* or branches of pedagogy. They are:

1. *General pedagogy* is *a basic scientific discipline* that studies basic laws of upbringing and education, theory of the pedagogical process, need, possibilities, and ways of its implementation.
2. *History of pedagogy* studies the evolution and the current state of pedagogical systems, goals, theory, and practice, the development of pedagogical learning, and the ideas for upbringing and training within different historical epochs.
3. *Comparative pedagogy* considers laws of functioning and development of educational and upbringing systems in different countries by comparing and finding similarities and differences.
4. *Didactics* is a theory of learning, mainly studying content and technologies and methods of teaching and learning in educational institutions.
5. *Private pedagogical methods* study laws of teaching and studying specific academic disciplines in all types of educational institutions.
6. *Theory of upbringing* considers laws, principles, methods, means, and forms of upbringing.
7. *Age pedagogy* studies peculiarities of upbringing, training, and education of a person at different stages of his life path, depending on specifics of educational activity within certain age groups. In particular, *preschool pedagogy, school pedagogy, pedagogy of vocational education, pedagogy of secondary specialized education, higher school pedagogy, and adult pedagogy* are distinguished.
8. *Professional pedagogy* studies laws, carries out theoretical justification, and develops principles and technologies of education and upbringing of a person, oriented to a specific labor and professional sphere of activity. It engages in problems of improvement of professional skills, retraining of workers, and acquisition of a new occupation at mature age.

Depending on the type of professional activity, *engineering*, *production*, *medical*, *theatrical*, *sports*, *and military pedagogy* are distinguished.

9. *Social pedagogy* contains theoretical and applied developments in the field of social upbringing carried out both in the fostering institutions and in various organizations, for which it is not a leading function, and explores upbringing forces of society and ways of their actualization by integrating capabilities of public, state, and private organizations.
10. *Special pedagogy* develops theoretical bases, principles, methods, forms, and means of upbringing and education of a person having deviations in physical or mental development.
11. *Correctional pedagogy* studies laws and causes of deviant behavior and develops ways and methods to overcome such behavior.
12. *Correctional labor pedagogy* contains theoretical justification and development of a practice of rehabilitation of persons in custody for crimes committed.

5. Connection of pedagogics with other sciences

One of the most important characteristics of any science is its connection with other scientific branches. This serves as an important source of development and is manifested in three aspects: first, some sciences in relation to other ones fulfill worldview and methodological functions; second, content of knowledge of certain sciences helps other ones to penetrate deeper into the subject of research; and, third, within the process of interconnection of sciences, their mutual enrichment by methods of research takes place.

Among the first, there were links established between pedagogy and philosophy, and psychology, which remain an important condition for development of pedagogical theory and practice.

First of all, pedagogical science is connected with *philosophy*, which, in relation to it, serves as a worldview and methodological basis. Philosophical ideas contributed to creation of pedagogical concepts and theories; they set the direction of search and serve as the methodological basis of pedagogy, being the basis for understanding goals of upbringing and education.

Many outstanding scientists-teachers turned to philosophical knowledge within the process of solving scientific problems. Development of the theory of education based on a philosophical ethical concept by the German teacher *Johann Friedrich Herbart* (1776–1841) is indicative in this regard. Public and personal moralities, according to the said scientist, rest on eternal and unchanging moral ideas. The main goal of education, in his opinion, resolves into assimilation of these moral ideas.

In the history of philosophy, two opposing concepts are distinguished, which influenced a solution of pedagogical problems. One of the concepts associated with Socrates and Plato, who believed that natural content of a human is decisive in its development, is that external conditions play a secondary role in its formation. Democritus and Epicurus adhered to the opposite point of view. They believed that the external conditions and circumstances of life

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exert a determining influence on development of a human. These two approaches to solving the most important pedagogical problem related to human development remain today as well.

A special place in the development of pedagogical science, methodology of its research, is occupied by dialectics as the philosophical basis of cognition of the surrounding world. Its content is composed of dialectical principles, laws, and categories.

Principles of dialectics reflect the essence of a human, its inner world, and the place in the surrounding world. They reveal the strategy of scientific and pedagogical knowledge and give the most general guidelines in this complex process. For example, the philosophical *principle of universal communication* reflects the complexity of the surrounding world and its phenomena, including pedagogical ones. It focuses on the analysis of pedagogical phenomena in the relationship not only with their internal elements but also with external factors and conditions, without which a reliable result of scientific research cannot be obtained. Other philosophical principles perform a similar function. Thus, the *principle of development* indicates the need to study pedagogical phenomena in their dynamics and historical and logical sequence. The *principle of determinism* requires discovery of causality, the analysis of the phenomena under study through the prism of factors conditioning them, etc.

Laws of dialectics possess the role of mechanisms, by which it is possible to identify and formulate pedagogical problems, predict development of pedagogical phenomena, and find ways of solving pedagogical problems.

The law of unity and struggle of opposites allows identifying contradictions in a pedagogical phenomenon, without which it is impossible to formulate a scientific problem, and this is an important step on the way to its solution. Examples of contradictions as the basis for formulation of a scientific problem are the contradictions between existing methods of teaching and new requirements for the learning process, conditioned by increasing the needs of training specialists.

The law of mutual transition of quantitative and qualitative changes allows predicting changes in pedagogical phenomena, to study the mechanism of their development. If due to the first law (of unity and struggle of opposites), it is possible to formulate a scientific problem; the second one helps to put forward a hypothesis on its solution and to work out ways of proof. Knowing the content of one of the central categories of the law under consideration, "measures," we perceive that achievement of new quantitative characteristics of pedagogical phenomena is impossible within the framework of the old quality. The law under consideration also provides the key to understanding the need to introduce new teaching technologies into the pedagogical process.

The law of the negation of the negation allows imagining the direction of development of pedagogical phenomena from simple ones to complex ones, observing a progress in this, seeing correlation between the new and the old, as well as many other aspects. With the help of this law, it is possible not only to predict changes in phenomena but also to orient oneself correctly in the choice of ways and means of purposeful influence on them. Thus, it is possible to explain the relationship between the class-lesson system developed by J.A. Comenius and its modern models, as well as the way of preserving valuable elements of the system in the course of its evolution.

One of the most contemporary pedagogical problems is correlation between traditional, classical forms and methods of teaching and education and nontraditional, innovative ones. The key to solving this problem is, to a certain extent, laid down in the law under consideration. In particular, its methodology requires continuity of and compliance with the boundaries of application of certain forms and methods in the process of education and upbringing.

Psychology, especially age and pedagogical, is particularly important for solving specific problems of education and upbringing. There are several most important links between pedagogy and psychology. The main one is the subject of research of these sciences. Psychology studies laws of development of a human psyche; pedagogy develops methods, ways, and means of its upbringing and development of personality. Upbringing, education, and training are nothing like development of psyche.

The second important point is commonality of research methods. The existence of a close connection between psychology and pedagogy is also evidenced by the interpenetration of basic concepts of these sciences. Pedagogy uses psychological knowledge to identify, describe, explain, and systematize pedagogical facts. One of the demonstrative manifestations of such relationship was formation of such branch of psychology as pedagogical psychology. An equally important feature of such relationship is methods of these two sciences. In pedagogy, many of them are borrowed from psychology. It concerns especially testing, interviewing, and other empirical methods.

Connection between pedagogical thought and psychological knowledge is reflected in views of many thinkers of the past. Therefore, according to Plato, all knowledge is a memory. The soul remembers what she was able to contemplate before its earthly birth. Thus, education and upbringing resolve into mastering methods and ways of such a memory.

Ideas of Aristotle are no less significant in this aspect. As already mentioned, he distinguished three kinds of soul in a human, vegetative, bestial, and intelligent, each of which manifests itself in various human functions. The three kinds of soul, according to Aristotle, correspond to physical, moral, and mental upbringing. The goal of upbringing, in his opinion, is to develop the higher sides of the soul, intelligent and strong-willed. Ancient Greek philosophers also believed that nature gives a human only a germ of abilities that should be developed during upbringing. Nature, according to ideas of the thinker, closely linked the three kinds of soul in a human, and during upbringing, we should follow it, linking physical, moral, and mental upbringing in a single process.

Psychology performs a methodological function in relation to pedagogy. For example, the personal approach developed in psychology finds expression in such pedagogical principles as individual and differentiated approach in the process of education and upbringing and reliance on positive qualities of a personality.

A very important methodological function in relation to pedagogy is the principle of the activity approach, which constitutes the core of psychology. It reveals upbringing possibilities of any kind of activity and requires the process of education and upbringing to be carried out in close connection with life.

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The psychological justification is also laid down in pedagogical concepts of teaching, developed in pedagogy. Therefore, the basis of the associative-reflex concept of training is psychophysiological laws of the conditioned reflex activity of the human cerebral cortex, as well as the mnemonic laws of psychology. Programmed training has developed on the basis of the psychology of behaviorism. Many pedagogical laws are based on the fundamental principles of psychoanalysis, Gestalt psychology, cognitive psychology, humanistic psychology, and other psychological directions and schools.

In modern conditions, the relationship between psychology and pedagogy develops in two directions. On the one hand, psychological research should be directed rather at advancing development of pedagogical theory and practice than at justifying of established forms and methods of teaching and upbringing. On the other hand, pedagogical research should not only be based on the achievements of psychological science but also stimulate their development in the right direction.

The research was spent more than 8 years. The advanced ideas of prominent teachers from 17 countries of Europe and Asia were studied and analyzed.

Pedagogy is closely connected with the biological sciences: *physiology*, *human anatomy*, and *medicine*. To understand mechanisms of managing physical and mental development, it is important to know laws of vital activity of the organism as a whole and its individual parts, functional systems, and basic conditions on maintaining health. Knowledge of laws of functioning of higher nervous activity makes it possible to design and develop teaching technologies and tools that contribute to optimal development of a personality [12–14].

Content of the pedagogical science is inextricably linked with *sociology*, *political science*, *economics*, *law*, and *other socioeconomic sciences*, which significantly supplement pedagogy with knowledge, special information about conditions of functioning of participants in the educational process, and subjects of pedagogical interaction.

Socioeconomic sciences substantially enrich methods of pedagogy. Especially, it concerns *sociology*. Many of its empirical methods after appropriate adaptation are widely used in pedagogy. We are talking about methods for studying preferences, multiple comparisons, statistical analysis of sociological information, expert assessments, etc.

Modern pedagogical thought cannot be full without a content of *historical* and *cultural knowledge* in it. Development of pedagogy and realization of its practical functions today imply an appeal to the historical past, as well as to achievements of culture in the broadest sense.

In recent years, connection between pedagogy and *mathematics*, *computer science*, *and programming* has increased significantly. New information technologies and equipment are being used more and more in pedagogical research; their didactic possibilities are increasingly being studied [7, 13].

There is a special relationship between pedagogy and *methods* of various academic disciplines. On the one hand, pedagogical science is the most important theoretical basis in relation to them, and, on the other hand, improvement and development of specific methods issue new theoretical and methodological tasks for pedagogy.

Pedagogy is closely interrelated with many other branches of scientific knowledge, *ethics and esthetics*, *rhetoric*, *ethnography*, *ethnology*, *management*, etc.

Speaking about the relationship of pedagogy with other sciences, it is impossible not to notice its responsive influence on them. For example, theoretical ideas about the role of educational collective in the formation of personality, fundamentally developed in pedagogy, have had and continue to have an impact on development of research on this problem in psychology, philosophy, ethics, sociology, management, etc.

6. Connection of pedagogy with practice

One of the important problems needed to be solved when mastering pedagogical knowledge is understanding the correlation of pedagogical science and practice. This is especially important in connection with a *significant expansion in modern conditions of areas of manifestations of pedagogical practice* and a clear increase in the impact of pedagogy on various spheres of human activity and communication.

Today, the scientific status of pedagogy is no longer questioned. The dispute turned into a plane of correlation with practice. Actual achievements of teachers become too ambiguous. In one case, they are conditioned by deep knowledge and skillful application of the theory; in another case, success is brought by the high personal skill of a teacher and the art of pedagogical influence and interaction, intuition, and instinct. There is not always a consistency between pedagogical theory and practice. It should also be taken into account that the development of pedagogy does not automatically ensure quality of upbringing and education. The theory to be transformed into appropriate technologies is necessary.

It should be noticed that *at present*, *pedagogy is rapidly progressing*. In recent decades, tangible progress has been made in a number of its areas, especially in development of new learning technologies.

There is another problem related to the scientific status of pedagogy. Many theorists, following the principles of classification of sciences proposed by the German philosophers Windelband (1848–1915) and Rickert (1863–1936), refer pedagogy to the so-called normative sciences. This is due to the content of knowledge in pedagogy. By now, many pedagogical laws have been expressing the most general tendencies in the development of pedagogical phenomena. For example, the law reflecting dependence of development of a personality on a social environment is multifactorial and, due to this, is ambiguously interpreted by various pedagogical schools. Thus, the sociogenic direction absolutizes the role of the social environment in development of a personality.

Representatives of the biogenic direction in pedagogy, on the contrary, give priority to development of personality to heredity rather than to the social environment.

In contrast to the above extreme positions, pedagogy should justify the dialectical unity of the social environment and the genetic, natural data of a personality in the process of its development.

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Polyvariety and ambiguity of conclusions of pedagogy often force it to establish specific norms for interaction of subjects and objects of upbringing, which are not always provided with scientific support.

Thus, in whole, it should be recognized that *pedagogy as a complex social phenomenon stands in the unity of two statuses, as a science and practice of teaching and upbringing*. Its second status can find its concrete manifestation in normative science or in the form of art.

Pedagogical practice in modern conditions is greatly expanded and manifests itself in such forms as upbringing, reeducation, general education, additional education, supplementary education, vocational education, industrial and in-house training, military training, postgraduate education, advanced training and retraining, continuous education, adult education, and educational and sociocultural activities [15–18].

Considering pedagogy as a science and practice, its connection with the so-called folk pedagogy or ethno-pedagogy should be taken into account.

Ethno-pedagogy is a specific set of rules and regulations that spontaneously developed over a long period of history in certain geopolitical and socioeconomic conditions of one or another social community.

It is closely connected with the history of people, their culture, values, and ideals and reflects the rich experience of coexistence of generations, their traditions, and continuity. Folk pedagogy is primary for every person. It finds its application in any family. Our ancestors nursed, raised, taught and brought up children, without the knowledge of pedagogical science in the proper sense of the word.

Thus, mastering of pedagogical knowledge is associated with the assimilation of general fundamentals of pedagogy, its branches, and concepts, which point to a certain class of essentially similar phenomena and constitute the subject of this science.

7. Characteristics of pedagogical technologies

Technology (from the Greek *techne*—art, skill, ability) is a set of techniques and methods of obtaining, processing, and reprocessing of raw materials and finished materials.

Since the early 1960s, the concept of "pedagogical technology" has spread. The reason for its emergence was the attempts to bring education to a qualitatively new level in the conditions of scientific and technological progress. Initially, the technologization of education was associated mainly with application of new technical means of teaching. However, today pedagogical technology is not just a set of organizational forms and methods for application of various teaching means but also research aimed at identifying principles of development and finding ways to optimize the educational process, applying new methods and developing educational materials and technical means of teaching.

In 1986, the UNESCO's formulation was given.

Pedagogical technology is a systematic method of planning, applying, and evaluating the entire process of learning and mastering knowledge by taking into account human and technical resources, as well as interaction between them to achieve a more effective form of education.

In general, pedagogical technologies are classified as follows: technology of education, upbringing, and development.

Training technologies can be divided into learning and self-learning technologies.

The process of implementing the content of the technology, prescribed by curricula, which is a system of forms, methods, techniques, and means of teaching ensuring the most effective achievement of the goals set is understood under the *training technology*.

Preparation for each lesson requires a lot of hard work from its supervisor and presupposes creation of the very technology. In turn, *creation of technology for conducting a lesson is associated with a certain sequence of actions, which can be represented in the form of the following algorithm*:

1. *Analysis and formulation of educational goals*. Whereupon, both the ultimate goals of the pedagogical process and the goals of the specific lesson should be analyzed.
2. *Selection of a concept of learning*, which will serve as the basis for organizing training activities in the course of a lesson.
3. *Actual creation of a training technology*. This stage includes a certain sequence of actions:
    - Organization of selection and structuring of educational material
    - Selection of arguments, evidence, examples, and definition of tasks and goals on formation of skills and abilities
    - Selection of a form of conducting a lesson
    - Selection of the most rational methods of teaching that should be used during a lesson
    - Selection of training and educational equipment
    - Selection of methods for activating students' educational and cognitive activities

According to the mentioned classification, let us consider an example of formation of a technology for conducting an academic lesson.

The initial stage is characterized by the need to analyze the content of the training prescribed by the documents on organization of academic work. Based on the findings, the goals that need to be given priority in the educational process are determined. In accordance with the goals determined, the didactic processing of the content is carried out, ensuring their achievement in the aggregate or due to the priority implementation of one of them.

The listed data forms the basis of the technology being developed.

Thus, the *training technology* is a system of activities for organization and implementation of the learning process, prescribing a certain sequence of actions and achievement of certain goals. It is characterized by the following parameters:

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- Learning goals should be specific and measurable.
- Pedagogical operations are reproducible.
- Operations form a complete process to achieve a goal.
- Teacher's subjectivity is minimized.

