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Blended Learning and Teaching in Higher Education

An International Perspective

Edited by

Maria Beatrice Ligorio and Francesca Amenduni

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About the Editors

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Francesca Amenduni is Senior Researcher and Project Manager at SFUVET (Swiss Federal University for Vocational Education and Training). Her research interests concern boundary crossing between school and workplace, the use of digital technologies in Vocational Education and Training, specifically concerning how to use digital technologies to support reflective activities.She is a member of the SC of the EDEN Network of Academic and Professionals and of the Collaborative Knowledge Building Group. She took her PhD in Experimental Pedagogy with a research on semi-automated assessment of Critical Thinking in essays and open-ended answers (AES).

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Editorial

Blended Learning and Teaching in Higher Education: An International Perspective

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Blended learning is not a new topic for educational research in Higher Education (HE). However, before the first wave of the COVID-19 pandemic, blended learning was studied by a "niche" of researchers and educators interested in technology integration in teaching and learning. It was not difficult to meet HE professionals who had never or had only poorly reflected on the topic of how to integrate digital technology in teaching and learning before March 2020. Many authors acknowledge the effectiveness of blended learning over face-to-face traditional courses [1,2]. Nortvig and her colleagues [3] proposed a more comprehensive comparison, which included e-learning with only online formats, a blended approach that mixed online and face-to-face teaching with in-person teaching. According to their review, it is clear that is not easy to compile a ranking and point out the best method, as many other factors influence the effectiveness of a teaching method, such as educator presence in online settings, the interactions between students, teachers and content, and deliberate connections between online and offline activities and between campus-related and practice-related activities.

The pandemic forced even the most skeptical HE actors (teachers, students, and deans) to deal with educational technologies. This shift to what we currently call Emergency Remote Teaching [4] brought mixed results, which can be explained by organizational aspects (e.g., infrastructure), teacher and student digital competences, and instruction modes. Despite the emergency, in a few cases, research shows better learning outcomes during the forced distance teaching period compared to traditional face-to-face classes before the pandemic [5,6].

Even in the most negative contexts, it was possible to experience positive aspects, such as opportunities for teachers' professional development. We recognize that these opportunities have not yet been fully exploited and we consider that understanding how to capitalize on the lessons received during the lockdown for the future is the next challenge. Indeed, the new educational scenarios are—at different speeds according to the pandemic scenario—going back to in-person teaching; however, many do not want to give up technology and the possibility of using education at a distance. In other words, the blended solutions are going to be even more popular.

Blended learning seems to be a favorable solution and is a field which has already attracted some attention; now, we need to re-focus on this, capitalize on what we have learned from the current situation, and combine them with what we already know from previous research.

The most basic definition of blended learning encompasses the possible combination of computer-mediated and face-to-face teaching. It is not a simple juxtaposition of physical presence and technological mediation, but a well-studied alternation of the two, aiming to make the most of the various components and design effective work contexts for both students and teachers.

Although this definition of blended learning is generally accepted, a huge variety of practices have been developed under this terminology. In light of the new technological awareness that educational settings have reached, there is a need to provide more detailed instructions and suggestions regarding how to design, implement, monitor, and assess blended learning.

The six papers presented in this Special Issue begin to answer to a few critical questions related to learning models, cognitive and social processes that could be intertwined in a blended learning program in HE and communication modes.

By looking at the six papers, blended learning has been interconnected with a theoretical model of constructive and interactive learning, specifically with collaborative knowledge construction [7–10], collaboration with external professional communities [11] and collaboration aimed at conceptual problem-solving [12].

Soliman et al. [10] described how synchronous and asynchronous Knowledge Building can be combined in new ways to provide students with more design time and a deeper engagement with the content and their peers. In Bent et al. [7], pre-service teachers developed their collective expertise through peer-feedback on video recordings of their professional practice. Through semantic network analysis, authors retrieved the progressive knowledge development of the pre-service teachers, which, at the end of the semester, adopted a new specialized vocabulary and were more able to interconnect conceptual topics. Ritella and Loperfido [8] described that a student-centered approach, such as Knowledge Creation, requires HE students to develop self-organization strategies in blended learning contexts. According to their findings, group self-organization changed across different phases of the collaborative task and involved the development of specific practices of self-organization. Sansone et al. [9] presented how a blended HE course could be enhanced through a Design-based research approach by improving students' perception of the acquisition of skills and knowledge through the different course editions. In the case of Amenduni et al. [11], collaboration occurred between an HE educational community and external professional communities. The participation of company tutors in an instant messaging environment moved HE students toward a more collaborative and reflective dynamic. Finally, Stahl [12] described the collaborative use of existing dynamic-geometry technology for Euclidean geometry (GeoGebra). The technology allows teachers and students to interact with the same material in multiple modes, so blended approaches can be flexibly adapted to students with diverse preferred learning approaches or needs, and structured into parallel or successive phases of blended learning. The technology can be used by online students, co-located small groups and school classrooms, with teachers and students having shared access to materials and student work across interaction modes.

The six papers described different Communication and collaboration modes—i.e., asynchronous or synchronous—which are involved and interconnected with the various existing platforms. Soliman et al. [10] described the combined use of Zoom for synchronous communication with the Knowledge Forum for asynchronous knowledge construction activities. Bent et al. [7] used the Iris Connect environment for students to upload their recordings of their teaching activities at VET schools. Communication between students occurred within the Iris Connect environment in the form of peer feedback among pre-service teachers. Amenduni et al. [11] described the use of Whatsapp as an instant messaging environment to support communication within an academic community (composed of students and academic and tutors) and between academic and professional community (composed of students, academic and company tutors). Sansone et al. [9] described the combination of different communication and collaboration environments: Moodle (for discussion), Padlet (for brainstorming) and Google Suite for collaborative activities (e.g., collaborative maps and writing). Stahl presented a recent feature of the GeoGebra environment, the "class function", in which a teacher can invite several students (a pod) to work on their own versions of the same construction, and the teacher can view each student's construction work and discussion in a Class dashboard.

Overall, this Special Issue provides a deeper understanding of what Blended Learning will be in the near feature, encompassing not the simple combination of online and physical presence, but a combination of delivery tools and media used to provide information and support interaction, a combination of different methods of instruction and teaching/learning, and a combination of learning contexts.

Conflicts of Interest: The authors declare no conflict of interest.

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Article

Becoming an Expert Teacher: Assessing Expertise Growth in Peer Feedback Video Recordings by Lexical Analysis

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Abstract: Teacher education enables students to grow from 'novice' into 'starting expert' teachers. In this study, students' textual peer feedback on video recordings of their teaching practice was analysed to determine the growth of their expertise in relation to blended curriculum design. The degree to which curriculum and literature influenced their feedback was assessed by semantic network analysis of prominent words from the literature that was studied, as well as the lexical richness and semantic cohesion of students' peer feedback and reflections. The lexical richness and the semantic cohesion increased significantly by the end of the semester. This means that students incorporated new vocabulary and maintained semantic consistency while using the new words. Regarding the semantic network analysis, we found stronger connections between the topics being discussed by the students at the end of the semester. Active use of video and peer feedback enhances students' active knowledge base, thus furthering effective teaching.

Keywords: teacher education; blended; curriculum

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1. Introduction

The lock down of schools as a measurement against the Covid19 pandemic resulted in en masse transfer from classroom teaching to on-line education. Students were trying to copy teacher and information centred classroom teaching, resulting mostly in 'talking heads' on the students' screens and the scrolling of information. This resulted in students complaining against on-line learning because they missed the interaction with teachers and peers. De Jong and Lans [1] discovered in their research among students and teachers in the first months of the lock down that students missed variation and interactions. Later during the Covid19 period in the Netherlands, the possibility of blended learning or a mix of on-line and face-to-face learning became possible. The present study is an example of such a blended learning situation. The study is framed in the context of the Erasmus+ knowledge Alliance video-supported collaborative learning (ViSuAL) project. The main objective of this project is to research pedagogy for using video in supporting collaborative learning [2]. In the present article, we report an experiment on bachelor-level courses of a Vocational Education and Training (VET) teacher education curriculum in the Netherlands. This experiment aimed to support student teachers' development from 'novice' to 'starting expert' by using students' video recordings and peer feedback in a blended curriculum.