Freedom of the teacher is possible in the range of actions that provides approximation to goals. Since implementation of technology is influenced by many variables related to characteristics of teachers and students, or conditions, in which the pedagogical process is carried out, creativity of a teacher cannot and should not be excluded.

It is supposed in any technology both at the stage of its creation and its implementation.

Training technologies can be classified according to the following parameters:

- By the object of impact
- By the subject environment
- By the means being applied
- By the organization of training activities
- By the methodical task

Progress constantly makes its own adjustments, including adjustments into educational activities as well. Newly created forms, methods, training means, and elements of an educational-material base potentially have significant opportunities to improve efficiency and quality of training of specialists. Such innovations have determined a new type of learning technologies, the innovative ones.

Innovation in pedagogy is considered development, creation, and introduction of various types of novelties and innovations that generate essential or significant changes in the quality parameters of the educational process.

Qualitative parameters may differ, depending on the types of pedagogical innovation, which are modernizing and reforming. In the first case, this means improvement of the educational process due to improvement of the qualitative parameters of the existing elements of technology and, in the second case, application of innovations radically changing the system of conducting a lesson.

Innovative training technologies in comparison with traditional technologies allow improving quality and efficiency of the educational process. This is performed on the basis of changing learning objectives, role positions, and functions of a teacher and students, specifics of organization of educational and cognitive activities, and forms of educational interactions.

Developing or applying already-tested training technologies in the system of higher education, it is important to proceed from the fact that the educational process should be built so that future specialists learn to acquire knowledge, skills, and abilities on their own and form the integral psychological structure of future professional activity [1, 4, 6, 8].

7.1. Innovative training technologies

Next, consider the basic innovative training technologies. They include design and creative technologies, technologies of the developmental learning, computer training technologies, and technologies of distant and modular training.

The basis of design and creative technologies is creative activity of students in the process of scientific research, solution of scientific and technical problems, and development of specific projects. The base of such technologies is a personality-activity approach, according to which education is not only assimilation of knowledge but also the ways of such assimilation, development of cognitive forces, and creative potential of students.

Within the project-constructive system, the activity of creating something new and the personality of a student come first, whereupon, its personal responsibility for the results of its developments and project implementation are focused.

Knowledge, skills, and abilities in such a system are considered not as a learning goal but as a means of developing a student and formation of a methodological style of thinking. As the main goal, the task of development of a personality, preparation for functioning, life activity in conditions of a technological society is put at the forefront. This goal is realized by development of abilities and acquisition of practical experience of self-education, creative professional activity, and improvement of personal responsibility for created and implemented actual projects into educational and life situations.

In this technological model, content of training is substantially changed. Unlike the formalized system of knowledge presented in the final form in traditional educational technologies, when implementing a design and constructive approach, instead of memorizing theories, laws, and formulas, special attention is paid to development of the ability to solve all kinds of theoretical and practical tasks and problems. The processes of design, modeling, research, and construction of various objects and processes are put on the first place. In this case, knowledge is systematized and structured in accordance with the hierarchy of cognizable objects and processes. A student should have open access to them through a database, reference book, or textbook and assimilate them in the context of the processes of design, modeling, construction, or research. The structure of presentation of educational information should be such that a student could trace the history of origin of this knowledge, not only in chronological order but also as a result of resolution of contradictions. Thus, in this model, knowledge becomes a means rather than an object of personal development.

Unlike traditional technologies with the dominance of memorization, whose effectiveness is affected by the content, form, difficulty, relevance, and volume of educational material, in the design and creative models, the basic mechanism is involuntary memorization, which, in combination with practical activity, can provide more solid, well-structured knowledge. In addition, the design and creative technology increases the degree of meaningfulness of the educational material due to the clarity, concreteness, and minimality of formulation of each project task.

Usually, the difficulty of the learning material is focused on an average student. The proposed educational environment provides an opportunity for each of them to establish their own

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level of complexity on an actual fragment of knowledge, which creates conditions for realization of the model of complete assimilation. Actually, the structure of the material essentially differs from the traditional one, the formal one predetermined by logic of the corresponding science. In the project and creative models, communication in the teaching material is established according to principles of the hierarchy of the material world and logic of common sense. Deployment of the system of concepts is performed in the dynamics of project activity.

In such technologies, the role of a teacher also changes. He ceases to be "the sole custodian of truth and knowledge," from a mentor turns into a project manager, a colleague, and a consultant. In this case, authoritarian pedagogy is replaced by the principles of cooperation and support that fit organically into this technological model.

The theory of the developmental learning is equally important in practice. The theory of the developmental learning originates in the works of J.H. Pestalozzi, A. Diesterweg, and K.D. Ushinsky. Its scientific justification was given by L.S. Vygotsky. The theory was further developed in the works of L.V. Zankov, D.B. Elkonin, V.V. Davydov, N.A. Menchinskaya, and others. In their concepts, education and development are represented as a system of dialectically interconnected aspects of a single process. Learning is recognized as a driving force behind a person's mental development and formation of totality of personal qualities in it.

Currently, a number of technologies have been developed that differ in their target orientations, content, and methodology peculiarities. Most of them are designed to teach school students, but they are also being actively introduced into institutional pedagogy. Thus, the concept of continuity and integrity of education is realized.

The key element of this technology is a comprehensive study of a personality, which is carried out by special methods and is intended not only to determine the initial level of intellectual development but also to determine the psychological characteristics of a personality, as well as leading strategies and styles of thinking. These data are further used to form optimized technological learning structures, as well as for the psychological support of the educational process, the main tasks of which are development of cognitive abilities of students, mastering of productive methods of educational activity by them, which best correspond to their personality types and development of reflexive abilities.

The following levels of knowledge mastering are distinguished:

1. *Acquisition, recognition, and familiarity*. In educational practice, this level is designated by the categories "to be acquainted" and "to have a notion." A student should be able to identify an object (a phenomenon), give its qualitative description, formulate characteristic properties, and indicate its relation to objects (phenomena) of the same kind.
2. *Copying and reproduction*. This level corresponds to the requirement "to know," implying the ability to reproduce the educational material with a specified degree of accuracy, to formulate and write down a law and definition, and to describe events and processes with sufficient completeness.
3. *Understanding* presupposes the ability to emphasize underlying cause-effect relationships in a structure of information, to present it in various forms.

4. *Skill* corresponding to the category "to be able to use," presupposing the ability to apply the knowledge gained to solve standard tasks of the relevant field of activity with possible usage of a reference material.
5. *Possession, transfer, and transformation*. This level may be identified by the category "to possess." In addition, this level allows you to transfer your knowledge and skills to other border areas of activity, to solve nonstandard tasks.
6. *Production of new knowledge*. This creative level corresponds to the categories "creative skill" and "creativity," presupposing the ability to create new socially significant objects. Traditional education did not set the goal to reach such a level; therefore, as a rule, it was not distinguished.

It should be noticed that the fifth and sixth levels are creative; they correspond to productive creative activity.

The system of methods for developing productive thinking based on the principles of creative pedagogy is equally important. It is filled with methods of developing imagination, fantasy, and abilities, not only to analysis but also to synthesis, ways, and means of overcoming stereotypes of thinking.

Currently, technologies of the developmental learning are increasingly applied in higher education (both in the traditional system of disciplines and in specialized courses of scientific and technical creativity, innovation, and training).

Computer training technologies (CTTs) are based on application of personal computers in their organic connection with learning goals, content of training, computer programs, and didactic methods of application as a means of training.

CTTs include the following components:

- Technical environment
- Software environment (a set of software means for implementation of a training technology)
- Subject environment (content of a specific subject area of science, technology, and knowledge)
- Methodological environment (instructions, methods of evaluation of effectiveness, etc.)

On this basis, a large number of *computer training means* has been implemented recently; they are automated training systems (ATS), automated training courses (ATC), computer simulators, training computer games, electronic textbooks, etc.

Application of computers in the learning process contributes to implementation of didactic principles and fills them with new opportunities:

- The principle of scientificity and usage of modern computer technology allow you to reflect in the educational process today's boundaries of science and bring students to the level of advanced knowledge.

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- The principle of visibility is implemented to a sufficient extent on the basis of multimedia technologies, image media, hypermedia, and hypertext.
- The principle of activity, working with a computer provides an increase in students' creative activity and improvement of mental processes (perception, association, intuition, etc.), which ultimately has a positive effect on the level of knowledge.
- The principle of systematicity and consistency is ensured through a programmed presentation of educational information, which determines the successful assimilation of not only the subject knowledge of the relevant science but also its structure, logic, and methods of study.
- The principle of individualization of learning is realized with the help of adaptive software that provides each student with its own level of complexity of the information provided.

Computerization of learning inevitably comes down to the processes of transfer of knowledge, on which the traditional system relies. However, just as printed materials and technical means of communication could lead to a huge expansion of possibilities of human cognition, fixation, and transfer of experience, a computer should increase the potential of human thinking and cause certain changes in the structure of mental activity.

In the learning environment created by a computer, the basic processes are organization and interpretation of information. This environment forms such characteristics of thinking as a propensity for experimentation, flexibility, coherence, and structurality. Learning conditions created by the "electronic environment" should contribute to development of creative thinking of students, to orient them to the search for nonobvious links and laws and to solve problems. Obviously, this system requires special organization of activities, interaction between teachers and students, and special learning environment.

Standard forms of information representation on the screen of a personal computer (PC) are text and graphic forms. They make it possible to use the PC widely as a learning tool, but it remains only an auxiliary, more or less supplementary to the basic, traditional means and methods. With the usage of only two forms of information transfer outside the capabilities of a personal computer, information is presented in a natural and familiar form for a person: audio, video, and animation.

No less significant lack of computer training is the lack of interactivity, that is, a student's ability to actively intervene in the process, ask questions, exercise self-control, and receive more detailed and accessible explanations for sections and fragments of educational material that are not clear to him. After all, these are methods that form the basis of learning.

However, the computer boom that has embraced our planet in the past decade has spawned new computer technologies allowing us to come close to transforming PC into a powerful educational tool, which, naturally, does not exclude the presence of a human teacher.

New CTTs, which allows to expand qualitatively training capabilities of PC and to provide interactivity of the communication process with it, have become called multimedia (from the English *multi* (a lot, many) and *media* (means)), and their usage in teaching, *multimedia technologies*. It is believed that their emergence will make a breakthrough and an unprecedented leap in the field of education.

A set of hardware and software providing such a representation of information, in which a person perceives it simultaneously and in parallel with several senses, is understood by *multimedia technology*. After all, in real life, this happens exactly when we receive more than 90% of information from the joint activity of the organs of vision and hearing, and not successively, as it is saved in PC.

To implement multimedia training technologies, it is required to have modern computers performing a large number of functions.

Despite only a decade of existence of this technology, the world has accumulated a lot of experience in development, creation, and usage of hardware and software training products. As they improve, the main advantages of multimedia are revealed.

They consist in the presence of branch points in training programs, which allows students to regulate individually the process of perception of information, whereupon, the more such points, the more intensive the program and the more flexible its usage within the learning process. Another advantage of multimedia is the ability to choose from several alternatives, followed by an assessment of correctness of each step. Current self-control is especially necessary in the process of self-education and self-learning.

Combination of audio comments with video information or animation, which allows you gradually, step by step, to explain the most complex processes in development of objects, should be recognized as an important advantage.

This type of training has one more, entertaining and emotional, advantage. Building of the learning process in the form of interactive educational games sharply increases interest and attention to a learning material, and the musical accompaniment brings esthetic satisfaction and improves quality of information.

With the usage of multimedia, the role of a teacher also significantly changes, which has become more effective in spending learning time, focusing on individual assistance to students, discussing information, and developing their creative approach.

Currently, there are quite a lot of different training courses. Of them, the most methodically prepared are interactive language courses that combine a colloquial dictionary with explanatory pictures, grammar training technique, set of situational dialogs accompanied by audio and video, as well as tests and possibility of pronunciation correction by recording the speech of a student.

The amount of knowledge generated by the mankind in the course of its development now doubles almost every 10 years. To maintain and support the scientific and educational potential of the higher school, it is necessary to provide student and teaching staff with wide and open access to accumulated information resources. The solution of this task is assigned to new distant learning forms.

Distant learning is understood as a complex of educational services provided with the help of a specialized information and educational environment at any distance from educational institutions.

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This is, first of all, a set of information technologies ensuring delivery of the major part of the learning material to students, interaction of students and teachers, provision of students with the opportunity to work independently to assimilate the learning material, and assessment of acquired knowledge, skills, and habits.

The means of implementing distant learning technology are divided into three main groups:

- Audiovisual (printed material, audio cassettes, videotapes, videodisks)
- Computer (computer training programs, electronic textbooks, models, interactive video, and multimedia programs)
- Telecommunication systems (teleconferences, videoconferences, e-mail, and video text work with databases in the direct access mode)

With the help of the telecommunication system, they give a student a wide range of opportunities for individual learning.

The distant learning technology is a combination of forms, methods, and means of interaction between a computer and a student within the process of independent but controlled mastering of a certain array of knowledge. It is built on the specific content accumulated in special courses and modules that are designed for distant learning and are located in data and knowledge banks, video libraries, etc.

The main features of the distant learning (DL):

- Freedom of choice of time and place of training, which makes it very attractive
- Provision of an opportunity to train citizens in those regions of a country, where there are no other opportunities for higher education, or citizens with physical disabilities
- The use of sophisticated modern technologies (with a fairly simple user interface), which makes the learning process more individual, effective, exciting, and interesting

As the main properties of distant learning, the following ones may be identified:

1. *Flexibility*. Students of this system basically do not attend regular classes (lectures, seminars) but work at a convenient time and at a suitable pace and place. Moreover, everyone can study as much as needed to master a subject and obtain necessary credits for selected courses.
2. *Adaptability*. The system of distant education provides each user with a choice, creation, and implementation of an individual trajectory of education or acquisition of skills.
3. *Modularity*. Distant learning programs are based on the modular principle. Each separate course creates a comprehensive view of a particular subject area. This allows forming of a curriculum, which meets individual or group needs, from a set of independent module courses.

4. *Economic efficiency*. World experience shows that the distant education costs 50% cheaper than traditional educational forms. Relatively, lower cost is provided due to usage of more concentrated representation and unification of content, orientation of teaching technologies to a greater number of students, and through more efficient usage of existing training areas and technical facilities.
5. *A new role of a teacher*. It is entrusted with such functions as coordinating the cognitive process, correcting the course taught, and consulting during preparation of an individual curriculum, management of educational projects, etc.

Distant learning technologies are one of the forms of the system of continuous education, which is designed to realize the human rights for information and education. Distant education opens equal opportunities for students and civil and military specialists in all regions of a country and abroad. This is due to more active usage of the scientific and educational potential of leading universities, various industry centers for training and retraining of personnel, as well as centers for professional development, and other educational institutions.

Modern technologies include the *modular training*. The essence of the *modular training* is that it allows each student to achieve specific goals of educational and cognitive activity independently (or with the support of a teacher). The so-called training modules serve as an educational tool.

Modular curriculum consists of a complex didactic goal (CDG) and a set of modules, M1, M2 … Mn, ensuring its achievement.

The complex didactic goal should determine the level of mastering a learning material, its use in practice, as well as in subsequent academic disciplines. To formulate a modular program, a teacher identifies the main scientific ideas of this discipline. Further, from the CDG, integrating didactic goals (IDG) are singled out, each of which has its own training module, M1, M2 … Mn. Since these modules contain large blocks of educational material, the integrating didactic goal is divided into private didactic goals (PDG), each of which has its own learning element, LE1, LE2 … LEk.

Thus, a "tree" of goals is constructed. Its top is CDG for building a modular program, the middle layer is IDG for building modules, and the lower layer is PDG for building learning elements. Management of the learning process is due to organization of control, analysis, and necessary correction. Before introduction of each new module, the input control of knowledge and skills of students and determination of the level of their readiness for mastering this module are conducted. In the course of work with each learning element, current and intermediate controls are carried out in combination with a student's self-control. After completion of work with the module, the output control is carried out in order to establish the level of mastering the material and the need for its improvement.

Development of a modular program requires from a teacher not only a deep knowledge of the material but also a high methodological skill. For effective independent work on studying the material for students, a module should be written in such words the teacher seemed talking with a student via the text, activated it to search, reasoning, and guessing. The style of writing should be accessible, focus on success, and inspire.

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Structure of a module contains a list of all learning elements included in it, for each of which information (reference to an available source), instructions with correct tasks, and recommendations for studying the content are given. Each learning element is preceded by the wording of a goal of its study, and at the end of the content part of the module, a generalization (summary) and a control task are offered.

Modular training integrates, to some extent, progressive experience accumulated in pedagogical theory and practice. In particular, the idea of activating educational and cognitive activity, which is provided by rigid logic of metered material supply and a clear system of self-control, is borrowed from the programmed learning. The system approach enriched the modular training with the idea of flexible management of the learning process due to the individual choice of the pace of mastering a material.

The great complexity of creating modules and considerable expenses for their publication and replication should be referred to the apparent disadvantages of the modular training technology. The usage of this technology requires high qualifications of teachers, their motivation, and availability to the modular training.

An important place in pedagogy is occupied by training technologies based on graphic methods of information compression. A typical example of training technologies based on graphic methods of information compression is the method of V.F. Shatalov, one of the outstanding teachers-innovators of the twentieth century. Using many years of experience in teaching mathematics and physics in the secondary school of Donetsk (Ukraine), he developed the so-called method of supportive signals in his "supportive compendium."