The use of video has shown its potential to impact teaching practice, both in teachers' pre-service education and in-service professional development [3–5]. However, the combination of video use with more current pedagogical approaches such as knowledge building or active, collaborative learning is rarely seen in the curriculum design. Teachers do not know how to cross the barrier of direct instruction and a 'knowledge-telling' way of teaching [3] and explore video's abilities to support collaborative learning [6–8].

In teacher education, videos are frequently used to improve authenticity in teaching practice. According to Radović et al. [9] more authenticity facilitates experiential learning while strengthening the ties between theory and practical learning experience. How to implement video use in lessons or how to design a curriculum with it is a challenge for teacher trainers and their students, especially how to do it with a more or less collaborative learning approach.

1.1. Problem

Teaching is a knowledge-rich profession [10] and teachers regularly evaluate knowledge in relation to their practice to update their knowledge base, thus improving their teaching practice. Being an expert is more than knowing a list of facts and formulas relevant to the teacher's domain [11]. Instead, experts organize their knowledge around core concepts or 'big ideas' that guide their thinking about domains and acting in the classroom.

According to Larkin et al. [12], beginners rarely refer to major principles. When watching a videotaped lesson, expert teachers' perceptions differ from those of novice teachers [13]. As novices, student teachers have different views and a different understanding of how to explain differences and deal with the differing opinions in the literature [14] and practices concerning reflective practices [15].

Expert teachers interpret practices according to very different standards, using more sophisticated pattern recognition and segmentation. Experts are not formed only by instructions on how to teach; 'it takes experts to make experts' [16]. To become an expert, a teacher also needs experiences in authentic practices [9]. Thus, in teacher education, students will not intuitively become expert teachers; there is a distinct need to stimulate and broaden their thinking about their acting in and organising their teaching practices [17]. In a collaborative learning setting, teachers may even strengthen their education practice so that students become 'starting' experts [18–20] (see Section 1.2). Meyer [17] observed that pre-service and first-year teachers who discussed knowledge concerning the facilitation of learning had limited views on the importance of learning. For second- and third-year students, Meyer [17] found that students had more ideas about the importance of prior learning. Thus, students' ideas about 'good' teaching probably grow during their studies as they are exposed to literature and to their teachers' expert knowledge.

Previous 'knowledge building' research confirms that it supports the literacy development of students, including vocabulary growth [21,22] and written composition and reading comprehension [23]. However, do peer feedback and reflection such as 'discussion and dialogue' increase students' use of the relevant knowledge they acquire from literature or lectures? During a course, one would expect that students' use of words related to these 'big' ideas in pedagogical theory, as crystallized expert knowledge would increase if they exchanged feedback with peers or wrote substantive reflections at the end of a course. This increased professional jargon use—the lexical growth—can be seen as an indication of becoming more expert.

1.2. The Impact of Peer Feedback

Do students learn from a collaborative learning setting where they give feedback to video recordings of their peers' teaching practice? Teachers must develop professional understanding of motivation, self-regulation skills, teaching ideas, and authentic situations in order to function as 'expert' teachers in practice. Training teachers by practice is a regular approach in teacher education [24]. The use of reflection can be seen as a self-critical and inquisitive process that improves teaching quality. This process generates thoughts and new knowledge about pedagogical decisions during the practice. In general, feedback is seen as a paramount requirement for improvement and self-reflection and is one of the core activities in developing one's professional identity [24].

The quality of the feedback is crucial. Adequate feedback positively influences the learning process and increases performance, but inadequate feedback decreases it [24,25]. With adequate feedback, the learner reflects on and improves his performance [24]. For

Gaudin and Chaliès [26], video in learning is a tool and not part of a curriculum; it enhances learning. Weber et al. [24] argue that the use of video develops more than a vision; it also fosters knowledge and increases choices during teaching, for instance about classroom management.

1.3. Reflection and Video/ Novice Experts

Novice and expert teachers have different knowledge about classroom management and a different professional vision [24]. Novice teachers also possess more limited understanding of their students' prior knowledge [17,24]. Thus, novice teachers' development depends on their understanding and perceptions of education and how they put these into practice [17].

Nielsen [27] revealed that structured collaborative analysis of video recordings of students' school practice leads them to a more nuanced consideration of concrete incidents and supports them in reconstructing their student experiences with a focus on student learning. Students say they benefited from the peer support and had a positive view of the structured approach. Ingram [28] also discovered a case of shifting from an egocentric focus towards a learner-centred focus when watching video clips with students. Moreover, peer dialogues also have a reflective power. They are comparable to the practical knowledge of students, for example, knowledge derived from experiential and practical experiences in the classroom and the richness of argumentation students have [29]. Dovigo [30] showed that when students analysed videos of their teaching activities together, they developed a sense of collaboration and shared understanding that led to a more reflective stance. This could strengthen their ability to transform educational principles into everyday teaching by bridging the gap between theory and practice. Calandra et al. [31] also found that students who captured their lessons on digital video and reflected on critical incidents produced broader perspectives than a group of pre-service teachers discussing immediately after teaching. It seems that video-aided reflection is an important instrument for facilitating the development of novice teachers into experts.

This brings us to the following question: is students' transformation from novice to expert reflected in an increase in lexical richness, semantic cohesion and constructive use of key terms from the literature they study? This study tries to answer this question by making use of a computational analytic technics, for example, natural language processing and semantic social network analysis. In that sense, the study contributes to one of the provocations for the future of the field of computer supported learning [32]: vigorously pursuing computational approaches to understanding collaborative learning. Of course, peer feedback is not collaboration in the sense of negotiation and interdependency; however, it is a matter of joint attention and meaning making true a kind of dialogue, for example, the peer feedback and student's making sense to their own way of teaching to increase their teaching practice. During the dialogues in the face-to-face meetings, students as members of a small group were engaged in a joint task, for example, to improve their way of teaching by communicating their practice by video, giving peer feedback and improving their ideas of teaching (knowledge construction). So, this study also provides insight if computational approaches are able to determine what happens with the lexical richness, semantic cohesion and constructive use of key terms from the literature during the students' 'collaboration' in the time of the course.

2. Materials and Methods

This study concerns a pre-experimental one-group case study design [33,34], where repeated observations are made. It follows the structure of x-O-x-O-x-O-x-O-Of, where x stands for a video recording of authentic teaching practice of a student teacher, O for peer feedback from several peers, and Of for students' final reflection assignment. Dependent variables to indicate the growth of expertise were lexical richness, semantic cohesion and betweenness centrality.

2.1. Participants

The student teachers worked together in small groups. The class group consisted of 15 part-time student teachers (ten males and five females) in a Bachelor's teacher education program in the Netherlands. The student teachers were already teaching in different domains at vocational secondary education schools (VET). The average age of the students was 42.4 years (sd 8.7).

2.2. Variables

Lexical richness has previously been used as one of the linguistic variables to assess Alzheimer's disease progression, where patients tend to have a low lexical richness rate [35]. In contrast to the loss of words and meaning as in Alzheimer's patients, our hypothesis is that students will acquire more vocabulary items and professional terms during the learning process, and that their lexical richness will be increased at the end of the course. Formal academic writings also present high values of lexical richness [36,37]. For this study, we used the Type Token Ratio (TTR) to measure the lexical richness of students' vocabulary. In our case, we evaluated the students' vocabulary each month to detect when it increased. While the lexical richness reflects the variety of the lexical items, it does not reflect the meaning that they create together. Thus, we included the assessment of the semantic cohesion of the students' comments as a complement to the lexical analysis. We used two metrics that reflected the semantic cohesion. The first one was based on the semantic similarity between all words in a given text. The second one was based on the centroid distance between all words given in a segment of text [38].