The supportive compendium is a compendium code, which can be recognized only by a student or teacher dedicated to it. This compendium is very concise; it contains one notebook page of the material of several lessons coded in a figurative, easily visible form. There are short key phrases, individual words and concepts, mathematical calculations, and numbers to remember on the page.

Arrangement of the material, frame, arrows, different fonts, and colors that highlight the main parts is strictly thought out and makes up a logically harmonious and systemic algorithm of reasoning, trajectory of movement of idea, and movement of thought. At the same time, this compendium is the base for a teacher's 20-minute lecture at a lesson. Naturally, when composing such a compendium, a teacher should show both its creative imagination and, to some extent, the art of presenting the maximum of information with the minimum of volume.

The annual material of a discipline (physics, mathematics, etc.) takes only 30–40 pages of a compendium. These supportive signals are then issued in a mass circulation as teaching guides, and teachers of the relevant disciplines may use them without spending much time on similar work.

Having such a supportive sheet in hands, a teacher begins a lesson with its detailed decoding, unfolding a condensed abstract into the full text. At the same time, if necessary, the teacher repeats the course of its reasoning twice or thrice at a rapid pace, without fear of repetition, while students would not see clearly a logical scheme of a question being posed.

Students independently, holding this supportive sheet before itself, recall the teacher's story and, naturally, using the textbook recommended to it, mentally unfold the scheme into the full text. Then, simultaneously, it again folds it into the supportive signal, whereupon, it does not remember and does not "cram," but works with its mind.

Here, a completely new kind of educational mental activity is proposed: folding and unfolding of a text concerning a material under study become a visual process of thinking and mastering the material.

Principles of compilation of supporting compendia:

1. *Conciseness*. Information complex (IC) in terms of perception should contain 350–500 bits. If 6–8 ICs are reflected in a compendium, the total amount of information of the supportive compendium should not be more than 3000–4000 bits or 600–800 characters. The second aspect of this principle requires a teacher to be able to tell a material on IC in 20–25 minutes. In other words, the material of a 2-hour lecture on the supporting compendium should be stated in 20–25 minutes.
2. *Structural properties*. When drawing up supportive compendia, the method of integration of didactic units of information assimilation is used, which allows presenting a material with the entire blocks and bundles. A supportive compendium contains about 4–5 blocks, the structure of which should be convenient for reproduction and memorization; that is, supportive signals are not necessarily arranged in rows but in a variety of ways.
3. *Emphasis*. The material of a supportive compendium is made "relief" by enclosing it in the framework of the most unusual configuration, using different fonts, colors, and arrangement of words (vertically, diagonally, etc.).
4. *Unification*. Symbols used as supportive signals must be unified. A situation, when in different blocks, the same symbol by inscription would have different contents, is not allowed. It is convenient to introduce certain icon symbols to indicate key or frequently repeated words (or whole combinations).
5. *Independence*. Each of the 4–5 blocks of a supportive compendium is displayed separately, with little or no link to other blocks. Thus, if one of the blocks is forgotten, the rest can be easily reproduced without it.
6. *Familiar associations and stereotypes*. Ability to skillfully select keywords is necessary. A good joke, an image, an anecdote, a drawing, etc. make it possible to revive an entire story in memory.
7. *Otherness*. Very often, when drawing up supportive compendia, the same mistake is made: they are similar as two peas in a pod. Infinite tables, circles, triangles, squares, blocks etc., as a result, are difficult to save in long-term memory. Supportive compendia should be diversified by form, structure, and graphic expression.
8. *Simplicity*. A supportive compendium should be simple for both memorization and reproduction. It is necessary to avoid fanciful fonts, complex drawings, pictures, charts, diagrams, etc.

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9. *Accuracy and clarity*. Accuracy, clarity, readability, and simplicity of graphic forms from the point of view of psychophysiological properties of a person allow to "capture" with an eye a group of letters or even words simultaneously, to increase the speed of recognizing letters and comprehending visuals.
10. *Color harmony*. Supportive compendia should preferably be in a color, the psychological aspect of which consists in influencing the mental state, which can either slow down the processes of assimilation or, conversely, promote them. First, color design of a compendium should provide a clear and comfortable perception; second, it should promote creation of an emotional uplift.

After a supportive compendium has been created, it is necessary to transfer it to a poster or make a slide and multiply it.

The next lesson in this discipline begins with the students (usually sitting with their backs to the board) on separate sheets reproducing from memory the compendium of the material from the previous lesson. At this time, four to five students are writing this compendium on the blackboards.

At the second stage, when everyone returns their test papers, an oral presentation of the material is practiced by a listener invited to the blackboard. Each student checks itself and compares its answers in its mind with the answers he has heard.

Obviously, within two training days, the compendium emerges before the eyes of a listener so many times, and the material is coded/decoded so many times that it becomes impossible to forget it.

A teacher checks knowledge in full, without spending a single minute of its off-hour time. The control is provided every day and concerns all students, because knowledge is checked in a folded form.

If the study of a material was a homework, then, at the beginning of the next lesson, students at a fast pace write a list of signals from memory and after 10–15 minutes pass it to a teacher. A teacher immediately sorts them into piles (marks five, marks four, and marks three) and announces the undeniable marks to the whole class. Those, who did not cope with the task or who did not manage it without any reproaches and edifications, get a dash in the class register, and they will have to learn and write a list of signals again.

A teacher is treated differently with tasks and examples: it does not give marks for their resolution and does not conduct any tests until the end of an academic year. As a rule, two to three typical tasks, which are mandatory for all, are solved on a lesson. A single listener solves a task at the blackboard, but the others do not write anything; they follow the blackboard, think, reason, and help. At home, each of them should solve this task again, solely, so that even the weakest student can cope. It is important that every student individually receives a set of tasks of varying degrees of difficulty for independent work.

The author of this training technology believes that everyone should study with fun, courage, and triumph. He himself leads them to victory by immensely increasing the measure of help and control. The usage of this technique confirms that it provides an increase in intensity of training by 1.2–1.5 times.

Shatalov's method has been widely used and spread in many schools in Russia and a number of other countries. It was successfully mastered and used by secondary school teachers and university professors but taking into account the specifics of vocational education.

The process of developing a specific pedagogical technology in pedagogy was called pedagogical design. It is carried out taking into account such didactic principles as scientificity, systematic character, systematicity, strength of teaching, unity of training, upbringing, and development of a student, considering individual abilities trained in the collective nature of the learning process. At the same time, the design of training technology relies on such principles of modern education as integrity, fundamentality, cultural conformity, humanitarization and humanization, connection between teaching and research, continuity of education, and link between learning and practice.

To succeed in this direction, a teacher should have certain qualities. Such qualities, first of all, are professional knowledge and pedagogical abilities.

Professional knowledge is the fundamental basis. This knowledge of a taught subject, pedagogy and psychology, forms and methods of teaching, technological organization of the educational process, and material and technical support. At the base of the teacher's work, enthusiasm concerning the subject and need for communication with students should be clearly seen.

Pedagogical abilities are individual prerequisites for successful activity and stimulators of professional growth. They point out the specifics of implementation of psychological processes and capability to find such technological approaches to the learning process that would contribute to successful pedagogical activity.

Evaluation of effectiveness of a training technology consists of the following components:

- Evaluation of completeness of presentation of educational information, which is revealed in the course of objective control of training lessons and inspection (final control)
- Evaluation of training results, which is made in the course of the current progress control
- Intermediate attestation of students
- Final state attestation
- Reviews on graduates

Given the increase in the level of knowledge, skills, and abilities, it is difficult to evaluate assimilability of a material theoretically. It is possible to analyze this only on extensive empirical material, comparing the average scores of students' progress by traditional and innovative technologies.

Therefore, training technology is a scientifically based system of methods, ways, techniques, and technical means that provides training with specified indicators of a certain category of students with respect to this subject in conditions that take into account temporary and financial and economic constraints.

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8. Conclusion

Any science including pedagogy is most commonly defined as the scope of human activity. Development and theoretical systematization of objective knowledge of reality take place in it. In general, *pedagogy* as a field of scientific disciplines on upbringing, training, and education of a person reveals laws of the pedagogical process, as well as formation and development of a personality in it. The main categories of pedagogy reflect its essence. Significant categories are self-education, self-improvement, pedagogical process, and pedagogical interaction. Creative application of various technologies in pedagogy is of particular importance now.

The application of teaching technologies presupposes an organizational arrangement of all the dependencies of the learning process, the alignment of its stages, the identification of the conditions for their implementation, and the correlation of methods, forms, methods, and means of instruction in conducting classes, with the abilities of the instructor and students. Modern educational technologies allow us to consider pedagogy with the modern realities of learning, education, and human development.

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Chapter 13

Style E Tactical Pedagogical Model

Sanmuga Nathan

Additional information is available at the end of the chapter

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Abstract

This chapter reveals the early development of eclectic game-based pedagogical model labeled as the Style 'E' Tactical (SET). The SET underpins Style E from Spectrum of Mosston teaching styles, variations of Teaching Games for Understanding (TGfU) models and constraints-led theory. The efficacy of SET was first tested as an experimental research comparing with two other teaching approaches developed from Mosston teaching styles and TGfU known as Style B Tactical and Style H Tactical among secondary school boys. The findings revealed that the SET achieved learning outcomes that were better than, or equal to, the results obtained from the two other teaching approach, as for speed, knowledge, skill execution, and tactical decision-making in field hockey. In another research tested among Malaysian aborigines' primary school students in 5 versus 5 mini soccer games, findings indicated no significant difference in skill execution between SET and TGfU pedagogical models. Whereas in handball study, findings indicated significant improvement via TGfU, SET for skill execution, and decision-making in 4 versus 4 game play, increased in knowledge and interest compared to the technical model. To conclude, this SET could bridge the disparity between varying student-teacher centered in game learning; however, more research is needed to fulfill the claim.

Keywords: SET pedagogical model, game play, varying skill levels, Mosston teaching styles, TGfU

1. Introduction

Physical education (PE) teachers may agree that helping elementary students mastering basic fundamental motor skills at times is very challenging as many will agree that direct instruction would be one of the best teaching approaches dealing with less-skilled and slow learners. Whereby, the fundamental motor skills such as catching, kicking, running, striking, throwing, jumping, and so on play an integral role as prerequisite elements for game play. Those students

with good grasp of these fundamental skills are able to catch up game play competence in secondary school much more easier compared to those students who are weak in fundamental skills. Therefore, the dilemma exists in game play instruction, when to use direct instruction or indirect such as employing game-based approaches (GBAs). In the lens of Malaysian PE classes, direct instruction approach via demonstration of skills and skill-led drills approach still considered useful before introducing game play approach for students in early primary years and secondary school in learning games. Based on some preliminary research in hockey and badminton, students need to be taught to practice game skills via skill drills prior introducing to tactical guided discovery game play approach. On the other hand, GBAs such as Teaching Games for Understanding (TGfU), Game Sense, and Play Practice, which are much sought types of pedagogical model via student-centered tactical inquiry approach, seem to be global approach [6, 15].

Tactical pedagogical model such as TGfU is a favorable global game learning approach proven by numerous research findings. However, when handling this approach, one must act with caution [5, 19, 20]. At times, this approach seems to be conundrum for slow and low-skilled learners to solve their game play problems as their cognition level, skill, and fitness do not support this approach. As game play configurations require players to grasp various elements such as basic motor skills, fitness, game tactical knowledge, rules and regulation, concentration, cooperation, and so on. Therefore, it is upheaval task for teachers to plan game activities especially employing tactical approach. What more in different situational learning environment with traditions, politics, and philosophy pose challenges for teacher in planning game play via GBAs.

Teaching games and enhance game playing abilities require a teacher to design various learning task considering students' varying abilities, learning environment, and biological and chronological developmental age. This requires teacher and educator to use different and eclectic models in dealing with students' varying abilities in game teaching and learning. Models seem to be entrusted game teaching and learning approach lately as it seems to be more holistic in curriculum alignment in sense of content, pedagogy and assessments [10, 16].

In the context of game teaching-learning in PE classes, the overall purpose of any means of instructions to fulfill three learning domains viz. psychomotor (motor), cognitive and affective. As Barret reiterated that all students learning tasks in PE be it motor, cognitive, and affective aspects require deliberate consideration and planning to cater the varying students' skill and ability levels. For example, motor aspect of passing a ball in hockey including hitting and pushing the ball to the partner. The skill of executing hitting and pushing to pass the ball, this skill needs to be learned before the players able to execute automatically [1]. Meanwhile, the affective aspects that include feeling of continuity of flow and the feeling of cooperation in executing the hockey task, players need to mold as well, whereas the cognitive aspects that include deciding whether to dribble or passing and deciding where to send the ball so as to score goals. Therefore, it is pertinent to consider these three domains, especially, and the motor domain as well as the cognitive and affective domain before preparing game play tasks, which are complex and chaotic for learning [8, 9].

Sometimes, it is necessary to group children by their ability levels in invasion games. Experts highlighted, a child who cannot run fast can never be tagged as the fast runner, so playing

game is embarrassing for the slow runner and boring for the fast runner while playing with low-skilled runner or player [19]. Those children who are involved in after school experience in playing invasion games such as soccer, hockey, and basketball, to name some, can dominate learning tasks and playing games in physical education context to an extent than the less-skilled children. At most of the times, less-skilled children never get opportunities to practice passing because high-skilled children tackle and steal the ball quickly. Therefore, opportunity should be given in learning tasks or game play according to the children's skill and ability group. Teachers through their instructional approach can group the children based on their skill level and do not announce that you are arranging groups by ability and skill level, just do it [21].

Metzler highlighted that there has been a shift in the research paradigm among authors with the majority of research into skills-based learning becoming largely irrelevant in game teaching. Moreover, model-based approaches such as TGfU, Sports Education model, Fitness model to name a few seem to be much-sought instructional model in physical education lately compared to teaching styles instruction [10]. On the contrary, motor learning exponents heightened the importance of the influence of constraints-led theory factors such environment, task and performer that can shape game learning and game performance. As mentioned earlier, environments may influence children or students to grasp higher skill or ability than students who do not involve in after school activities. Considering on such scenario, it is pertinent for teachers to choose the right type of teaching and learning instructions and activities to cater all levels of students to match the motor, cognitive and affective levels.

Therefore, considering these pitfalls and pedagogical dilemmas, the author of this chapter introduces an eclectic pedagogical model known as Style E Tactical (SET). The development of Style E Tactical (SET) evolved around Style E or inclusion of Mosston teaching style, the original model of TGfU, revised TGfU model supported by tactical framework elements from Tactical Game Model by Mitchell, Grffin and Oslin and some elements from constraints-led theory [2, 7, 11, 14–17].

2. SET pedagogical development

Theoretical background provides the provisions and guiding principle for the author to develop pedagogical model of Style E Tactical (SET). First, the author unpacked the underpinnings of spectrum of Mosston and Ashworth teaching style that do have some unique styles that are able to address and shaping of players on learning to play game [12]. As depicted in **Figure 1**, there are 11 styles arranging from teacher's centered teaching to student-centered learning styles. However, in this present SET pedagogical model, the Inclusion Style or Style E from this spectrum was selected. As this teacher-centered behavioral style as teacher provides opportunities for individual students or in groups to practice a task at their chosen entry level of difficulty. Furthermore, they too self-assess their performance using established teacher-prepared criteria sheet. The early part of this lesson labeled pre-impact or the planning stage as the teacher prepares the task of subject matter or content and materials with different entry

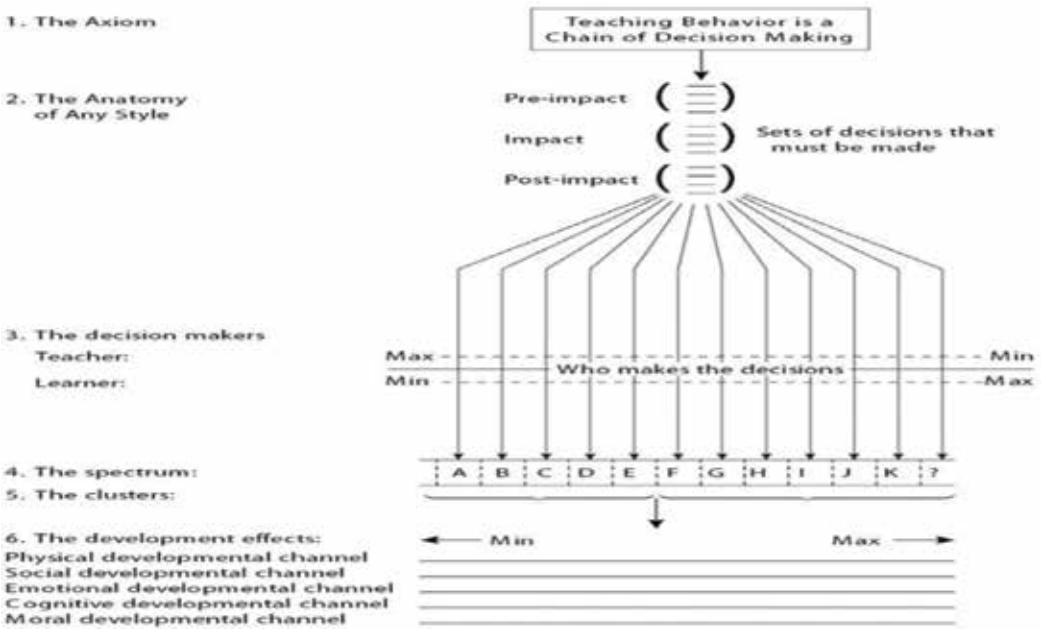

Figure 1. Mosston and Ashworth teaching styles (with permission from Sara Ashworth).

of difficulty level for all learners so that varying students will enjoy and capable of doing the planned task by the teacher. Next, the impact stage deals with the task or lesson intervention, while post-impact refers to reflection on teaching had on students learning.

On the other hand, the original TGfU model with six steps of learning as illustrated in **Figure 2** was coined practically in Loughborough University in the late 1960s, much more sought learning game play model via tactic skill learning approach compared to linear and structured skill-led model [2, 13] despite TGfU being established as the instructional model globally in game curriculum of physical education and coaching setting. However, as mentioned by Kirk and Macphail, the original TGfU should be aligned with the emergence of new learning theory to stay relevant, therefore, revised TGfU model as reflected in **Figure 3** also play an important role in supporting the original TGfU model [7].

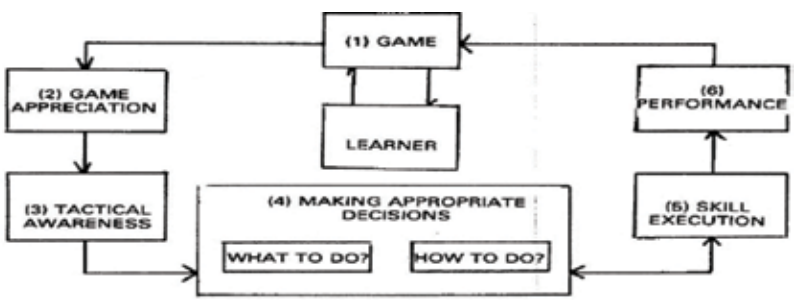

Figure 2. Original TGfU model with permission from Rod Thorpe.

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The original and revised models of TGfU [2, 7] were further blended with Tactical Game Model (TGM) by Mitchell, Griffin and Oslin [12]. As TGM proposes attacking strategy, defending strategy, and restarting as integral part, tactical strategy of game play as well as the importance of assessment in a game play, hence, Game Performance Assessment Instrument (GPAI) was introduced to assess the tactical decision-making, skill acquisition within small-sided game play situations [14].

Skill acquisition stems robustly among motor learning theory generator for long time and skill execution crucial for any game play. These motor learning advocates the values of constraints-led theory (CLT) in shaping and chaining players with game skills, movement skills and game play knowledge. The motor learning proponents argue that the constraints-led framework can help physical educators to build their teaching and learning instruction using different tasks, level of performer, and environmental constraints to explain how learners acquire movement skills and decision-making behaviors. The constraints-led approach was developed based on ecological psychology and dynamical system. The constraints-led theory, as shown in **Figure 4**, is divided into three categories such as performer, environments, and task as these factors that interact shape students' behaviors as created by Newell to provide a framework for understanding how skills and movement patterns emerge during task performance [17].

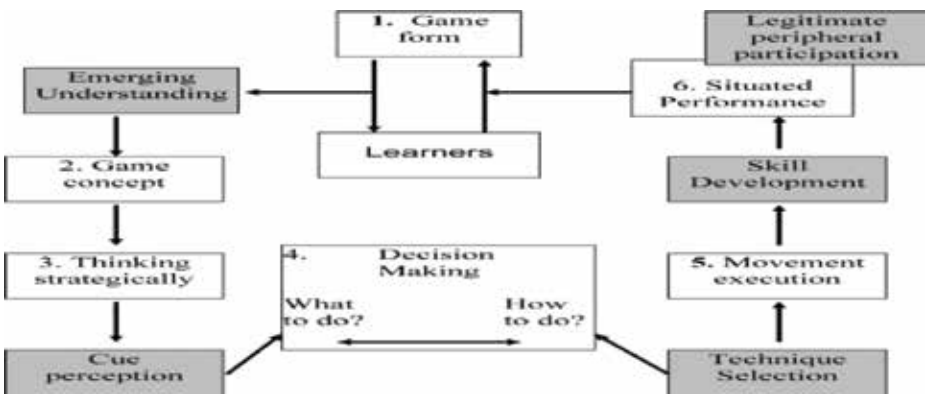

Figure 3. Revised TGfU model by Kirk and Macphail [7] with permission from Prof. David Kirk.

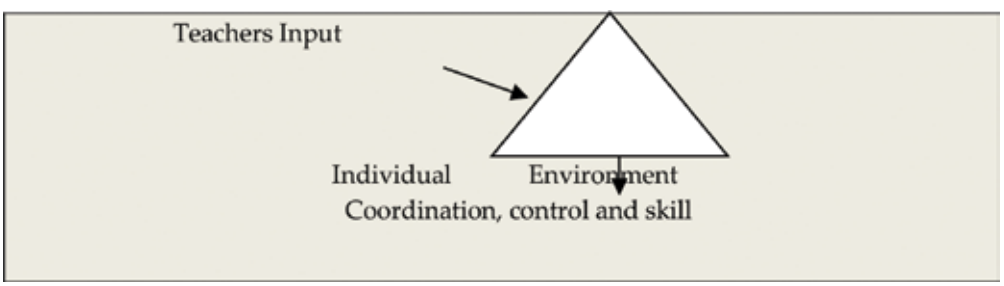

Figure 4. Constraints-led theory.

2.1. The SET pedagogical model development

The innovative pedagogical model of Style E pedagogical model (SET) still at initial stages of development specially designed for invasion types of games learning such as hockey, soccer, and so on. The heuristic is being developed by principal researcher and SET creator Sanmuga Nathan [15, 16]. This model dwelled using various combination predominantly using Mosston's teaching style of E (Inclusion Style) in terms of pre-impact, impact and post-impact framework and activities merged with six steps of learning from original model of TGfU [2] and skill drills development and cues from revised TGfU model. Besides, this SET pedagogical underpins three important elements (task, performer and environment constraints) of constraint-led theory [17]. As learning game play and game performance to a great extent underpins the influence of learning task, the performer or students and environment condition during practicing game play. Therefore, lesson task designed by the teacher should consider the level of performers.

What is of value is an exploration of these models, from an integrated perspective, with the possibility that such a model could provide a firm basis leading toward the development of a stronger conceptual framework for teaching invasion games, with the additional bonus of optimization of individuals' different performances [16]. However, to date, still lack of research and practical experience in addressing players with different ability, skill level and environmental constraints learning the game play and upgrading game performance. The teaching and learning dovetails do consider the important dynamics of social interaction and emotional values of a varying range of students' skill levels and ability [15, 4]. As such, the SET pedagogical model aims to cater for students at different entry learning levels as well as a learner's emotional and social characteristics.

As **Figure 5** represents schematic SET pedagogical caters students' varying skill abilities. With the intention of catering for students who have different levels of ability in games (high, medium and low), the emerging eclectic pedagogical model of SET was conceived to achieve an improvement in psychomotor, cognitive and affective learning output and outcomes as to support the product and process curriculum. Thus, the principal aim with this approach is to improve learning process and game play performance in terms of tactical decision-making and skill performance as well as social–emotional values. Through the application of the SET model, there is every probability that students' game learning and playing competency can be upgraded. The heart of SET pedagogical model and the lesson tasks were prepared during preimpact stage in three different difficult entry levels viz. high, medium, and low difficulty levels to cater students in three different skill levels. Meanwhile, in impact stage, the teacher clustered students into high-skilled, medium-skilled and low-skilled without informing the group according to their skill levels and enable them to engage tasks according to their skill level. Their game play task follows the sequence of activities: first activity involves warming-up and game-related strategies. The second activity is based on analyzing tactical topic, application discussed tactic in small-sided game play, and some tactical drills. The third

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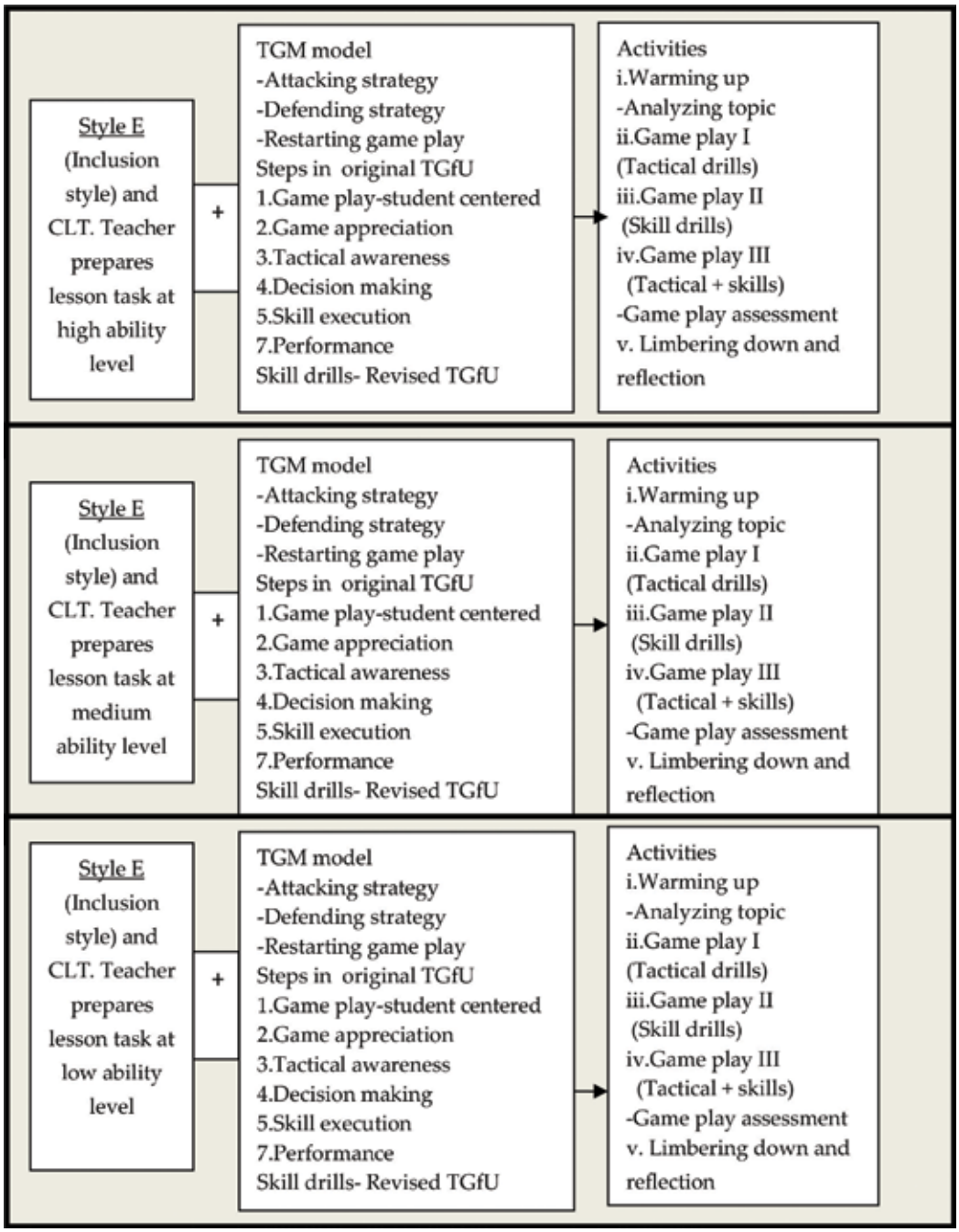


Figure 5. Schematic SET pedagogical caters students' varying skill abilities.

activity revolves around skill discussion and application skill execution in small-sided game play plus skill drill activities. Then, the fourth activity proposes efficient application tactical-skill in game play situation, as at this stage, the students will be evaluated using modified game play observation instrument (GPAI) and limbering down. Oral and written reflection will made by students and teacher at the post-impact lesson stage.

Table 1 illustrates some lesson guiding principle and tactical framework (attacking strategy, defending strategy and restarting game play) in planning game-based lessons for invasion game such as field hockey, while **Table 2** depicts wall and net game play herewith an example of badminton game play. The game lesson dwelled around using tactical topics, learning standard (1 refers to Psychomotor, 2 refers to cognitive and 3 refers to affective standards), learning objectives through psychomotor, cognitive and affective domains correspond to learning standards through SET pedagogical model.

Unit	Topics: tactical problems/ assessments	Learning objective domains	Learning standards
1	**Scoring** Maintaining ball possession Adopted GPAI Affective domain assessment	**Psychomotor:** To create players who are able to possess, retain the ball, and be able to make accurate passes to teammates **Cognitive:** So players can utilize the declarative knowledge of the games and are able to make basic tactical decisions during the game **Affective:** To learn to enjoy the game play	1. Able to execute ball control and execute accurate passing skills of in field hockey 2.1. Able to describe the importance of ball control and passing skills. 2.2. Able to justify when and where to use passing skills. When and where to apply open space tactics while attacking and when to cover while applying defending strategy during 2 vs 2, 3 vs 3, and 5 vs 5 game play 3. Able to demonstrate happiness while engaging in the activities
2	**Scoring/attack** - Attacking the goal - Creating space in attack Adopted GPAI Affective domain assessment	**Psychomotor:** To permit players to be able to control the ball and make skillfully make accurate passes, dribble, anticipate, tackle and score goals To enhance players, not in possession of the ball, ability to be able to provide "width" and support to the attacking players **Cognitive:** Players are able to make meaningful tactical decisions related to passing, dribbling, tackling and scoring goals Affective: To enable players to enjoy the game	1. Able to execute ball control and execute accurate skills of passes, dribble, anticipate, tackle and score goals in field hockey 2.1. Able to describe the importance of passes, dribble, anticipate, tackle and score goals in field hockey. 2.2. Able to justify when and where to use passes, dribble, anticipate, tackle and score goals. When and where to apply open space tactics while attacking and when to cover while applying defending strategy during 2 vs 2, 3 vs 3, and 5 vs 5 game play 3. Able to demonstrate happiness while engaging in the activities
3	Prevention of scoring/defense - Defending space - Winning the ball Adopted GPAI Affective domain assessment	Psychomotor: Players know how to defend the space and goal from the attacking team. Players are able to use skill, such as ball control, passing, dribbling, anticipating, and tackling in defense. So that players can repossesses the ball from attacking players Cognitive: Players are able to make correct tactical decisions using declarative and procedural knowledge to win the ball when	1. Able to defend space and goal skills from attacking team in field hockey 2.1. Able to describe the importance such as ball control, passing, dribbling, anticipating, and tackling in defense in field hockey. 2.2. Able to justify when and where to use passes, dribble, anticipate, tackle and score goals. When and where to apply open space tactics while attacking and when to cover while applying defending strategy during 2 s 2, 3 vs

Unit	Topics: tactical problems/ assessments	Learning objective domains	Learning standards
		defending space Affective: So that the students enjoy the game	3, and 5 vs 5 game play 3. Able to demonstrate happiness while engaging in the activities
4	Prevention of Scoring -Winning the ball Adopted GPAI Affective domain assessment	Psychomotor: So that players are able to use skill such as ball control, passing, dribbling, anticipating, and tackling in defense. Players can repossesses the ball from attacking players Cognitive: Tactical decision making using declarative and procedural knowledge to win the ball back Affective: Appreciation and enjoyment of the game play	1. Able to use skill such as ball control, passing, dribbling, anticipating, and tackling in defense in field hockey 2.1. Able to describe the importance in field hockey. 2.2. Able to justify when and to use skill such as ball control, passing, dribbling, anticipating, and tackling in defense and repossesses the ball from attacking players. When and where to apply open space tactics while attacking and when to cover while applying defending strategy during 2 vs 2, 3 vs 3 and 5 vs 5 game play 3. Able to demonstrate happiness while engaging in the activities
5	**Restarting Play** - Push in - Hit in Adopted GPAI Affective domain assessment	**Psychomotor :** So that the players will employ correct push or hit skills with accuracy during the restarting of the game **Cognitive:** To encourage players to make correct tactical decisions, using declarative and procedural game knowledge **Affective:** So that the students enjoy the game play	1. Able to employ correct push or hit skills with accuracy during the restarting of the game 2.1. Able to describe the importance push and hit in field hockey. 2.2. Able to justify when and to use skill such as push or hit skills with accuracy during the restarting of the game. When and where to apply open space tactics while attacking and when to cover while applying defending strategy during 2 vs 2, 3 vs 3, and 5 vs 5 game play 3. Able to demonstrate happiness while engaging in the activities

Table 1. Invasion game topics, learning standard, learning objectives, and assessment.

On the other hand, **Tables 3a** and **3b** provides a lesson plan and task card using SET pedagogical model for hockey, while **Tables 4a** and **4b** illustrate a lesson plan and task card for badminton. These lesson plans were planned based on learning content, learning standard, learning objectives in terms of psychomotor, cognitive, and affective domain, teaching aids, ways to foster critical and creative thinking skills and assessments based on three objectives domain. The manipulation of lesson activities based on different game situation, discussion and application of tactics, skills via guided discovery approach predominantly and some skill drills with cue perception to improve skill developments, different task cards for students in varying skill groups of high-skilled (HS), medium-skilled (MS) and low-skilled (LS). As per lesson, each group of students will be provided with task cards to assist their learning pursuit as depicted in **Tables 3b** and **4b**.