We used KBDeX, a social network analysis application for knowledge building discourse to calculate the betweenness centrality to measure the extent to which a word influenced other words in the conceptual network of words [39]. The reason is that we wanted to know the mediating function of the words that are representative of topics emerging in the literature. At the word level, a betweenness centrality value of 1 means that a word is highly influential, whereas a value of 0 means that a word is equally as influential as other words. The betweenness centrality measures the number of node pairs and the shortest path between them that passes through a node. It suggests that the selected node works as a key mediator in linking other nodes [39–41].

2.3. Procedure

As part of their four-year curriculum, the students took part in a course about pedagogy. The course content comprised the six main roles of a teacher [42] and collaborative learning. During the course, which lasted four months, the students had to follow lectures and read literature, and also video-recorded their own teaching practice in VET schools. They uploaded their recordings into the Iris Connect environment in which they could provide monthly peer feedback on the video recordings of peers. To give their commentary on each other's recorded videos, students were divided into four small groups. In the last month, the student teachers used the peer feedback and course literature to write reflections on their teaching practice as a final assignment. The data we collected consisted of students' comments (peer feedback) on video recordings during their teaching at VET schools in the Netherlands and their final reflections.

2.4. Analysis

To determine the 'expert' growth of the students', we used two analysis methods and reflections as expertise indicators. Firstly, we used semantic analysis by applying topic modelling to determine underlying dimension topics in the literature represented by related terms. Secondly, we used lexical analysis. For the lexical analysis, we used the complete peer feedback dataset of the entire class group. We explored the students' peer feedback discourse by using the peer feedback and reflection data from each of the four student sub-groups. Thus, we tackled this part of the analysis as a multiple case study design [43].

2.5. Topic Modelling of the Literature Students Had to Study

We identified topics by applying topic modelling methods, a probabilistic technique used in machine learning (ML) and Natural Language Processing (NLP), to explore a collection of documents. A topic represents a group of words with a high likelihood of occurring together in a document [44]. The rationale behind this method is that meanings are relational [45,46]. The resulting group of words may also be interpreted as lexical fields. The meaning of the words in a lexical field depend on each other; together, they form a conceptual structure that is part of a particular activity or specialist field, such as a lexical field associated with school (e.g., teacher, book, notebook, pencil, student, etc.).

We used a well-known statistical language model, Latent Dirichlet Allocation (LDA), to generate the topics [44]. The data used for this analysis corresponded to the literature used by students during their course. We used the LDAvis [47] library in Python, which allowed us to compute topic models and visualise topics in a Cartesian-like space. This library uses LDA as a technique to identify topics [48]. For the topic modelling analysis, we did not consider the time as a variable to analyse the topics' evolution during the semester.

We pre-processed the data by conducting the usual tokenisation, lemmatisation, and part-of-speech (POS) tagging. Tokenising involves separating a text into sentences and sentences into words. Lemmatisation reduces a word to its canonical form; for example, nouns are put into their singular form (children-child), and verbs into the infinitive form (was-be). POP tagging identifies the lexical part of speech, whether a word is a noun, a verb, an adverb, and so on. This process allowed us to filter tokens by their POS tags and used only nouns and adjectives, which are some of the linguistic features common in informational writings [36]. The reason for filtering only using nouns and adjectives is that we wanted to analyse the attitude towards learning and teaching of the student teachers. Moreover, the frequency of nouns and adjectives has been used to analyse the differences between scientific writings and technical reports. According to Biber and Conrad [36], academic prose has a higher frequency of nouns than conversations.

Thus, using these linguistic features to track students' attitude towards learning and the student teachers' teaching was justifiable, since the data originated in a conversational forum. Moreover, students learned an academic writing style, which is more informational, during their studies at the university; it was also close to academic prose. We expected that these linguistic features would be more prominent at the end of the semester. To determine the number of topics in a model, Korenčić, et al. [38] proposed to evaluate the semantic cohesion of the topics with semantic measures. The authors suggest training the models with n topics, where n is the number of topics, initially set at two and growing until a given number. Then, the semantic cohesion is assessed for each topic, and a final score is associated with each model. The model with the best score values is thought to be the one that people will interpret more easily. In our case, we trained 20 different models to find the best model with the most coherent topics based on proposition. The model with the best semantic cohesion value was designated as the model with the ideal number of topics.

2.6. Lexical Analysis of Students' Peer Feedback Comments

To perform the lexical richness analysis, we used the TTR measure to analyse the students' interventions on a digital platform:

$$TTR = \frac{number\_of\_types}{number\_of\_tokens}, \tag{1}$$

where $number\_of\_types$ represents the counting of different words (no repetitions) and $number\_of\_tokens$ is the number of all words in a given text, including repetitions. To compute the semantic cohesion, we used the vector representation of words (word embeddings) that captured part of the semantics of the language [49]. To measure the semantic cohesion, we used two approaches: the first one was based on the word similarity between a group of words, the second on the centroid distance. These analyses were conducted in a longitudinal setting, where we considered each month as time markers during the semester. We then measured the growth of both the lexical richness and the semantic cohesion of the students' peer feedback comments over time. We did not use any grammar or spelling correction, since we wanted to keep the texts in their natural setting. However, we conducted text normalisation, which involves lemmatisation. After computing the TTR for all students' interventions, we used a boxplot to visualise their distribution over time.

We expected to see that the semantic similarity and the semantic cohesion in the students' peer feedback had increased during the course.

2.7. Social Semantic Network Analysis

Because of the complex and dynamic nature of peer feedback and reflections, we adopted a mixed-methods design to seek clarification of results. More specifically, we adopted a sequential approach of social and temporal network analyses. First, we prepared the raw data from comments, the literature and final assignments and second we selected the ten most prominent words in each of the topics identified by the topic modelling analysis. We used these words in the knowledge-building discourse explorer (KBDeX), a content-based social and temporal network analysis tool [50]. KBDeX visualizes three network structures (persons, words, and notes). These networks can be analysed by unit-by-unit construction, and the process of the network building can be paused and resumed. With this social semantic network analyses (SNA), we could determine how topic terms function as key linking mediators in the conceptual growth of the students' peer feedback and reflections over time. KBDeX analysis is based on the co-occurrence of words in a note. Network visualisations show the combined words, notes, and networks of co-creation by students. It is also possible to observe the strengths of connections between words and notes over time in network metrics.

The first stage of the analysis consisted of quantitative analyses on the total group level. Thus, we used social and temporal network analyses to examine group network patterns. This helped us to determine the number of different words representing the topics with central constructive functionality in the peer feedback and reflections over time. The second stage consisted of qualitative analyses where we analysed the content and context of central word-related notes to identify specific knowledge construction in each of the four student groups.

Interventionary studies involving animals or humans, and other studies that require ethical approval, must list the authority that provided approval and the corresponding ethical approval code.

3. Results

3.1. Topic Modelling

When evaluating the topic modelling, we found that the model that gave more semantically coherent topics contained seven topics (see Table 1). The first measure that we used to evaluate the cohesion of topics concerned the semantic similarity of the group of words that belonged to a single topic. For the semantic similarity-based measure, the values go from 0.0 to 1.0. The higher the value, the most coherent a topic is. The second measure concerned the distance centroid of all words belonging to a topic. For the distance centroid-based measure, the values start from 0.0; the maximum value is delimited by the vector space representation. In this case, lower values express a high semantic cohesion. When selecting a model, we kept the highest value for the semantic similarity-based and one of the lower values for the distance centroid-based, leading us to the model with seven topics (see Figure 1 and Table 1).

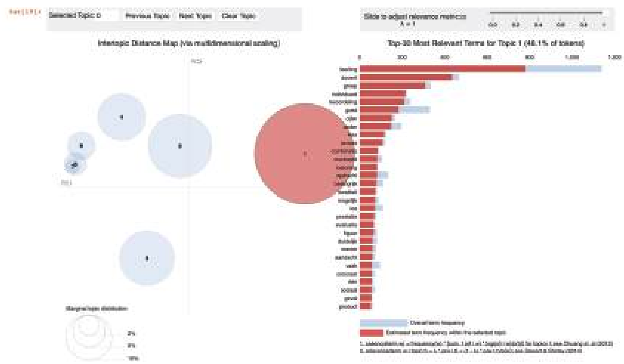

Figure 1. Visualisation of seven topics in LDAvis library [47]. The circle in red represents topic one, which has been selected to show the words that comprise it.

Table 1. Models and number of topics are presented in the first column; columns two and three contain the corresponding semantic coherence for each model. The model with seven topics presents the best semantic coherence values.

Models and Number of Topics	Semantic Similarity-Based	Distance Centroid-Based
2	0.34	22.57
3	0.32	23.04
4	0.32	21.52
5	0.32	22.38
6	0.33	21.22
7	0.35	21.25
8	0.30	21.81
9	0.32	22.08
10	0.31	21.76
11	0.31	21.26
12	0.29	21.74
13	0.26	22.49
14	0.28	21.51
15	0.28	22.57
16	0.26	21.99
17	0.27	20.99
18	0.26	22.01
19	0.27	20.94
20	0.28	21.65

The topics could be interpreted as: (1) Testing and monitoring (students, teacher, group, individual, judgment, good, mark); (2) Group and interaction (knowledge, interaction, new, other); (3) Working on an assignment (answer, assessment, part, assignment); (4) Teacher's role (role, education, level, development, attitude); (5) Constructivism and learning theory (subjective, reality, information, constructivism); (6) Learning process (cognitive, learning activity, child, learning process, affective); and (7) Behaviourism and learning theory (active, instruction, environment, behaviourism, perspective).

3.2. The Lexical Richness and Cohesion Analysis

Figures 2 and 3 show the semantic cohesion distribution with both approaches (semantic similarity-based and distance centroid-based). In the two approaches, we see that students' semantic cohesion increased in the participation in the fourth month. For the semantic cohesion based on the semantic similarity (Figure 3), the values varied from 0 to 1. A higher number signifies a higher semantic cohesion. We can see higher semantic values in the fourth month: the values of the comments were in the range of 0.16 to 0.4. The third month contained the highest semantic cohesion values, but their distribution was more dispersed than in month four. For the approach based on the distance centroid, a smaller value expresses a higher degree of semantic cohesion (Figure 4). In both cases, the semantic cohesion was higher in the last month, which reveals that the students' semantic cohesion increased over time.

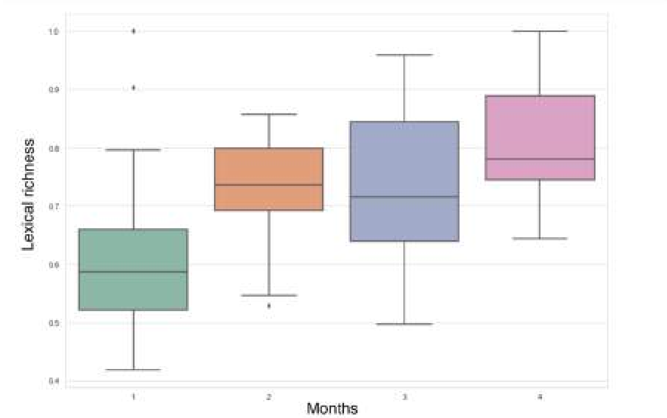

Figure 2. Results for lexical richness using the TTR score.

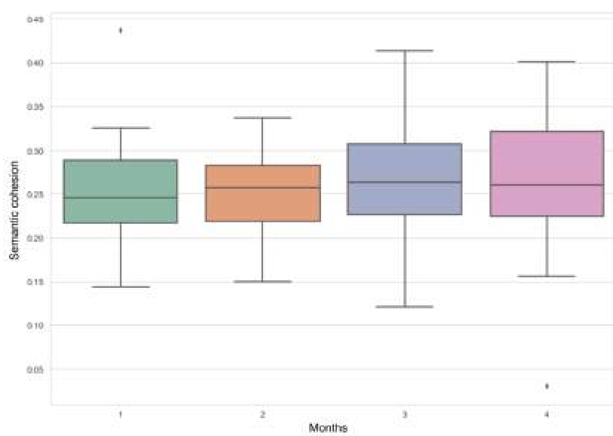

Figure 3. Results for similarity-based semantic cohesion.

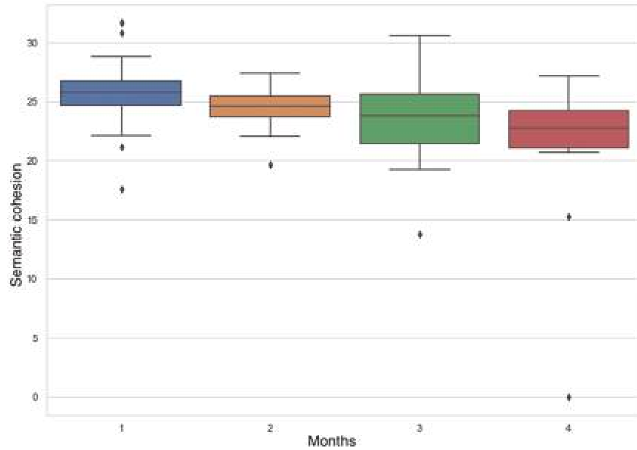

Figure 4. Results for Distance-centroid-based semantic cohesion.

A step forward regression analysis was carried out to determine the predictive value of the predictor variables' lexical richness' and 'semantic cohesion' (both semantic similarity-based and centroid distance-based) for the 'peer feedback given in a particular month' (dependent variable). Two significant models appeared (Figure 5) within the first model, lexical richness, and the second model, lexical richness and distance centroid-based semantic cohesion. The latter significantly had explained extra variance to model two, indicating its own specific characteristic (See Figures 6 and 7).

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	95.0% Confidence Interval for B Lower Bound	95.0% Confidence Interval for B Upper Bound	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	.280	.450		.621	.536	−.613	1.172		
	lexical_richness	3.144	.623	.434	5.048	.000	1.910	4.378	1.000	1.000
2	(Constant)	2.072	.887		2.336	.021	.314	3.830		
	lexical_richness	2.525	.666	.348	3.791	.000	1.205	3.845	.841	1.189
	semantic_cohesion2DCB	−.056	.024	−.214	−2.329	.022	−.104	−.008	.841	1.189

a. Dependent Variable: time

Figure 5. Two regression models turned out to predict significantly the month of the comments. Coefficients: model summary and ANOVA table.

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics R Square Change	Change Statistics F Change	Change Statistics df1	Change Statistics df2	Change Statistics Sig. F Change
1	.434[a]	.188	.181	.890	.188	25.478	1	110	.000
2	.476[b]	.227	.212	.872	.039	5.426	1	109	.022

a. Predictors: (Constant), lexical_richness

b. Predictors: (Constant), lexical_richness, semantic_cohesion2DCB

c. Dependent Variable: time

Figure 6. Two regression models turned out to predict significantly the month of the comments. Coefficients: model summary and ANOVA table.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	20.172	1	20.172	25.478	.000[b]
	Residual	87.092	110	.792		
	Total	107.264	111			
2	Regression	24.302	2	12.151	15.965	.000[c]
	Residual	82.962	109	.761		
	Total	107.264	111			

a. Dependent Variable: time

b. Predictors: (Constant), lexical_richness

c. Predictors: (Constant), lexical_richness, semantic_cohesion2DCB

Figure 7. Two regression models turned out to predict significantly the month of the comments. Coefficients: model summary and ANOVA table.