Standard-based curriculum propagates the importance of curriculum alignment of instructional design and assessment. Therefore, **Table 5** presents game play instrument adapted from

Unit	Topics: tactical problems, assessments	Learning objectives	Learning standards
1	Restarting (Service) Scoring strategy Adopted GPAI Affective domain assessment	**Psychomotor**: Students able to execute badminton skills of high, low forehand and backhand service, technically sound in game play situations **Cognitive**: Students able to discuss and apply where to send high, low forehand and backhand back service during offensive strategy in badminton game play situations **Affective:** Students able to take responsibility to organize, administer positive and encouraging doubles mini game play situations	1. Able to execute high, low forehand backhand service badminton game play 2.1. Able to describe high, low and backhand service. 2.2. Able to justify when and where to use low and high service 3. Able to demonstrate happiness while engaging in the activities
2	Scoring strategy and defending strategy Adopted GPAI Affective domain assessment	**Psychomotor**: Students able to execute badminton movement skills to the base, forehand overhead clear as well as underhand stroke of clear, technically sound in and singles doubles mini game play situations **Cognitive**: Students able to discuss and apply when and where to create space in attacking strategy and close space during defending strategy in doubles mini game play situations **Affective:** Students able to take responsibility to organize, administer positive and encouraging doubles mini game play situations	1. Able to execute movement skills to base, as well as able to executive skills of forehand overhead-underhand stroke of clear in badminton 2.1. Able to describe various movement skills to base, skills of underhand and overhead stroke of clear. 2.2. Able to justify when and where to use underhand and overhead stroke of clear. When and where to apply open space and close space tactics while attacking and defending strategy during doubles game play situations 3. Able to demonstrate happiness while engaging in the activities
3.	Scoring strategy and defending strategy Adopted GPAI Affective domain assessment	**Psychomotor**: Students able to execute badminton movement skills to the base, forehand overhead clear as well as underhand stroke of clear, technically sound in doubles mini game play situations **Cognitive:** Students able to discuss and apply when and where to create space in attacking strategy and close space during defending strategy in doubles mini game play situations **Affective:** Students able to take responsibility to organize, administer positive and encouraging doubles mini game play situations	1. Able to execute movement skills to base, forehand overhead-underhand stroke of clear in badminton 2.1. Able to describe various movement skills to base, skills of underhand and overhead stroke of clear. 2.2. Able to justify when and where to use underhand and overhead stroke of clear. As well as when and where to apply open space and close space tactics while attacking and defending strategy during doubles game play situations 3. Able to demonstrate happiness while engaging in the activities
4.	Scoring strategy and defending strategy Adopted GPAI Affective domain assessment	**Psychomotor**: Students able to execute badminton forehand and backhand drop short, technically sound in doubles mini game play situations **Cognitive**: Students able to discuss and apply when and where to create space in attacking strategy and close space during defending strategy in doubles mini game play situations **Affective:** Students able to take responsibility to organize, administer positive and encouraging doubles mini game play situations	1. Able to execute executive skills of forehand and backhand overhead drop short badminton 2.1. Able to describe various movement skills to skills of underhand and overhead drop short. 2.2. Able to justify when and where to use underhand and overhead drop short. As well as when and where to apply open space and close space tactics while attacking and defending strategy during doubles game play situations 3. Able to demonstrate happiness while engaging in the activities

Unit	Topics: tactical problems, assessments	Learning objectives	Learning standards
5.	Scoring strategy and defending strategy Adopted GPAI Affective domain assessment	**Psychomotor**: Students able to execute badminton forehand and backhand drop short, technically sound in doubles mini game play situations **Cognitive**: Students able to discuss and apply when and where to create space in attacking strategy and close space during defending strategy in doubles mini game play situations **Affective:** Students able to take responsibility to organize, administer positive and encouraging doubles mini game play situations	1. Able to execute executive skills of forehand and backhand overhead drop short badminton 2.1. Able to describe various movement skill to skills of underhand and overhead drop short. 2.2. Able to justify when and where to use underhand and overhead drop short. As well as when and where to apply open space and close space tactics while attacking and defending strategy during doubles game play situations 3. Able to demonstrate happiness while engaging in the activities

Table 2. Net/wall game topics, learning standard, learning objectives, and assessment.

Class: Grade 5-6 **Time: 8.00-9.00 Topic: attacking strategy, ball control, and dribbling**

Learning standard:

1. Able to execute ball control, dribbling skills of in field hockey. 2.1. Able to describe the importance of ball control and dribbling skills .2.2. Able to justify when and where to use dribbling skills. When and where to apply open space tactics while attacking and when to cover while applying defending strategy during 2 vs 2, 3 vs 3, and 5 vs 5 game play. 3.1. Able to demonstrate happiness while engaging in the activities

Learning objectives

Psychomotor: Students different skills group (High Skills (HS), Medium Skills (MS), and Low Skills (LS) able to execute ball control, dribbling and cover skills, technically sound in 2 vs 2, 3 vs 3, and 5 vs 5 game play situations

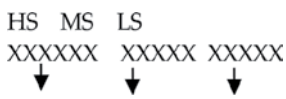
Cognitive: Students able to discuss and apply when and where to create space in attacking strategy and cover space during attacking and defending strategy in 2 vs 2, 3 vs 3, 5 vs 5 game play situations

Affective: Students able to take responsibility to organize, administer positive and encouraging doubles mini game play situations

Elements across curriculum (EMK): Creative and critical in examining tactics and skills in field hockey. **Teaching aids**: Racket, shuttle, nets, skittles, poster, video

Evaluation of T&L: Skills execution and tactical decision making base on modified GPAI observation instrument.

Reflection: By teacher and students reflection using affective assessment

Learning development	Activities of T& L (instructional activities)	Organization	Discovery (discussion and questions)
Preimpact (planning done by teacher)	Teacher plans activities based on students' different ability levels (HS, MS, and LS)	Teacher divides students based on ability level, without telling them their ability level. Teacher guides the group to choose the activities such 2 vs 2. 3 vs 3, and 5 vs 5. Adjusting game play size, goalmouth, ball and so on.	Topic of discussion difficulty varies according skill groups. Groups will provided with task cards.
Phase 1 Discussion on strategy of attacking and defending tactics, Dynamic warm-up with hockey sticks	**Warming-up** activities with sticks and ball using zigzag running and ball control skills with roll and tap as dominant activities	Based on skill groups. Students in the given specific area roll, tap and control ball ac warming up activities 	Q: Why do roll and tap ball A: To control ball and important for 3 vs 3 dribbling activities.

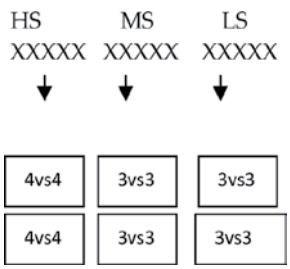
Phase 2 Planning and applications of tactics and skills (15 min)	**Mini game 1** Creating space for attack and closing space and cover while defending 3 vs 3 (HS)/12 min (2 sets of goal mouth), 3 vs 3 (MS)/10 min (1 set of goal mouth), 3 vs 3 (LS)/8 min (1 set of goal mouth)		Q: How do you attack the goalmouth? A: Passing, looking open space to attack at goal mouth. Q: How do you cover your opponent from scoring in your goalmouth? A: Man-man tackle or zone marking.
Phase 3 Skill drills (15 min) Planning and applications skills ball control, dribbling and cover in game play (15 min) Adapted GPAI observation	**Group skill drills** i. Dribble and ball control in pairs ii. Cover in two pairs. **Mini game 2** 4 vs 4 (HS)/12 min (2 sets of goal mouth),12 min 3 vs 3 (MS)/10 min (1 set of goal mouth), 3 vs. 3 (LS)/8 min (2 set of goal mouth)		Q: How do dribble ball A: Using low or high dribble especially employing India dribble technique.
Phase 4 Reflection (5 min) Affective Assessment	Closure Reflection and cooling down	XXXXXXXXX (HS, MS, LS) T (Teacher)	Cooling down Summary and reflective discussion.

Table 3a. An SET pedagogical model lesson plan for field hockey.

HS group	MS group	LS group
Learning task 1 Mini game situation 1 Task: Creating space for attack and closing space and cover while defending in 3 vs 3 for 12 min (2 sets of goal mouth) Skill drills in groups **i.** Dribble and ball control in pairs **ii.** Cover in two pairs **Learning task 2** Mini game situation 2 Task: Efficient skill execution in 4 vs 4 for 10 min (4 set of goal mouth)	**Learning task 1** Mini game situation 1 Task: Creating space for attack and closing space and cover while defending in 3 vs 3 for 10 min (1 set of goal mouth) Skill drills in groups **i.** Dribble and ball control in pairs **ii.** Cover in two pairs **Learning task 2** Mini game situation 2 Task: Efficient skill execution 3 vs 3 for 10 min (2 sets of goal mouth)	**Learning task 1** Mini game situation 1 Task: Creating space for attack and closing space and cover while defending in 3 vs 3 (LS)/8 min (1 set of goal mouth) Skill drills in groups **i.** Dribble and ball control in pairs **ii.** Cover in two pairs **Learning task 2** Mini game situation 2 Task: Efficient skill execution in 3 vs 3 (LS)/8 min (2 set of goal mouth)

Table 3b. A task card for field hockey game play activities.

GPAI instrument with permission from Mitchell, which is able to assess students' game play performance in terms of psychomotor, cognitive domain, and affective domain-based SET pedagogical model. Based on adapted GPAI instrument, teacher can observe students' varying skill levels modified small-sided game through various parameters of game play such as psychomotor domain ball control, support players without ball, skill execution (passing, dribbling, tackling and scoring), cognitive domain, (passing, dribbling, tackling, and scoring), and affective domain (positive and negative behaviors as reflected in **Table 6**).

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Class: Form one **Time: 8.00-9.00 Topic: Badminton (Forehand stroke)**

Learning standard:

1. Able to execute high, low forehand backhand service badminton game play. 2.1. Able to describe high, low forehand, and backhand service. 2.6.3. Able to justify when and where to use low and high service. 3. Able to demonstrate happiness while engaging in the activities

Learning Objectives

Psychomotor: Students able to execute badminton skills of high, low forehand and backhand service, technically sound in game play situations

Cognitive: Students able to discuss and apply where to send high, low forehand and backhand back service during offensive strategy in badminton game play situations

Affective: Students able to take responsibility to organize, administer positive and encouraging doubles mini game play situations

Elements across curriculum (EMK): Creative and Critical thinking in examining tactics and skills

Teaching Aids: Racket, shuttle, nets, skittles, poster, video

Evaluation of T &L: High and low service execution and tactical decision making (GPAI instrument)

Reflection: By teacher and students (before, during and after game play)

Learning development	Activities of T& L (instructional activities)	Organization	Discovery (discussion and questions)
Pre-impact (Planning done by teacher)	Teacher plan activities based on students different abilities level (HS, MS and LS)	Teacher divide students base on ability level, without telling them their ability level. Teacher guides the group to choose the activities	Topic of discussion: Question for discussion varies difficulties according skill groups. Groups will be provided with task cards.
Phase 1 Warm up, and followed discussion o skills (10 min)	Warm-up: students in HS and MS practicing footwork from the base to the base of court. Looking at pictures and video students create warming up activities via footwork. LS play forehand service game with volleyball	Half court singles	Q: Why footwork important in badminton game play? (HS and MS). Q: How to execute footwork? (HS and MS). Q: Where do you send the softball so that you win a point (LS)?
Phase 2 Planning and applications of tactics and skills (15 min)	**Mini game situation 1** (Creating space): Push and attacking opponent at open space at the back. Work across the grid in half court singles using overhead clear	Half court single 1 vs. 1 (Forehand grip and game play, Q&A, 15 minutes for HS) .1 vs 1 (Forehand grip and game play 12 min for MS) 1 vs 1 (forehand grip and game play with Q &A 12 min for LS)	Q: How do you score a point in badminton? (HS, MS, LS)) Q: How do you stop your opponent from scoring? (HS, MS, LS) Q: How can you push your opponent back? (HS, MS) After pushing your opponent back at baseline, where the space you can attack? (HS, MS). Q: How do you attack the front space rather? (HS) What skill do you use? (HS and MS)
Phase 3 Planning and applications of skills (Q& A forehand high	**Skill drills** **Forehand service**	Half court singles 1 vs. 1 (forehand high and low service)	Q: What sort of service, could you use or single and doubles game play? (HS, MS).

and backhand low service application in skill drills and game play) (30 min) Teacher teach forehand and backhand service (LS)	 **Mini game situation 2** **i.** Application of forehand high, low service in single using half court. **ii.** Skill drills **Backhand service**  **Mini game situation 3** ii. Application of backhand low service in single using full court	2 vs 2 (backhand low service)	Q: When do you use forehand high, low and backhand service? (HS, MS). Q: How to execute forehand service? A: *Forehand grip. Shake hands with racquet, thumb on ten o'clock, all four fingers wrapped around the grip. Thumb and first finger of the hand create a "V" shape on the racket handle. Palm is leading the movement, fingers are spread* Q: How to execute backhand service? (HS, MS).A: *Use a short, relaxed thumb grip. Place the racket out in front of the body. Place shuttle on racket. Backswing. Take the racket back a short distance. Open racket face slightly. Make forward swing. Push through and strike the shuttle out of the hand and follow through.*
Phase 3 Reflection (5 min)	Closure Reflection and cooling down	Whole	Cooling down Summary and reflective discussion.

Table 4a. An SET pedagogical model lesson plan for badminton.

2.2. Research findings

The initial work of SET model was compared with two other developed teaching models, which have combination of TGfU and Style B and H from Mosston teaching style characteristics. These two styles labeled as SBT (Style B combined with Tactical element of TGfU) and SHT (Style H combined with tactical elements of TGfU) [14]. Through the application of the SET model to practical game training in the sport of field hockey, this model was tested and evaluated using balanced factorial design with repeated measures technique. Analysis of the results revealed that the SET model achieved learning outcomes that were better than, or equal to, the results obtained from the two other teaching models for most learning domains (general skill, knowledge and ball control, decision-making, skill execution in mini game play and interest) specifically for the sport of field hockey. As for speed and accuracy for the execution of general hockey skills, it is revealed that the SET model together with SBT and SHT training models demonstrated a significant improvement in speed and accuracy, immediately after the training intervention (posttest 1), Wilks' Lambda = .888, $F(4, 426) = 6.492$, $p < 0.01$. The SET

HS group	MS group	LS group
Learning task 1 Warm-up: students in HS practicing footwork from the base to the base of court. Looking at pictures and video students create warming up activities via footwork. **Learning task 2** Tactical (Creating space) 1 vs. 1 (Forehand grip and creating space game play 15 minutes, via Q&A, **Learning task 3 (30 min)** Q & A Forehand service and skill drills **Mini game situation 2**. Application of forehand high, low service in 1 vs 1. Q & A backhand service and skill drills **Mini game situation 3**.: Application of backhand low service in single using full court	**Learning task 1** Warm-up: students in MS practicing footwork from the base to the base of court. Looking at pictures and video students create warming up activities via footwork. **Learning task 2** Tactical (Creating space) 1 vs. 1 (Forehand grip and creating space game play 12 minutes, via Q&A, **Learning task 3 (25 min)** Q & A Forehand service and skill drills **Mini game situation 2**. Application of forehand high, low service in 1 vs 1. Q & A backhand service and skill drills **Mini game situation 3**.: Application of backhand low service in single using full court	**Learning task 1** LS play forehand service game with volleyball Learning task 2 Tactical (Creating space) Half court single 1 vs 1 (Forehand grip and creating space game play 12 minutes though teacher instruction) **Learning task 3 (20 min)** Forehand service and skill drills – teacher instruction **Mini game situation 2**.: Application of forehand high, low service in 1 vs 1. Backhand service and skill drills – teacher instruction **Mini game situation 3**.: Application of backhand low service in single using full court-teacher instruction

Table 4b. A task card for field badminton game play activities.

training model showed that performance was retained from posttest 1 to posttest 2 without the training intervention of speed of execution of general hockey skills as compared with the other two training models $F(2,148) = .201$, $p < 0.01$. As for declarative and procedural knowledge, the three programs SET, SBT, and SHT training programs indicated significant improvement at posttest 1, with Wilks' Lambda = .920, $F(4, 420) = 4.51$, $p < 0.01$. On the other hand, for ball control, decision-making (passing, dribbling, tackling, scoring) and skill execution (passing, dribbling, tackling, scoring) showed that the SET model together with SBT and SHT training models produced significant improvement immediately after training intervention for ball control, decision-making and skill execution in 3 versus 3 game play at posttest 1, Wilks' Lambda = .676, $F(6, 188) = 6.773$, $p < 0.05$. However, the SET training model only showed sustainability or retention of performances for skill execution from posttest 1 to posttest 2.