A MANOVA with similarity-based semantic cohesion as dependent variables and time ('the particular month of peer feedback') as variate appear with a significant MANOVA effect for time (F = 3.17; Df = 9.324; p = 0.01; Eta 0.197; Power 0.99).

The univariate tests showed a significant effect of time for lexical richness (F = 8.82; Df = 3.108; $p < 0.000$; Eta 0.197; Power 0.99). Therefore, the lexical richness was not the same for the peer feedback in each month. Semantic cohesion based on similarity did not show a significant time effect. Consequently, it did not differentiate between peer feedback for individual months. Distance-centroid based cohesion showed also a significant effect of time (F = 4.73; Df = 3.108; $p < 0.004$; Eta 0.116; Power 0.89)

Post-hoc analysis showed a significant difference between the lexical richness for month one compared with months two, three, and four ($p < 0.005$; 0.000; 0.000). Months two, three, and four did not differ from each other (Figure 8). Post-hoc analysis concerning semantic cohesion based on distance centroid showed significant differences between months one, three, and four ($p < 0.002$; 0.001). Month two did not differ from the other months. Thus, month three only differed from month one, like month four (Figure 9).

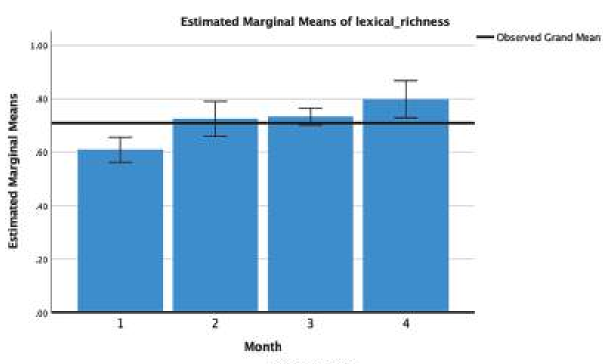

Figure 8. Lexical richness marginal mean per month.

3.3. *Kbdex Social Semantic Network Analysis*

3.3.1. Quantitative Results:

The quantitative analyses at the total group level revealed that, of the 34 selected words related to the seven topics covering the literature students had studied, 16 words functioned as key mediators (Table 2). These words linked other conceptual expressions by students and, in that way, contributed to the lexical richness and student's understanding of the role of teachers in classroom interactions.

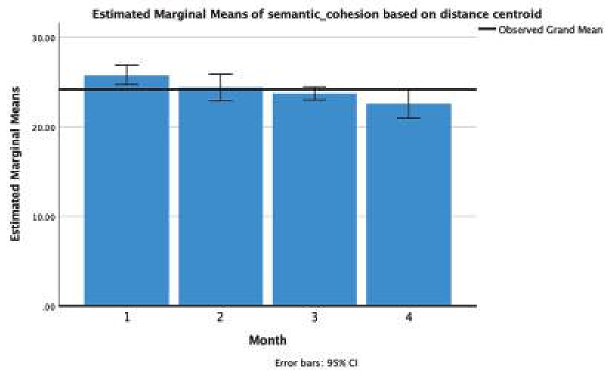

Figure 9. Semantic cohesion based on distance centroid.

Of the seven topics, 'testing and monitoring' was represented five times in the list; 'group and interactions' four times; 'working on an assignment' twice; 'role of the teacher' three times; 'constructivism and learning theory' once; 'behaviourism and learning theory' three times; and 'learning process' was not represented.

Table 2. Selected topic words and degree of betweenness centrality calculated by KBDeX.

Word Related to a Particular Topic	Degree of Betweenness Centrality
t1t7 student	0.036
t1 good	0.036
t3 assignment	0.036
t1t2 teacher	0.036
t3 answer	0.022
t4 role	0.022
t2 other	0.021
t4 attitude	0.015
t1 group	0.015
t2 knowledge	0.012
t5 information	0.011
t4 level	0.009
t2 interaction	0.009
t1 individual	0.004
t7 active	0.004
t7 instruction	0.001

We carried out a MANOVA, where the variates were the selected words and the dependent variable was the betweenness total centrality in each feedback or reflection contribution. Group (four student work groups) was the between factor. A multivariate effect was found for the Group factor (Figure 10). This means that not all four student work groups were equal in how they used words related to topics.

Multivariate Test Results

	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power [b]
Pillai's trace	1.769	10.419	48.000	348.000	.000	.590	500.102	1.000
Wilks' lambda	.064	10.806	48.000	339.858	.000	.601	511.895	1.000
Hotelling's trace	4.741	11.129	48.000	338.000	.000	.612	534.188	1.000
Roy's largest root	2.429	17.611[a]	16.000	116.000	.000	.708	281.779	1.000

a. The statistic is an upper bound on F that yields a lower bound on the significance level.

b. Computed using alpha = .05

Figure 10. A multivariate effect for the degree of betweenness centrality as a function of students' work group.

A univariate test resulted in significant differences (Figure 11) in the key mediation role of the following lexical terms related to the literature topics: Student (t1t7); Good (t1); Attitude (t4); Interaction (t2); Answer (t3); Role (t4); Instruction (t7); Assignment (t3); Group (t1); and Part (t3) (tx stands for indicating the topic).

Univariate Test Results

Source	Dependent Variable	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power [a]
Contrast	t1t7 student	.643	3	.214	15.312	.000	.263	45.937	1.000
	t1 good	1.246	3	.415	42.619	.000	.498	127.857	1.000
	t4 attitude	.013	3	.004	15.441	.000	.264	46.322	1.000
	t2 interaction	.006	3	.002	11.846	.000	.216	35.537	1.000
	t1 individual	.000	3	.000	.	.	.	.	.
	t3 answer	.908	3	.303	44.709	.000	.510	134.128	1.000
	t4 role	.020	3	.007	7.261	.000	.144	21.783	.981
	t2 knowledge	.000	3	.000	2.002	.117	.044	6.005	.505
	t5 information	.000	3	.000	1.146	.333	.026	3.437	.303
	t7 instuction	.004	3	.001	29.969	.000	.411	89.907	1.000
	t3 assignement	.003	3	.001	3.125	.028	.068	9.374	.716
	t1 group	.001	3	.000	2.973	.034	.065	8.920	.692
	t3 assessment	.000	3	.000	.	.	.	.	.
	t2 other	.000	3	.000	1.605	.192	.036	4.814	.414
	t4 level	.000	3	.000	.457	.713	.011	1.371	.140
	t1t2 teacher	.000	3	.000	1.433	.236	.032	4.298	.373
	t3 part	.000	3	.000	2.971	.034	.065	8.912	.692
	t1 judgement	.000	3	.000	.	.	.	.	.
	t2 new	.000	3	.000	.790	.502	.018	2.370	.217

Figure 11. Univariate tests results for the different topic words, some of which showed a significant effect as a function of students' work group.

3.3.2. Qualitative Results:

To better understand the knowledge construction process, we carried out a qualitative analysis of the students' comments. The comments were linked to topic words that had the highest degree of centrality at the end of each of the four months and in the reflections in month five. There was a focus on subgroup that supported the quantitative analysis of the topic 'modeling' and the Kbdex analysis of lexical richness over time. This provided a deeper understanding of the students' development. Individual group summaries are presented below.

3.3.3. Group One:

In peer feedback for month one, students used topic terms of equal importance (Figures 12 and 13): 'student', 'interaction' and 'answer'. These terms connected most strongly to ideas in the peer feedback. In month two, the students did not give feedback, and in month three, the topic 'role' also connected more strongly to the other three terms. Over time, the conversations and the peer feedback changed from how a teacher can present himself and interact with students, to the different roles of teachers and what role is important in a particular stage of a lesson.

The final assignment reflections in month five showed that the students had integrated more topics than in the peer feedback during months one and four. The peer feedback was more disconnected and over time the relations of the topics increased and showed a stronger connection. In the students' reflections, the topic terms 'student', 'answer', 'interaction', 'good' and 'role' showed the strongest connection. In the reflections by the students, 'answer' was quite important, which suggests that students were especially interested in answering and responding to the pupils' learning in a way that stimulates collaborative learning.

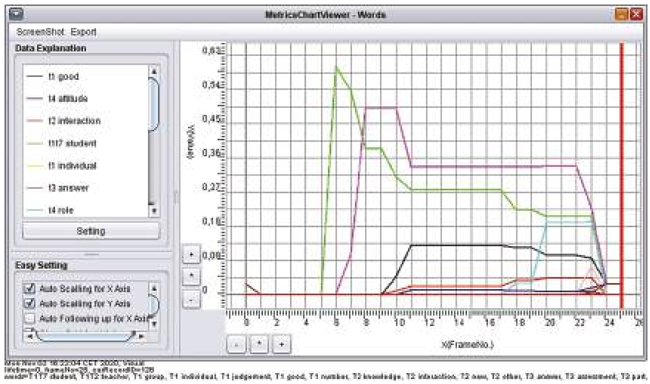

Figure 12. Degree of centrality of various topic terms in the feedback and self-reflections.

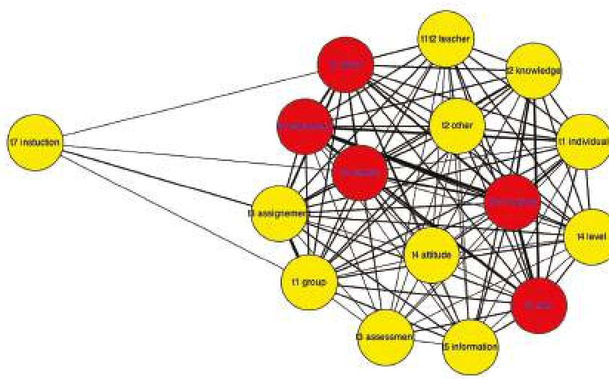

Figure 13. Word network for work group one.

3.3.4. Group Two:

In month three, the topics 'student', 'good', 'interaction' and 'assignment' were strongly connected. These terms are from topics t1 and t3 and come from the literature used in the lessons. It is remarkable that the betweenness centrality was higher at the end, because this group gave little peer feedback during the entire course. The reflections showed that the topic 'answer' also made a strong connection in the final assignments (Figures 14 and 15).

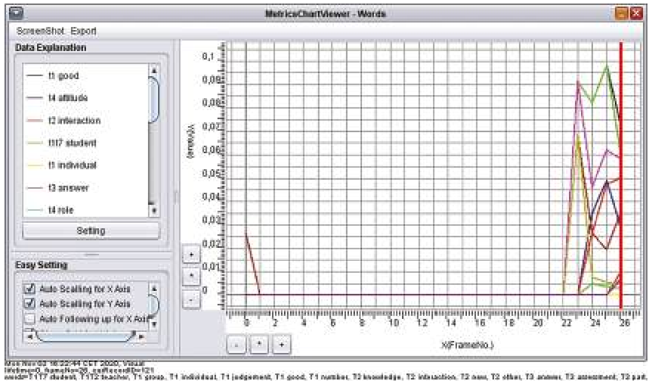

Figure 14. The group mainly used the literature-related topic words during month 4, and their reflections showed that the students integrated more topics than in the peer feedback in months one and three.

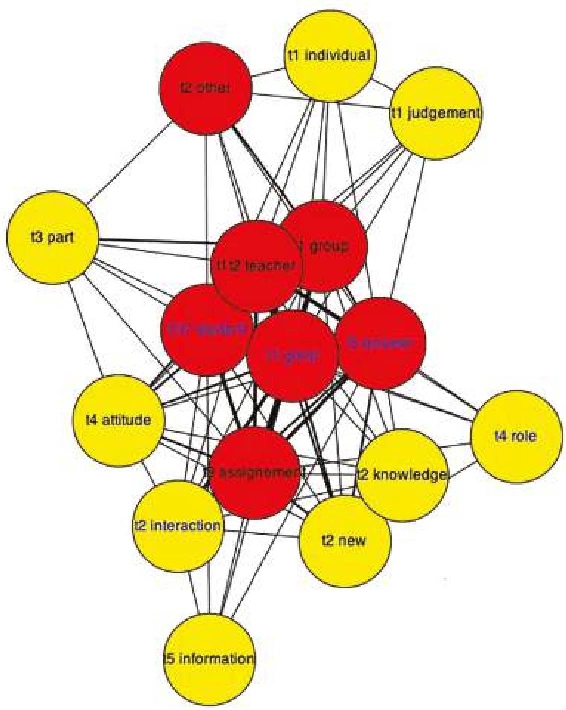

Figure 15. Word network for work group two.

3.3.5. Group Three:

During month one, few topic terms were used. In month two, feedback was more orientated on how communication supports class management. In the third month, the teachers' role as communicator and coach emerged in the feedback, with strong focus on 'good' interaction. Month four showed more class management feedback but focussed on the teacher's instruction, interaction and physical position in the classroom. The last feedback round and the self-reflections showed that students integrated a wider variety of content in the concepts (Figures 16 and 17).

In the final word-relational network, 'good' and 'teacher' were positioned very centrally in the semantic network, and therefore in the ideas students developed. This centre connected the aspects of group processes, interaction, attitudes (of students and teachers), instruction, answers of students to questions and feedback. Moreover, in the network analysis with information, level, development, active, others, learning process, individual, knowledge, new and role. The topics (1) 'testing, monitoring, control', (2) group interaction, (7) behaviourist learning theory/instruction, (3) working on an assignment/task and (4) role/attitude were becoming more and more related to each other during the feedback discourse converging in the final self-reflections.

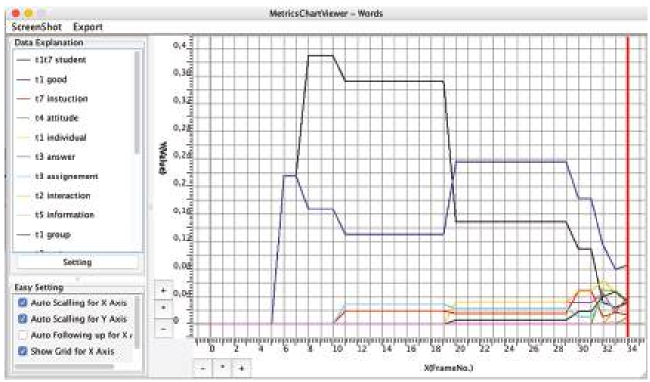

Figure 16. Degree of centrality of various topic terms in the feedback and self-reflections of group three.

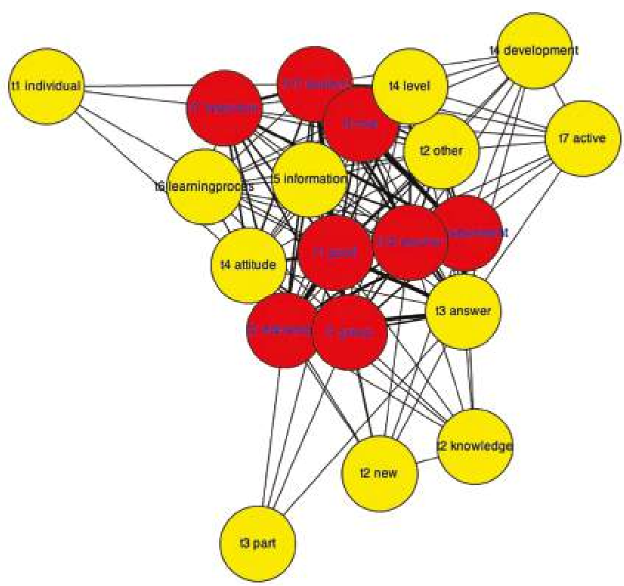

Figure 17. Word network for work group three.