In another quasi-experimental physical education study, Farihan Sulong examined the effects of Teaching Games for Understanding (TGfU) and Style E tactical (SET) pedagogical model on aborigines' primary school student in 5 versus 5 mini game in Malaysia using intact sampling of, $n = 30$, male, aged 10 ± 12 years old who were equally divided into two groups of TGfU and SET [3]. This study completed 6 weeks of intervention. Players' game performances were evaluated in terms of decision-making (attacking and defending), skill execution (passing, receiving the ball, dribbling and scoring) in a modified game situation of 5 versus 5. The data were analyzed using one-way ANOVA. Findings indicated there was no significant difference in game component of skill execution between these two pedagogical models. However, as for decision-making, component findings indicated there was significant difference between the

GAME OBERVATION INSTRUMENT FOR HOCKEY (Adopted GPAI)

AGE GROUP: ……. Team: …….. Game: ……

Date:……. Evaluator: ……,

Scoring Key

5 = Very effective performance, 4 = Effective performance (Usually), 3 = Moderately effective performance (Sometimes), 2 = Very weak performance, 1= Very weak performance (Never)

Components and Criteria

- Skill execution (passing, dribbling, tackling and scoring) – Players pass the ball accurately, reaching the intended receiver
- Decision making (passing, dribbling, tackling and scoring)- Players make appropriate choice when passing, dribbling, tackling and scoring (i.e., passing to unguarded teammates to set up a scoring opportunity – right decision)
- Ball control –Players able to control the ball
- Support – Players attempt to move into position to receive a pass from teammates (i.e., forward the goal)

Key: BC: Ball Control, DM: Decision Making SE: Skill Execution

pass: passing, drib: dribbling, tack: tackling sc: scoring, sup: support

Team:…….

	Name/Number	**BC**	**DM**				**SE**				**SUP**
			pass	drib	tack	sc	pass	drib	tac	sc	
1											
2											
3											
4											
5											
6											
7											
8											
9											

Adopted GPAI with permission Mitchell et al. [12].

Table 5. Game play observation instrument for psychomotor and cognitive domain.

TGfU (7.33 ± 4.92) and SET (3.86 ± 2.55), F (1,28) = 5.85, p = .022, $p < 0.05$) after intervention. As conclusion, SET needs further research to confirm the as effective as TGfU model for aborigines' students for game play outcome. In another study, Palanippan investigated the effect of TGfU, SET Pedagogical Style and Technical model among junior secondary school boys 13 ± 14 via quasi-experimental study in terms of skill execution (passing and scoring) and tactical decision-making (passing and scoring) in 4 versus 4 mini game play and enjoyment aspect in handball [18]. The results revealed that there was a significant improvement using instructional models of TGfU, SET and Technical on the posttest score for passing, scoring and decision-making ability in 4 versus 4 game play. Qualitative findings for enjoyment aspect showed that TGfU and SET instructional models enhanced students' skill mastery, knowledge and increase of interest compared to the Technical model.

Affective Domain Assessment Net and Wall Games (Field hockey)

Name of student: ……

Class: …… Evaluated name:…… Team: ……. Observation date**: ……..**

The purpose of this assessment is to keep track of behaviors displayed by students learning tasks and game play. Whether or not you assign a point value to the categories is your decision. Keep in mind that games are self-officiated, so there will be opportunities to observe students taking responsibility for their behavior

Points

Positive behavior identified 5 4 3 2 1 negative behavior identified

Acceptable behaviors	**Unacceptable behaviors**
Supports and encourages teammates	Lacks any show of support or encouragement for teammates
Follows all call without argument	Argues or breaks rules regularly
Other	Other
Total	Total

Adapted with permission Mitchell et al. [12].

Table 6. Game play observation instrument for affective domain.

3. Conclusion

The SET pedagogical is still an early part of implementation; therefore, more research and validation are needed to further improve the SET pedagogical model across different culture and background. This pedagogical model could bridge the disparity between teacher-centered approach and students' game learning across physical education and coaching context.

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Chapter 14

Learning Styles in Physical Education

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Additional information is available at the end of the chapter

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Abstract

The learning styles are cognitive, affective, and physiological traits concerning how students perceive and process information, which is why their knowledge is relevant to enhance the methodologies of classes by teachers and learning strategies by students. Although there are several models that define and evaluate learning styles, a few of them have been used in physical education, highlighting the theories of Alonso, Gallego and Honey, the Kolb model, Herrmann's theory of brain dominance and Model VAK. The few studies carried out in this sample show a preference for reflexive, divergent, dominated B (organized) and D (holistic) styles and for a kinesthetic style. Further studies are required on how students perceive and process information in various areas of education, with the aim of contributing with one more tool to improving the teaching-learning process.

Keywords: learning styles, physical education, reflective, diverging, dominance, kinesthetic

1. Introduction

The term learning style refers to the fact that people use different methods to learn. Although these strategies vary according to what one wants to know, each one develops and enhances cognitive traits, preferences, and tendencies to face a knowledge process, aspects that are defined as a learning style [1]. In 2007, Camargo and Hederich [2] defined the concept of style, explaining that its origin does not correspond to the educational context, but comes from the arts, referring to the characteristics of an esthetic trend identifiable and distinctive. According to Camargo and Hederich, the term style begins to be used in psychology toward the decade of 1950 to talk about certain differentiating or individualizing traits in the characterization of a person.

According to Camargo and Hederich, a definition of learning styles is described as the cognitive, affective and physiological traits that serve as stable indicators of how students perceive, interact, and respond to their learning environments, that is, they have to do with the way students structure content, form and use concepts, interpret information, solve problems, select means of representation, and so on. The affecting traits are linked to the motivations and expectations that influence learning, while the physiological traits are related to gender and biological rhythms [3].

Another definition states that the expression learning styles have to do with how the mind processes information, learning strategies to work content and how this process is influenced by perceptions [4]. It can also be defined as sets of behaviors and attitudes in relation to the learning context [5]. Some principles about learning styles have been identified, among which the following criteria stand out: (a) styles are preferences in the use of skills, but are not skills in and of themselves; (b) a relationship between styles and skills generates a synergy more important than the simple sum of the parts; (c) people have profiles or patterns of styles, not a single style; (d) styles are variable according to tasks and situations; and (e) people differ in their stylistic flexibility [6].

On the other hand, Woolfolk [7] chooses the concept of preferences, on learning styles, and defines it as the preferred way of studying and learning such as using images instead of text, working alone or in groups, learning in structured or unstructured situations and in other relevant conditions such as an environment with or without music, the type of chair used, and so on. The preference for a particular style may not always guarantee that the use of that style will be effective. Hence in these cases, certain students can benefit by developing new ways of learning. Finally, one of the most widespread definitions in the scientific community is that of Keefe [8] who proposes that learning styles are physiological, cognitive, and emotional modes of how human beings receive and process information.

This chapter addresses the main theories concerning learning styles (CHAEA, Kolb, VAK, Brain Dominations, etc.) with their characteristics. Afterward, we summarize the findings of different scientific works in this area, in Spanish, between 2010 and 2017, made by students of physical education or of related study.

2. Models of learning styles

Since the 1960s of the last century, different models have emerged to explain and classify learning styles, while some focused on the selection of information and others on how to acquire knowledge. The most relevant model in the field of education is given in the following section.

2.1. Divided brain model

Sperry [9] generates a model known as a divided brain, which relates the right hemisphere to spatial reasoning, visualization, creativity, musical aptitudes, and the simultaneous and satisfactory processing of information. This hemisphere is identified with a nonverbal, imaginative, and holistic thinking style. For its part, the left hemisphere is related to sequential and

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temporal thinking, with analytical processes such as language comprehension-production, sequential reception of information, sequence numbers, logical analysis and rationality [10].

The existence of these functional differences between the two hemispheres and their independence in regard to perception, apprehension, memories, and feelings, including the argument that the surgical separation of the brain divides the mind into two distinct spheres of knowledge and opens the possibility of dual knowledge in a normal brain [11]. This has led to the idea of the existence of two modes of thought and learning styles, which implies the need for two ways of teaching since a left hemispheric student would have abstract thinking, while a right hemispheric student would be the possessor of a more concrete logical thought [10].

2.2. Model VAK

The VAK model (Visual, Auditory, and Kinesthetic) was proposed in 1978. The characteristics of these learners are as follows [12]:

a. **Visual style:** Learn more if you do it through the visual channel. He/she likes to get the most visual stimulation possible, prefers reading and studying graphs. Oral lectures, conversations, and instructions without visual support can produce anxiety and confusion. These learners require the visual stimulation of information boards, videos, film, words written on the board, a book or notepad, as they will better remember and understand the information and instructions they receive through the visual channel. If you attend a conference or receive instructions verbally, you should take note.

b. **Auditory style:** This type of student learns better through hearing, for example, with oral explanations. You can better remember and understand the information if you read aloud or if you move your lips while reading especially when it comes to new material. You can benefit by listening to electromagnetic tapes, lectures, class discussions, teaching other peers, or conversing with the teacher.

c. **Kinesthetic style:** This type of student learns best through experience, making more profit by engaging in physical activities in the classroom. Your active participation in the different tasks, trips and role played in the classroom will help you remember the information better. Sitting at a desk for many hours is uncomfortable, needs frequent rest and, above all, physical action in games and dramatic activities.

Currently, there are several instruments for measuring VAK learning styles, one of which has five dimensions: immediate environment, own emotionality, sociological needs, physical needs, and psychological needs, evaluated through Dunn's Learning Styles Inventory (LSI) and Dunn composed of 104 items with three alternative answers each: true, false, and I do not know. This instrument was designed for children between 3 and 12 of the US educational system [13].

2.3. Kolb's model

On the other hand, the Kolb's model defines learning as the process of creating knowledge through experience, that is, learning is generated from subjective experiences and based on it and together with other authors schematized the process in four stages [14]:

a. **Concrete experience:** the world is experienced through the senses such as sight, hearing, touch, smell and taste, and these senses generate learning.

b. **Reflective observation:** reflections on personal experiences are analyzed and sought to understand their meaning.

c. **Abstract conceptualization:** the extent to which the analysis of experiences is integrated and synthesized, inferences are created about why things are as they are.

d. **Active experimentation:** when theories are tested in daily reality, a new knowledge and understanding are generated that can be applied in life.

These four stages work in the same way, becoming a cycle, in which experience is transformed into action, and each cycle perfects and helps to generate understanding. Kolb argues that if a cycle is skipped, learning is incomplete so it will generate a slower, more limited process with little group impact. In the **Figure 1** are observed the different dimensions of this model.

From this, it poses and describes the following learning styles:

a. **Divergents:** capture information through real and concrete experiences and process them reflexively.

b. **Convergents:** perceive abstractly by way of conceptual formulation and actively process this information.

c. **Accommodators:** capture information from concrete experiences and actively process them.

d. **Assimilators:** perceive abstractly and process it reflexively.

Kolb designed an instrument to evaluate learning styles that consist of 12 sets of 4 words (where each represents a style) and the evaluated one must number between 1 and 4 each concept based on which characteristics define him/her better.

Figure 1. Learning styles Kolb's model [15].

2.4. Model by Ned Hermann

From the split-brain model [9] and the triune brain [16, 17] which posits the existence of three brain layers, each representing an evolutionary state called the reptilian brain that would be responsible for control muscular, respiratory, cardiac, balance, and so on. A second layer that is named as a paleo-mammalian brain or limbic brain that manages the emotions, instincts, ingestion, confrontation, flight, sexual behavior, and the tendency to gregariousness. The third layer is called neo-mammalian brain or neo-cortex brain where the invention and the abstract thought are located. Based on these two theories, Herrmann [18] elaborates a model of the brain constituted by four quadrants that represent different ways of operating, of thinking, of creating, of learning and, in sum, of coexisting with the world. The characteristics of these learning styles are as follows:

a. **Dominance A:** corresponds to the left-cortical hemispheric mixture. They are analytical, logical, quantitative, based on facts, intelligent, distant, ironic, competitive and individualistic. They learn by reasoning and using logic.

b. **Dominance B:** corresponds to the left-limbic hemispheric mixture. They are organized, sequential, retail, and introverted people. They learn from experience through routine and organized structures.

c. **Dominance C:** corresponds to the hemispheric right-limbic mixture. They are original, independent, with a good sense of humor, who like interpersonal relationships and situations involving emotions and feelings.

d. **Dominance D:** corresponds to the right-cortical hemispheric mixture. They are intuitive, holistic, integrative, extroverted, and emotive people. They like to listen and ask, to share, and to evaluate the behavior of others.

The author of this model elaborated the Herrmann Inventory of Brain Dominance that consists of 40 adjectives that describe the types of behaviors organized in 10 columns with four concepts each. The evaluated should weigh the adjectives of each column with values between 1 = less dominant and 4 = more dominant [19]. The results give scores on dominance A (logical), dominance B (organized), dominance C (interpersonal), and dominance D (holistic).

2.5. Model by Alonso and Gallego y Honey

This model was based on the instrument of Honey and Munford, elaborated for professionals of companies of the United Kingdom, which has been adapted and validated by Catalina Alonso. The classification given by this model has the following characteristics [3]:

a. **Assets:** Like new experiences, they are open-minded, nonskeptical, and willing to undertake new tasks. They are people who live in the here and now.

b. **Reflective:** They like to observe the experiences from different perspectives. They gather data to analyze them carefully before reaching any conclusions. They prefer to be cautious and look well before acting.

c. **Theorists:** They tend to be perfectionists. They usually seek to integrate facts into coherent theories. They like to analyze and synthesize. For them, rationality and objectivity are priority issues.

d. **Pragmatics:** Its main feature is related to the practical application of ideas. They are realistic when it comes to making a decision or solving a problem. His philosophy is: if it works, it is good.

The Honey-Alonso Questionnaire on Learning Styles (CHAEA) consists of two parts: one about socio-academic data that consist of 19 questions; the second one consists of 80 items on learning styles, randomly arranged, corresponding 20 questions to each style, and only the positive responses to the sentence are counted.

2.6. Model of Felder-Silverman

The first model proposed by Felder and Silverman [20] had five dimensions: understanding, processing, perception, reception, and organization; later, the latter was eliminated. Each dimension is evaluated by a scale ranging from 11 to −11. The different dimensions of this theory are described in **Table 1**.

In 1992, Soloman developed the Inventory of Learning Styles using the dimensions of the Felder-Silverman model. The instrument has 28 items [22]. Subsequently, Felder and Soloman [23] created the Index of Learning Styles (ILS) consisting of 44 items with two possibilities of

Dimension.	Characteristics
(1) Preference to process: this is divided into active and reflective.	Active students learn by working with the material, applying it and testing things. They like to work in groups to discuss what has been learned, tend to retain and understand information through activities.
	Reflective students prefer to work alone and they like to think about the material used to learn.
	They also prefer to think carefully about information rather than discussing, applying, or explaining it.
(2) Preference to perceive: this is divided into sensory and intuitive.	Sensory students like to learn facts, use sensory experiences as a source of information, are careful and detailed, realistic and practical.
	Intuitive students like theoretical rather than fact, are creative, innovative, like to relate things, abstractions and mathematical formulas.
(3) Preference to receive: this is divided into verbal and visual	Verbal students prefer words, written or oral explanations.
	The visual students remember better what they have seen (drawings, graphs, figures, etc.), the pleasure of reading the slate, books or manuals.
(4) Preference to understand: this is divided into sequential and global	Sequential students have a linear progress of their learning, since they learn with accumulation of information, are logical and retail.
	Global students learn great leaps, absorbing information from many things at once, with difficulty in understanding connections between them and with interest in extensive knowledge spanning many areas.

Table 1. Dimensions of Felder and Silverman's theory [20, 21].

response (a or b). Each dimension is represented with 11 questions, whose score is calculated by subtracting the answers b from the answers a.

2.7. The Grasha's model

Another model of learning styles that has drawn particular attention in recent years is the one proposed by Grasha. This theory is based on the observation of patterns of behavior related to students' preferences when it comes to interacting with their classmates and their teachers in the classroom. The author [24] postulated six styles of learning based on three dimensions of bipolar character: (a) student's attitudes toward learning (participatory vs. elusive); (b) perspectives on peers and teachers (competitive vs. collaborative); (c) reactions to classroom teaching procedures (dependent vs. independent). According to Grasha, although these styles in each dimension are bipolar, it does not mean that they cannot be complemented since they only represent extremes, among which different types of profiles can be formed. The characteristics of the proposed styles are described as follows:

a. **Participatory:** They are good elements in classes, enjoy the session, and try to be outstanding most of the time. They have a lot of readiness for school work.
b. **Elusive:** They do not show enthusiasm in class. They do not participate and remain isolated. They are apathetic and disinterested in school activities. They do not like to be in the classroom for long.
c. **Competitive:** They study to demonstrate their supremacy in terms of the use or qualification of others. They like to be the center of attention and receive recognition for their achievements.
d. **Collaborative:** They like to learn by sharing ideas and talents. They like to work with their classmates and teachers.
e. **Dependent:** They show little intellectual curiosity and only learn what they have to learn. They visualize teachers and their peers as guiding figures and/or authority to carry out their activities.
f. **Independent:** They like to think about themselves. They are autonomous and confident in their learning. They decide what is important and what is not, and enjoy working alone. They avoid teamwork.

The Grasha-Riechmann Learning Styles Scale [25] consists of 60 items, with five response scores ranging from 1 = Strongly Disagree, to 5 = Strongly Agree. To know the predominant style of learning the scores corresponding to each style are added and divided by 10, to find the average of the items assigned to each style.

3. Research on learning styles in physical education

A review of the works published between the years 2010 and 2017 shows few studies on the learning styles in students or professionals of the Physical Education, a situation that happens in many of the careers of education, being the areas of health and engineering that present

more inquiries about this subject. We used Dialnet, Redalyc and Scielo databases, in addition to the scientific collaboration network Researchgate. The search yielded a total of 2220 articles on learning styles (Dialnet = 911; Redalyc = 86; Scielo = 203; Researchgate = 1020), 13 of them met the following criteria: (a) Published since January 1, 2000 until July 31, 2017; (b) Spanish language; (c) research articles; (d) university population; (e) career in physical education or related.