3.3.6. Group Four:

During the four months, the terms 'good' from the topic words 'testing and monitoring', and 'student' from t1 and t7, for example, 'behaviourism and learning theory' were very connective and central to the structure of the feedback and reflections. This was indicative of thinking centred on pupils and the role of the teacher in supporting learning. The centrality, that is, the connectiveness of these terms, also assumed a more connective position, and more evenly distributed connections were observed. This was especially true of terms related to t7, 'behaviourism and learning theory', like instruction, guidance and support by the teacher, and for t5, 'constructivism and learning theory', the presence of more student-centred thinking in the reflections indicated that students were thinking more deeply, and often used their knowledge experiences in the practical assignments to build their own knowledge. Achieving this required not only a particular student attitude and interaction related to the role of the teacher and student (t4) and interaction with peers, but also opportunities for questions and answers (t3) during instruction or when working on an assignment (t3) (Figures 18 and 19).

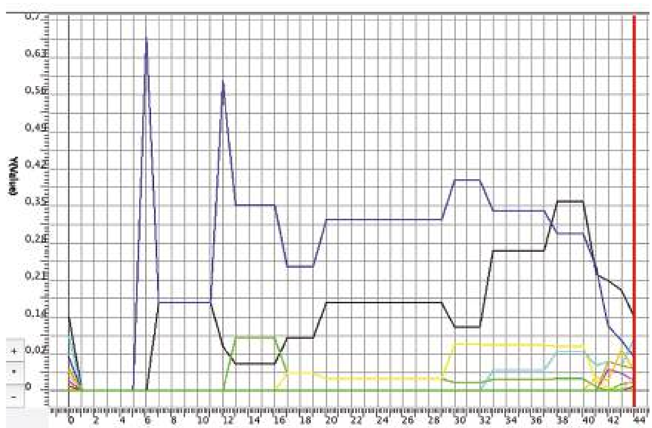

Figure 18. The degree of centrality in student work group.

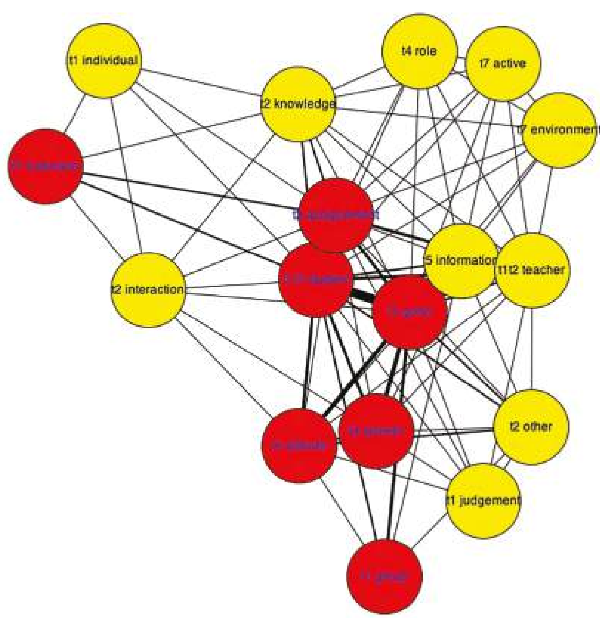

Figure 19. Word network for work group four.

4. Discussion and Conclusions

Overall, our results lead to the conclusion that the lexical richness in the students' peer feedback and reflections increased, indicating that these students were developing from novices into experts. This is in line with Bransford [16] and other literature referred to in the introduction. That video recordings of students' authentic teaching practice stimulates this developmental process is illustrated by one of the students' reflections: 'Where I work, we are unfortunately not allowed to film or make audio recordings.. I personally regret this, because I know from previous experiences how much I can learn from this. Through video interaction you will look at yourself in a very different way and you remember images better than words.' This illustrates the importance of the practice to becoming an expert, as [9] have concluded, but similar to the 'learning by doing' pedagogical approach, it is only effective when students reflect on their practice [51].

It can be concluded that the students' use of 'expert vocabulary' grew during the course, as evidenced by the lexical richness and the semantic cohesion based on centroid distance. In other words, students incorporated new vocabulary and maintained semantic consistency.

In the beginning of the course, student teachers had little knowledge of the literature concerning interaction and teaching practice. Giving more useful, content-related peer feedback on peers' teaching practice requires more knowledge and understanding that leads to a cohesive teaching concept. This developed during the course, as could be seen by two factors. First, lexical richness increased steadily over time for all four subgroups. Second, relations in the word networks at the end of the course were stronger (indicated by thicker lines between the words) than in the word networks at the start. At the end of the course, stronger relations were established between a larger number of topic keywords. Thus, expanding students' activities with video recordings, feedback, interactions and reflections did not hinder their conceptual development and growth of expertise.

Our findings shows that the influence of peer feedback on video recordings of authentic teaching situations stimulates the creation of new 'personal' concepts about teaching. The findings may encourage student teachers to update their knowledge base by using pedagogical and methodological insights offered by the teacher trainer and the course literature. The findings can motivate student teachers to improve their teaching skills and practice, and make them realise that recognising relevant patterns in their thinking about teaching will help them become more expert: true professionals.

4.1. Limitations of the Study

Although there are interesting findings, this study has limitations. First, the number of respondents was limited, and there was no intervention or control group. Secondly, there was only one teacher trainer involved and the influence of teaching style, experience and other personal characteristics were not investigated. Furthermore, the influence of collaborative learning by peer feedback was not investigated at an intensive level of collaborative learning as was intended.

Although we analysed data from several points in time, as in an equivalent time sample design, no effect of testing, selection, or other internal validity errors is to be expected. This is because the students did not know about the analysis, and the data consisted of their periodic feedback instead of repeated survey answers. The Covid-19 pandemic had an impact on the teaching practice during the experimental period and some student groups were unable to give peer feedback at the agreed-on times. Nonetheless, lexical growth and use of 'expert' concept words were still observed.

4.2. Practical Implications

This study shows that students who actively use video, record their own teaching practice and exchange peer feedback can enhance their active knowledge base. This helps students to integrate 'cold' knowledge from the literature with personal knowledge derived from experiential and practical experiences, and to incorporate it into a 'warm' teacher's knowledge base promoting effective teaching and student learning.

We are aware that knowledge is an important factor in becoming an expert teacher. It is true that the competences of an expert professional teacher also involve skills, attitudes and motivational variables [52]. Even so, self- knowledge about these skills, attitudes and motivations is also important, as can be seen from one student's reflections: "(...) the role as presenter was my strongest point of this lesson. Because I speak enthusiastically about my lesson and adopt a calm attitude, I can reach everyone well. This also makes the student enthusiastic and I try to convey the subject content well. Because I am still fairly young, the students trust me and I can quickly build a bond with them. I think this is one of my strongest points, though this can also be a pitfall, because I can lose dominance in the class sometimes. I am happy, and I am still the teacher and not their friend."