The studies found included samples of students from Spain (2 studies); Spain-Venezuela (1 study); Costa Rica (1 study); and Chile (9 studies). Honey-Alonso questionnaire (CHAEA) was used in eight studies; Kolb's inventory in two studies; Brain Dominance Inventory in one study; and the visual–auditory-kinesthetic (VAK) research in two papers.

A research carried out at the University of Castilla-La Mancha in Spain, where the CHAEA was applied to evaluate learning styles for 315 students of physical education, shows that the predominant style is the Reflexive (44.01%), then Active (23.44%), theoretical (19.01%) and finally the Pragmatic (13.54%). When comparing between males and females, the former presented higher scores in the Reflexive and Pragmatic styles [26]. Another study using the same instrument was carried out at the University of Concepción in Chile, evaluating 65 students of physical education, revealing that the Reflexive style has the highest score with 15.1 of 20 possible. It follows the Pragmatic style with 13.1 points, Theoretical style with 12.7 and the Active with 11.9. When comparing between women and men, the latter have higher scores in the four styles [27].

In another study using the CHAEA, 227 students of Physical Education of the University of Granada and Alicante in Spain were evaluated, obtaining an average of 15.37 points in the Reflective style, 14.29 in Theoretical style, 13.08 in the Pragmatic style and 11.73 in the Active style [28]. An investigation at the Universidad de Los Andes-Táchira in Venezuela and the University of Valladolid in Spain evaluated 124 and 107 students of physical education, respectively, showing in the Venezuelan institution scores of 14.78 points in the Reflexive style, 12.89 points in Theoretical style, 12.79 in the Pragmatic style and 11.86 in the Active style. The Spanish students presented scores of 14.24 in the Reflective style, 12.77 in the Active style, 12.44 in Theoretical style and 12.42 in the Pragmatic style. Both groups do not present differences in learning style scores by academic institution [29].

A study of 2014 in Costa Rica [30] tested 204 high school students in the Teaching of Physical Education of Sport and Recreation, of Bachelor in Promotion of Physical Health and of the Degree in Sports Performance of the National University. In all three races, students scored higher in the Reflective style (14.40; 14.34 and 14.48, respectively), then in the theoretical (13.45, 13.50 and 13.37, respectively), in the Pragmatic style (13.26, 13.85 and 12.42, respectively) and finally the lowest scores correspond to the Active style (12.35, 12.83 and 11.90, respectively).

An investigation of 2014 in Santiago, Chile, evaluated 151 students of physical education of the SEK University, showing that the preferred style is the Reflective with 14.33 points, followed by the Active with 13.64, then the Theoretic with 13.63 and finally, the Pragmatic with 13.53 points [31].

A study using the CHAEA-36 questionnaire in 102 students of physical education from a private university in Santiago de Chile shows that the reflective and theoretical style are those that present

Instrument.	Authors	Year	Predominant style
Honey-Alonso Learning Styles Questionnaire (CHAEA)	Gil et al. [26]	2007	Reflexive
	Madrid et al. [27]	2009	Reflexive
	Belasco et al. [28]	2011	Reflexive
	Gutiérrez et al. [29]	2012	Reflexive
	Salas-Cabrera [30]	2014	Reflexive
	Maureira et al. [31]	2014	Reflexive
	Maureira et al. [32]	2016	Reflexive
	Serra-Olivares et al. [33]	2017	Combined and active
Kolb's Learning Styles Inventory	Maureira et al. [34]	2013	Divergent
	Maureira et al. [35]	2015	Convergent
Ned Herrmann's Inventory	Maureira et al. [36]	2016	Dominances B y D
VAK Inventory	Maureira et al. [37]	2012	Kinaesthetic
	Flores et al. [38]	2015	Kinaesthetic

Table 2. Sample on some research on learning styles in students of physical education.

a higher score, with averages of 6.98 and 6.38 points, respectively [32]. Another study using CHAEA-36 evaluated 122 physical education students at the Universidad Católica de Temuco in Chile, showing predominance in two combined styles with 56% and Active with a 21% [33].

In relation to studies using the model of learning styles of Kolb was found a research carried out in 2013 in the Metropolitan University of Education Sciences (UMCE) and the University SEK (USEK) both in Santiago de Chile. At the UMCE, first-year students of physical education are preferably Divergent with 48% of cases, then Assimilator with 22%, Resident with 17% and Convergent with 13%. In the same institution in the fourth year students are Divergent in 62% of the respondents, then Assimilator in 18%, Accommodation in 12% and Convergents in 8%. Meanwhile, in the USEK 1st year students are Acclimatizers in 32% of cases, Divergent in 27%, Assimilators in 26% and Convergents in 15%. In the fourth year, 59% of students are Divergent, 18% Assimilator, 16% Resident and 7% Convergent [34]. Another study carried out with 192 students of physical education at SEK University in 2015 shows that 42.2% of them have a Convergent learning style, 27.6% are Assimilator, 21.9% are Accommodator and the 8.3% is Divergent [35].

Using the model of Ned Herrmann, 102 physical education students from a private university in Santiago de Chile were evaluated, showing higher scores in the (organized) and D (holistic) brain dominance, while the dominance A (logical) and C (Interpersonal) have less development [36].

In relation to learning styles based on the Visual, Auditory or Kinaesthetic (VAK) model, 227 students from the SEK University of Chile were evaluated, the kinesthetic style being the predominant in all career years, followed by the visual style and finally the auditory [37]. Another study from 2015 that evaluated 127 students of the 1st and 4th year of physical education at a

private university in Santiago de Chile shows that the preferred style is kinesthetic, followed by the visual and after these the auditory, a situation that occurs in both the levels [38].

In summary, it is possible to notice that in 7 out of 8 studies using the CHAEA questionnaire, students showed a preference for reflective style, in samples of students from Spain, Costa Rica and Chile (**Table 2**). These students like to analyze the information, they are cautious and look out the experiences from many points of view.

Kolb, Cerebral dominance, and VAK models have been tested in samples with students of physical education of Chile, so will be interesting to carry out measurements in other countries, to test these models with similar samples but with different social and cultural realities.

4. Conclusions

In addition to the theory of learning styles, there are different cognitive factors that influence this process, such as intelligence, creativity, personality, motivation, among others [39], so it would be utopian to ask teachers to control all these variables, since each subject is different, but it is possible to try to measure them, obtaining a more objective description of the group of students, to know where to start, not only in knowledge but rather a diagnosis of who we are going to educate and how these people prefer to learn.

Knowing the theory of learning styles is imperative for the educator, in addition to using the most appropriate strategies according to the characteristics of each individual [40]. For example, Dunn and Dunn indicate that children should be educated using methods that fit their perceptual preferences [41].

On the other hand, it is not only necessary to know the learning styles of the students by the teachers, but also it is the task of the educator to adapt the style of teaching to the way of learning of its students, where the teaching process and learning will be significantly improved [42]. This does not mean that the teacher needs to plan four or five different strategies to face the challenge but to incorporate in the teaching strategy didactic elements that cope with the diversity of participants and find the way to explain the main key and core concepts or ideas from more than one point of view, perspective, *and*/*or* example, ranging from several intellectual and practical approaches.

Another important point is to separate the academic success from the qualifications because there are several investigations of learning styles measuring and correlating these variables [43–47], some with some degree of correlation and most with negative results. Researchers reached the conclusion that the student not knowing his style of learning does not know how to use it to study. Therefore, it is not only necessary to measure learning styles but also to teach them how to use them appropriately.

Finally, and insisting on the relevance of using learning styles as a tool that will facilitate the teacher and the learner in the learning process, it is surprising to see that in a review with the main theories of learning styles (CHAEA, Kolb Inventory, Brain Dominance, VAK, etc.) in

university students of physical education between 2000 and 2017, only 13 articles, similar situation that occurs when all the studies on learning styles are reviewed in educating students in their diverse disciplines [48]. Therefore, this situation leaves us with a very important task to develop in the coming years as experts in physical education, to proposing and structuring appropriate methodologies for each style of learning, enhancing the self-knowledge and learning of these students.

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Chapter 15

Clumsiness and Motor Competence in Physical Education and Sport Pedagogy

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Additional information is available at the end of the chapter

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Abstract

One of the main objectives of physical education and sport (PES) pedagogy in schools is to develop motor competence in children. While many schoolchildren practice sports, there is a group of children that does not receive the educational opportunities to be competent. These children show low motor competence and poor motor coordination. International agencies have called this condition as developmental coordination disorders (DCD) and its definition in short is "poor motor performance in daily activities that is not consistent with the child's age and intelligence, and is not due to medical condition." Physical education and sport teachers are the first interventionist with these children. They have the first opportunity of providing primary care to these children. In this chapter, motor coordination problems in school, its prevalence, how these children learn, how physical education and sport teachers can detect them, and why physical education and sport pedagogy must be concerned with this problem, will be analyzed.

Keywords: low motor coordination, motor learning difficulties, teaching, education, schoolchildren

1. Introduction

Children and youth receive numerous physical health benefits from practicing physical education and sport (PES) in school, including better fitness and cardiovascular function, better metabolic function and health, and psychosocial benefits. Despite these benefits, many children continually fail to meet PES recommendations. Physical education should help all children acquire the basic movement foundation needed to access a wide range of physical activities across their lifespan, and without this foundation, children will find it difficult to choose an active way of life [1].

Physical education teachers describe children who look awkward as clumsy, poorly coordinated, or low-skilled. These children have difficulties acquiring and performing basic motor skills such as running, jumping, catching, or throwing. Most physical education classes present children with these problems, and many of them have learned that they will never improve this condition by practice, effort, or instructions [2]. Clumsy children often abdicate responsibility of their performance with "I can't" statements becoming increasingly frequent [3].

In the last few decades, the research related to children's motor clumsiness and their effects on development have increased [4–8], to the extent that this problem has been included in the Statistical Manual and Diagnostic of Mental Problems, DSM-5 [9]. One of the paradoxes of this problem is that children, who have it, do not present a disease or a medically diagnosed difficulty as the cause of it [10, 11] although there are efforts to discover the neurological and brain's connection [6]. They are children who present difficulties in learning motor skills like those that are part of the programs of physical education and sport and show an inefficient and asynchronous motor behavior when they carry out motor tasks, which are usually done by the rest of the people without problems, both at work and leisure [11].

Regarding the prevalence of this condition, and taking into account the existing problems of its identification and use of different measuring instruments, the estimate varies between 5% and 18% in children aged between 4 and 11 years with more boys than girls [6, 7, 10, 11], although the gender differences are still controversial and their effect on adulthood persists. By the time that these children reach adulthood, they may no longer have the desire to participate in physical and healthy activities, and this condition affects their lifestyle and healthy habits [10–14].

There are still controversial aspects surrounding the identification of these children and the ability of different professionals to identify them [15]. This controversy is reflected in the different results of different studies around the world and the different tools that researchers use. This difficulty causes inactive lifestyles, because these children do not develop the motor skills necessary for participation in physical activities and sports, as well as in professional activities that claim the use of the body and movement coordination. All this may affect their social interactions and their health and physical vitality [14]. This physical vitality is clearly diminished and may present risk factors associated with the development of cardiovascular diseases in adulthood [13–15]. The problem is that many children will never acquire the skill level necessary to advance to a higher level of motor competence, and they will be children with a deficit of practice and without motor skill experience, manifesting delays in fundamental motor skill development.

2. Method

There are a lot of research and information about developmental coordination disorders in therapeutic contexts; however, this body of research is scarce in physical education. The review of available research included here promotes an understanding of the subject area and the criticisms that have been made on the topic with special attention given to physical education and sport pedagogy [18]. The purpose of this chapter was to describe the behaviors of clumsy children in physical education and sport classes, how they learn motor skills, and the role of physical education and sport pedagogy in their motor competence. Three areas of

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literature were analyzed to allow a better understanding of this problem: (1) literature about the concept of clumsiness, low-skilled children, or developmental coordination disorders; (2) literature dealing with the identification of the low-skilled children in physical education and sport classes; and (3) literature reporting how clumsy children learn motor skills and the role of physical education and sport programs in increasing their motor competence.

3. Clumsy children and physical education and sport classes

Currently there is some concern for clumsy children in physical education and sport classes. Many times, teachers consider that children are clumsy when they are less able in a single or a group of motor tasks, simply based on their low performance in comparison with peers of the same age. These children can experience continued failure in classes, playground, and physical education activities, and it is probable that they manifest a deficit in movement understanding, organization, and control too. There are many terms that physicians, educators, and therapists have been used to characterize these children until arriving at the agreed term of *developmental coordination disorders* (DCD). Terms such as developmental dyspraxia, perceptual-motor impairment, perceptual-motor dysfunction, minimal brain dysfunction, motor development retardation, motor clumsiness, motor coordination problems, or awkward child syndrome have been employed in the scientific and pedagogical literature. Physical education teachers have known them as low-skilled students or simply as clumsy children.

The American Psychiatric Association [9] in its Statistical Manual and Diagnostic of Mental Problems, DSM-5, has called it as developmental coordination disorders (DCD) to which they ascribe the following characteristics:

- Problems with the organization of the movement and its spatial-temporal structure.
- Qualitative differences in their movements compared to those made by their peers.
- The presence of other associated problems that affect their functioning in school life or in their daily activities.

Some physical education researchers [16, 17] define clumsy children as those individuals who have motor learning difficulties and display asynchronous and inefficient motor behavior when attempting to carry out motor tasks that they would commonly be expected to accomplish under reasonable circumstances. Others [19] highlight the cultural component of this clumsiness and consider that these children do not perform culturally normative motor skills with acceptable proficiency. It is considered that children are clumsy when they show real difficulties to coordinate the movements that affect their school life both in the classroom and especially in their activities in the gymnasium or the playground. It is necessary to emphasize the danger of labeling a schoolboy as awkward, as well as the etiquette that it is necessary to show parents who wish to know their opinion about these movement problems that they observe in their children [20].

An idea must be clear; in all physical education classes, there are children who show different degrees of movement difficulties, and the question is to know to what extent they can be palliated and what PE teachers can do.

But who are these children? Which are their main characteristics? How do their problems manifest in physical education classes? An analysis of the different studies carried out on these children shows that globally they possess at least four global characteristics:

- They have a psychophysical integrity that makes them normal for all purposes, hence the difficulty of establishing the causes of such difficulties.
- They have difficulties in carrying out and learning the motor skills of the physical education program.
- They show a delay in fundamental motor skills.
- Its condition does not have to be a global awkwardness, but rather shows a great heterogeneity and specificity.

Their movements in the gym are uncoordinated and ineffective, not having the resources, or the competence, necessary to respond to the requirements of the physical education or sport learning classes. Their fundamental motor skills tend to be behind the rest of his peers, being aware of this situation, which further aggravates his condition. Physical education classes are a source of tension and anxiety for him because of the difficulty in being able to carry out the motor tasks as proposed by the teacher or when he must play with their peers. In the gym, they feel disoriented; they do not know when they should act, and when they do, it is too soon or too late, and their peers scold them, when they do not laugh at him. This situation can cause them to end up hating the subject [2, 3].

PES teachers need to have a more concrete idea of what really characterizes a clumsy child because his difficulties could be shown in some tasks, but not in others. Thus, some schoolchildren may find manual tasks very difficult, while for others, difficulties arise when they must move globally to meet the requirements of the class. While for some it is difficult to perform ball games, for others it is to maintain balance and control in space. This mosaic of difficulties makes it difficult to establish a single profile [21].

Different authors [21, 22] emphasized the existence of a series of characteristics among the students with these problems of coordination:

1. These children show a high variability from one trial to another when they carry out motor tasks.
2. They continue to act in the same way even if the situation no longer requires it.
3. Sometimes they are unable to separate their performances from those made by a model, becoming its mirror.
4. They seem to manifest problems of integration of the different parts of the body, and when they are going to jump, and need the coordinated action of the two arms to make the jump, one of the arms acts while the other remains rigid and does not collaborate in the action.
5. They can have problems of dynamic balance, instability, and tremor, especially in those tasks that demand a certain control and precision in the performance.

6. They fall easily after jumping, throwing, or kicking a ball.
7. When they move, incorporate strange movements that give an awkward appearance to their performances.
8. They are not able to follow rhythms especially when the rhythm is imposed from the outside.
9. They show lack of control of the strength when they pass too strong the ball that can hit his partner, which no longer will choose them as a couple in the next class.
10. They can have problems to plan their actions.

Clumsy children problems, far from having a defined profile, can be manifested differently and before different tasks and situations. This makes the identification as well as the establishment of its possible causes complex, since while some children may present problems of a kinesthetic or visual nature [23], for others the problems may lie in the slowness of processing, the difficulties to retain visual patterns in short periods of time or in their low knowledge of the actions they have to perform [6, 7].

Children progress through the various stages of motor development, and clumsy children tend to lag their peer's motor competence and learning sport skills. These children have not reached the level of desirable motor development to be able to practice with competence in physical education classes. His fundamental skills are in a stage very elementary for his age. Its functionality is clearly delayed with respect to the rest of his class. This difficulty makes them constantly watched and criticized by their peers and, in many cases, by their teachers and parents who think that their problem is due to their lack of interest in the subject, because they do not pay due attention to what must be performed. But sometimes, the teacher is presented with the difficulty of not being able to easily identify the possible causes of this condition, accepting that the child will grow out of it and implementing *a wait and see* policy.

One of the serious issues that emerge from the lack of knowledge and training of physical educators is that this group of at risk children is left without the educational support that they need [24]. A good assessment would be essential and more information and training would be desirable.

4. How to detect these children in PE and sport classes

Knowing what children can do is basic if teachers who want to evaluate their motor competence and if they develop within the margins of the desirable for their age. Knowing what children can do helps the teacher to know:

- The current situation of children and their evolution over time.
- What affects motor development of children and what influence their motor coordination.
- What to do and get informative feedback of the effect of the pedagogical interventions with these children.

Teachers have difficulty with the identification of clumsy children. The limited emphasis placed on motor development in their graduate training contributes to this limited knowledge of motor skill learning difficulties [24].

There are many tools that physical education professionals have developed to know how their students move and develop in the classes [25], but many of them do not have the qualities of measurement that offer the security to the professional that with their employment they will obtain valid and reliable information. Therefore, it is necessary, in a systematic, simple, and useful way, to determine if the process of developing motor competence is being carried out reasonably and within healthy margins.

There are different tools and instruments (batteries, checklists, and tests) that permit confirmation of a teacher's intuitions. However, it is important to know what to evaluate and what kind of instruments is more appropriate. There are different assessment tools available [26]. On the one hand, there are tests or batteries developed to compare the performance of schoolchildren with respect to previously established norms in a set of physical and motor skills [27]. On the other hand, there is another set of tests or batteries based on the existence of a series of performance criteria based on the research and the opinion of the experts, which establishes which are the most relevant morphological characteristics of the tasks evaluated in every age group. In this case, there are no norms but levels of performance and a series of criteria.

Each type of instrument demands a competence of the teachers. They must know in depth how to present and organize the application of the test or battery, apply it, and interpret the individual results with respect to the norm. In the second type of instruments, an adequate knowledge of the child motor development and about the characteristics of the fundamental motor skills is demanded.

Among these instruments, we would highlight batteries and tests such as Body Coordination Test for Children (KKTK) [28], the Movement ABC-2 Battery [29], Bruininks-Oseretsky-2 of Motor Performance [30], or the MAND motor test [31]. These comprehensive tests use product and/or process forms of assessment. They require more time for administration and more skill in the movement domain for a competent interpretation, something that many PE teachers do not have.

In this sense, motor tests like the stay in step gross motor test [32] or the GRAMI-2 Motor Test [33] are short motor tests developed with the objective of a quick screening of children and being able to detect those children with motor coordination problems in physical education and provide information to teachers for the adaptation of programs and intervention. These tests have a group of tasks with a great power of clumsiness prediction like hopping, bouncing, or lateral jumps. It has the advantage of being easily administered by the PE teacher in the class schedule.

Some of these batteries or motor tests are accompanied by observation sheets or motor checklists that can be used by teachers. This is the case of the observation checklist accompanying the MABC-2 battery [29, 34], scales for the assessing the motor performance [35], the Coordination Disorders Questionnaire (DCDQ) [36], ECEF Motor Competence Scale [37], or the Fine Motor Competence Questionnaire [27]. There are also different scales, inventories, or questionnaires to be used by parents to detect coordination problems in childhood [38].

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5. How clumsy children learn motor and sport skills

Unless poorly coordinated children have been previously referred by their parents and consequently identified by a medical practitioner or therapist, the first interventionist with these children is the PES teachers. They have the first opportunity of providing primary care to these children, but unfortunately, they do not offer adequate help probably because they do not have the knowledge and skills necessary to teach clumsy children [39].

In the last decade, there have been numerous efforts to develop intervention procedures to alleviate or solve the effects of coordination problems among school-aged children. These procedures are highly related to the training and experiences of their authors; hence they can be classified differently. We could say that they move between two poles, between those focused on the processes involved that need to be improved or remedied, and those focused in developing specific functional skills so that children can interact in a competent way in the social and cultural context in which they grow and develop [24, 40]. When teachers instruct clumsy children, they need to answer several questions over what to teach and how to teach, which teaching style is the most appropriate for clumsy children or which are the true needs of these children [41]. These questions demand the teachers to know in depth the children's motor development [19].

Professionals and researchers call for the development of intervention programs that help these students overcome their coordination problems [16, 17, 41, 42]. School-based physical education programs are of a more general nature than clinical interventions. It is common that in studies in which intervention programs have been developed with clumsy children, too little attention was paid to the teacher's competence to teach and develop the tasks under study.

Sport pedagogues have usually addressed the teaching of physical education and sport programs with at least three instructive procedures, namely (1) the most direct procedure, (2) a procedure in which they have allowed the participation of the students in different decisions, and (3) an approach explicitly centered on the children [43].

One of the intervention models that has received special attention for its favorable results and which has great potential in PES classes is the so-called task-centered approach [44, 45]. In this approach, children perform in a specific way those functional motor tasks that the teacher considers more important, since they allow the learning of more complex skills and permit interactions with other members of the class, but also it has its disadvantages, since the child many times does not actively participate in any of the instructional decisions.

It is necessary to consider several aspects when choosing a task-centered approach in the teaching of specific tasks [46] and that supposes organizing everything so that:

1. The child receives a clear idea of what is to be learned.
2. The child receives key information about the movement.
3. The child receives specific feedback from his actions.
4. The child receives an abundant practice for the learning of these skills.
5. The child perceives success in 80% of the occasions.

This procedure has nothing to do with a teaching by command style or a militarized approach of teaching, in which all is done in the same way and at the same time. This procedure does not avoid the development of an atmosphere of achievement, effort, and personal progress [47]. Task-specific interventions provide a practical option to deal with the heterogeneity of these problems.

There are other proposals in which students are asked to explore their perceptual and motor space of work, so that they try to perceive affordances and discover the procedure of action that better solves the problem. These are procedures that some scholars have called nonlinear pedagogy and others ecological task analysis. In these approaches value is given to discovery and exploration, and the teacher does not need to use so abundantly the explanations and establish the contexts of practice that favor these processes [48, 49]. Teaching clumsy children in physical education must adapt to the individuals' needs of these children. Teaching those specific cultural skills necessary for being involved in the activities of the class needs to concentrate in the movement skill and practice until they can execute them with sufficient proficiency.

Many pedagogues have proposed different teaching methods depending on the nature of the task and the peculiarities of the children [44]. It is important to remember that many clumsy children do not excel at almost anything and that they may have certain desires that fit properly which could be a source of proposals for the teacher.

To the schoolboy who would like to play ball with his teammates, he demands that we teach him to catch, pass, and throw, specific skills that can constitute the program of work of a specific period. Performing a developmental task analysis of fundamental skills may be a good decision to work with these students. With this type of analysis, the teacher can develop a wide range of tasks and learning experiences, as well as being able to use it as an individualized evaluation tool, since it allows the elaboration of a performance profile with interesting nuances of complexity for the follow-up of the progress [40]. Ecological task analysis (ETA) [49] has established different classifications of motor tasks from a functional point of view, i.e., according to their functional objective, establishing four categories: locomotion, manipulation of objects, projection and trapping of objects, and maintenance and orientation of the posture.

The pedagogical research in which this perspective has been adopted in working with awkward children is very scarce. For its proponents, there are four steps that should be taken [49]:

1. *Establish objectives by structuring the physical and social context*. This will be the first decision to be made, which involves asking questions such as what do my students need to master? What kind of skills should they use? How should I structure the environment? What modifications should be made to reach the goal? How should I present skills to help them to understand it and feel motivated to reach them? Undoubtedly the interests and desires of children are a great clue to establish the objectives. This introduces emotional variables in the process, and this emotional dimension has a significant influence in clumsy children when they are learning motor skills.
2. *Allow the student to look for possible solutions to the problems raised, and take advantage of these solutions to consolidate these patterns of movement and move toward more complex ones.* This search can give the teacher a high number of keys to understand the motor dynamism of

these children and their difficulties. It is likely that new synergies and coordination will emerge as a solution to the proposed task and that they will collide with what is expected; it is interesting to contemplate them and assess their functionality in these children.

3. *Manipulate the constraints related to the subject, environment, and task*. The teacher can handle the most relevant variables of the learning situation so that children can exercise its possibilities of action. It means, on the one hand, to vary certain dimensions of the task, the context, and even the child and, on the other, to assume that there is not a single correct solution to achieve the established objective but that there are different possibilities and that all have their potential to be exploited in the dynamics of each session. This is of great interest for clumsy children who feel cornered by the idea that there is only one way to carry out the tasks.

4. *Provide appropriate instructional support*. If in previous steps the concern was to establish the most favorable conditions of practice, this step refers to the need to offer the necessary supports to children. It is very likely that they will have difficulty understanding tasks in the first trials and that it will be necessary to offer them support and keep going. It is necessary to find a balance between excessive direction that limits and a lack of direction that causes insecurity and loss of motivation.

Teachers know that until they have mastered a task, they go through a series of stages in which motivation, information, and feedback as well as attention progress in a variable way [44, 50]. These children show limitations in their ability to attend to the relevant aspects of the tasks. Managing information and moving simultaneously are very problematic for them; hence teachers should select the information to be transmitted and not to exceed the attentional capacity of these students. These children can learn to attend and to listen properly and to look in the right direction; hence teachers must know what information will be needed to help direct their attention to the area of greatest information relevance [51].

Probably one of the concerns of teachers is to ensure that students have a high willingness to learn and practice. The students bring with them a whole series of expectations about what will be developed in the classroom, the teaching context, the material, the teacher, and the tasks themselves, and in the case of clumsy children, these previous expectations often lead them to not want to go to class because they hope they will fail again, their classmates will laugh, and their teachers will not give them the necessary attention. They have always been adjusting to the level of the class, a level that they are not able to achieve, which has undermined their confidence in a very remarkable way. Teachers must be sensitive to the needs of these students and do so in a positive way, as they are always poorly viewed in class and are likely to begin to show signs of learned helplessness, reacting aggressively and with inappropriate behaviors [3, 40].

Clumsy children in physical education and sport classes do not perceive as meaningful the tasks they practice, and therefore, they are not motivated. It is necessary to consider the interests and needs of these students. To choose key fundamental motor skills that allow them to play and participate with their peers in other activities is a way of giving meaning to the practice. The motor learning process in physical education and sport classes entails putting into action all sensory-perceptual channels of children, which in the case of clumsy children could be the origin of their difficulties.

Adopting a multisensory approach is very appropriate for the child to relate what he sees with what he listens to and with what he feels when mobilized. With practice and patience, these children learn to feel the movement; however, when it is decided to mobilize kinesthetically to the students, it is necessary to consider not only the spatial reference and its trajectory in the correct orientation; the child's participation in the mobilization is very important, since guiding in excess does not favor motor retention [52].

But last, *what kind of practice will be most appropriate for these students? How much practice will they need to improve their motor competence? Which organization of practice will be the most appropriate?*

It is common in physical education and sport classes to practice the tasks in a global way, as they are, focusing the teacher overall and less on the details of it, but for many clumsy children, many of these tasks presented in class are very difficult to grasp globally; they have problems remembering the parts that compose them, so it is appropriate to think of more analytical procedures and its combinations.

Procedures like part-whole learning can be effective with different tasks and different children. For some specialists, the progressive part learning procedure has proved to be very effective with children with clumsiness since it progressively allows the components of a motor task to be mastered and combined to show the skill as it is globally [46, 53, 54]. Children with clumsiness present peculiarities in their way of conceiving the organization of the task and of representing it, which makes it necessary to switch constantly back and forth between the components of the skill [55, 56].

An important aspect in the work with these students is to assume that their physical condition is far below that of the rest of the classmates. They have a deficit of activity, which makes them vulnerable to fatigue [57]. Clumsy children showed lower explosive power, muscle strength and endurance, and cardiorespiratory fitness. Overall, these children had lower levels of physical fitness, even with normal body mass index [58]. These children need to repeat tasks that they are learning many times, but this consumes energy that in many cases they do not have, which leads them to be in a situation that even their safety can be compromised.

Teachers should be aware of this situation, hence the importance of providing rest periods, which can also avoid boredom and deterioration of their performance. It is important to consider that the same tasks can be done in different ways [59], suggesting that variability of practice can be a good resource for teachers. This procedure can help children to learn and being motivated but, sometimes to begin a class directly with a variable practice approach, can be uncertain to clumsy children who seek to establish a relatively stable motor pattern that gives them confidence [60].

Repeating the same action many times in the same way, to progressively introduce variations of the same task, can be an excellent way to promote the application of what has been learned to a similar situation and to promote the process of transference. Clumsy children while practicing need to be given feedback on improvements and progress they are achieving, as well as how to overcome the difficulties they are encountering. These children have less motor experience, which means that their knowledge is less and that teachers often make the mistake of offering too imprecise or too precise feedback.

The message must be to help these children to understand what they are going to practice. It is also appropriate to remember the difficulties of attention and retention that these children can manifest, which leads them to focus their efforts on what it is not relevant, hence the importance for teachers to analyze tasks before presenting to children [55, 56].

It seems logical to think that the work in large groups does not favor learning for these students; hence individual work or small groups are the best alternative. This work in small groups helps these children to participate in physical education classes, if teachers organize their classes properly and do not leave these decisions to children who will always ignore their more clumsy classmates. Small groups not only allow the child to practice with other peers with different levels of competence but also favor the process of socialization and relationship among them, inciting cooperation and acceptance of other less competent [61–63].

Providing feedback on what is being practiced is an essential aspect of progress [53]. Clumsy children need informational support to progress, but it is not necessary to give supplementary information in each stage because of the danger of making the child dependent on teacher's interventions. It is important for the teacher to show interest in children's learning. One of the most remarkable aspects of the narratives of clumsy adults is that when they were children, teachers did not pay attention to them [12, 13]. Pedagogical research is showing how effective it is to create an atmosphere of work in which children are recognized for their effort and dedication and where teachers offer feedback on good achievements [64] and when their students request them.

6. Why physical education and sport pedagogy must be concerned with this problem

As already indicated in the first sections of this chapter, the first professionals who meet these children in school are the classroom and physical education and sport teacher. The movement difficulties presented by these children represent a great challenge for them when discussing teaching methods that can be used to work to improve their motor skills.

But, why must PE teachers be concerned with this problem? The main objective of physical education in schools is to develop motor competence in all children, not only in skillful children. To be competent it is necessary to begin being incompetent, and PES teachers must provide their children with the tasks and experiences that help them to improve their motor coordination. The identification and teaching of these children are the responsibility of these teachers. If physical education teachers do not care about clumsy children in school, who will?

These children, boys and girls, need more attention and more patience from their teachers. Why? Because they do not follow the same pace of learning than that of their classmates, and because the physical education environment generates feelings of failure in these children [63]. Clumsy children often feel they do not have control over the environment and are unable to prevent motor failure. It is in this situation when they begin to develop what has been called learned helplessness [65, 66]. Teachers need to be aware of these circumstances and establish a pedagogical atmosphere where these children could practice without being

judged by their peers. These will then ensure that their clumsiness can be kept at a minimum and provide them with tasks, motivation, and confidence that permit them to achieve success.

These children need a learning environment that considers the difference, a warmer teaching context where peers can understand that everybody has their own process of learning. They are able to acquire specific motor skills, but they have problems to transfer general aspects from one skill to another [67]. This problem can be solved by a task approach that first selects skills that are nuclear and necessary to learn other skills, to apply to different situations and to permit participation in play and games, and, second, breaks skills down into easier steps and offers multiple opportunities of practice and feedback [68]. Clumsy children need extensive teaching and continual reinforcement. PES teachers have to assume that with these children, it is necessary to reteach fundamental skills (catching, running, landing, throwing, etc.). These children avoid playing and practicing outside classes and have a lack of motor experiences and a deficit of practice [55]. Physical education and sport is for all children regardless of their level of motor competence, and if teachers are aware of clumsy children, their pedagogical strategies can be designed to help them to be more competent and enhance their experiences in class.

7. Concluding remarks

Physical education and sport pedagogy must be more concerned with this problem than it has been until now. It should consider what professionals should do with children with coordination problems in the class. It should investigate what teaching methods are most appropriate and how to achieve a climate of learning and teaching appropriate for these students with these specific needs.

It must be considered how to train teachers so that they are able to direct their eyes not only toward those who are competent but also toward those who have a low motor competence and developmental motor coordination problems. Identification of these children is not an easy task, which is the reason for developing objective assessment tools for PES teachers for early recognition of this "at-risk" group. Quick and simple screening devices like checklists or motor test like GRAMI-2 motor tests are appropriate for PES teachers given the limitations of their training in motor development, the difficulty to identify motor coordination problems, and the time constraints.

If these children are not correctly identified, they are not going to receive the educational opportunities and support to alleviate the effects of their condition. Well-developed physical education and sport programs can contribute to the motor skill learning of poorly coordinated children and alleviate their social problems.

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In a plural, complex, and diverse society, the school faces many challenges. Teachers must prepare their students for future professions, unthinkable nowadays, and the digital competences of teachers and students are one of the axes of an advanced school. This book presents a set of works rigorously elaborated by authors of different disciplines, on the role of information and communication technologies (ICT) in educational centers and on the use of digital resources in the initial and continuing teacher training to improve them, as well as in the teaching of different subjects to achieve a better academic and social performance of students. Besides, the reader will find some innovative experiences in physical education to achieve a better physical, emotional, and social performance of students.

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