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Institutional Review Board Statement: This study was conducted according to the guidelines of the Declaration of the Aeres group Ede, and approved by the institutional review board.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

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Article

The Designing and Re-Designing of a Blended University Course Based on the Trialogical Learning Approach

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Abstract: To have a positive impact on students' development of crucial skills, blended university courses need careful planning to fruitfully integrate learning settings as well as methodologies. The authors adopted Design-Based Research to design a blended university course based on the Trialogical Learning Approach, and then to redesign it according to the learning outputs and the overall learner's experience. The first iteration of the course (a.y. 2015) was followed by an observational study that aimed to identify student perceptions of (1) the impact of the course on the acquisition of the targeted knowledge–work skills and (2) strengths and areas for improvement to be considered when re-designing the subsequent edition. A total of 109 students participated in the two editions of the course under scrutiny in this research. The data corpus included students' self-report questionnaires investigating the development of specific knowledge–work skills and focus group interviews that explored students' perceptions. The data showed this blended course had a generally positive impact on students' perception of acquisition of skills and knowledge, which increased between one edition and the next. This positive impact seemed to correspond with course refinements made by the teacher and with the activities that received greater attention in the second edition of the course.

Keywords: learning design; higher education; Trialogical Learning Approach

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1. Introduction

As universally known, in February 2020, the health emergency known as "COVID-19" forced education systems all over the world to transition online as a result of the forced closure of schools and universities. Unfortunately, in many non-Western societies this brutally meant to interrupt each form of education and learning, considering the various economic, social, and technological limitations they experienced, apart from "COVID-19". In the rest of the world, in subsequent months, we witnessed numerous efforts to ensure the continuation of the school and academic year, with teachers of all levels rushing to find the right tools for videotaping lessons, assigning homework, and verifying students' learning. Predictably, the results of this collective effort have not always been optimal. This is likely due to the suddenness of the transition from one mode to another, and, above all, a lack of methodological preparation. Many teachers improvised online learning without adequately reflecting on how to design effective online teaching and learning practices [1]. Technology, in fact, can only be fruitfully integrated into educational contexts through a thoughtful transformation of practices and consequent re-elaboration of knowledge. This is true at any level of education and particularly at the university level. Facilitating effective, active learning in online contexts can be complex because academic achievement should involve not only knowledge acquisition, but also meaningful and lasting learning in which learners construct new knowledge, actively participate in learning episodes, and experiment with new skills [2,3]. As a consequence, and beyond any educational emergency, we believe that the best integration of technologies in higher education is oriented towards a fully blended approach. "Blended" is a term with different meanings [4,5]; in our interpretation, it does not involve only mixing face-to-face and computer-supported settings. Instead, we proposed a vision of learning in which many aspects are blended: pedagogical methods, individual study and group activity, and a large variety of tasks and end products [6,7]. Nevertheless, for technology to support this kind of active learning, teachers must be able to adapt flexibly to technological affordances and innovations, contextual constraints, and resources [8], while searching for the best "blending" of methodologies, activities, and settings. Yet, given the current educational challenges and the complexity of the learning contexts we are talking about, the need for a rigorous and scientific approach to didactic planning is evident, in which teachers and designers share, modify, and re-use effective, proven pedagogical plans [9]. Specifically, the concern was to support the decision-making processes of teachers who want to make informed decisions on the best teaching strategies to use.

In this paper, we demonstrate how using a structured process of blended-course design, review, and refinement can facilitate more positive learning experiences and knowledge acquisition. To this end, we first describe the teacher's design of a blended university course based on the Trialogical Learning Approach, which we proved as a pedagogical framework capable of supporting teachers in planning a variety of methodologies, strategies, and educational activities, effectively implemented in the intersection of online and offline settings.

2. Theoretical Framework

The Trialogical Learning Approach

The Trialogical Approach to Learning (TLA) [10,11] is a relatively recent theoretical construct that integrates "monological" and "dialogical" approaches to learning with a third element: intentional processes involved in the collaborative creation and development of knowledge artifacts shared within and useful for the community, the "shared objects". The acquisition and participation metaphors of learning [12] are, in this approach, embedded in the knowledge creation metaphor. This metaphor goes beyond many traditional dichotomies and focuses on both individual and social processes, as well as on the conceptual knowledge and social practices needed to foster collaborative creativity. The general aim is to sustain learners' development of knowledge work skills [13,14]; that is, individual capabilities (e.g., metacognition, ITC skills) that are linked both to the community (e.g., collaboration, communication) and to epistemic knowledge and skills (e.g., critical thinking, information management).

TLA is applied through six Design Principles (Table 1) that guide the planning of technology-based teaching and learning activities designed to facilitate shared engagement with knowledge artifacts.

Clearly, the TLA DPs function as general operational guides for the teacher, whose task is to decide how to achieve the objectives set out in each of the six formulations. As such, the importance of pedagogical design is clear. Some type of formalization, in fact, is particularly useful when introducing new practices such as those advocated by TLA [15].

Table 1. The Design Principle for the Trialogical Learning Approach.

The Design Principle	How to Apply Them
DP1 Organize activities around shared objects	Didactic activities must converge towards the collaborative construction of artifacts:designed for real uses, thus acting as a bridge between formal learning contexts and workplace contexts, embodying the skills that learners need to acquire.
DP2 Supporting integration of personal and collective agency and work	It is necessary to combine individual and group:promoting individual and collective responsibility and motivation, encouraging the development of relational skills.
DP3 Fostering long-term processes of knowledge advancement	The learning situation should be lengthy enough to allow: the iteration of different cycles of the same activities an advancement of knowledge when moving from one version to another of the same knowledge object.
DP4 Emphasizing development and creativity through knowledge transformations and reflection	Learning must involve different forms of knowledge: declarative, procedural, implicit; and different formats: text, pictures, multimedia, case-experience. Reflection should be promoted with the aim of improving learning and individual and group practices.
DP5 Promoting cross-fertilization	It is crucial to create connections beyond formal learning contexts and across communities and institutions to promote the development of new ways of interacting as well as new languages and tools.
DP6 Providing flexible tools for developing artifacts and practices	Learning activities and goals should be underpinned by a conscious use of technologies, led by the teacher who deliberately and flexibly selects technologies that allow students to create and share, reflect, and transform knowledge practices and artifacts.

3. The Research

3.1. Objectives

The present paper describes a teacher's process of designing and re-designing a TLA-based blended university course by considering students' feedback and perceptions. Specifically, our research questions (RQ), pursuant to observational data generated in each of the two iterations of the course, were:

i. RQ1: What is the impact of the course on students' perceptions of their development of specific knowledge–work skills?
ii. RQ2: Which strengths and area of improvements do the students find in the course?

3.2. Method

The design and subsequent re-design of the blended course explored in this paper was based on Design-based Research (DBR) [16]. DBR focuses on the analysis of educational practices by interrogating the planning of innovative interventions and subsequently observing the (not)/functioning elements. In this way, limits are identified, and further interventions are re-designed to overcome or address these limits. The aim of DBR, in fact, is to directly impact practices, while simultaneously stimulating the theoretical progress: The value of a theory is evaluated based on how much its principles improve the practice. Methodologically speaking, DBR is grounded in real-world interaction contexts, rather than in laboratory settings; hence, research results need to be connected with both the design process through which results are generated and the setting where research is conducted [17].

Consistent with DBR, this research is based on different iterations of the course, each consisting of four phases: (1) course design, (2) implementation, (3) data collection, and (4) re-design. Specifically, we applied this procedure to two iterations (a.y. 2015 and 2016).

3.2.1. Data Collection

To answer our RQs, we generated data around students' perception of their skills using the following tools:

1. Contextual Knowledge Practice questionnaire (CKP-q), completed anonymously at the end of the course. The questionnaire comprised 27 Likert-scale items that interrogated students' perceptions of the extent to which they developed specific knowledge–work skills (1, not at all; 5, very much). The items were organized in seven scales built around the TLA design principles [18]: (1) collaborate on shared objects (DP1); (2) integrate individual and collaborative work (DP2); (3) development through feedback (DP3 and DP4); (4) persistent development of knowledge object (DP4); (5) understanding various disciplines and practices (DP5); (6) interdisciplinary collaboration and communication (DP5); and (7) learning to exploit technology (DP6). Students were asked to declare to what extent (1, not at all; 5, very much) they perceived themselves to have acquired the related skills at the end of the course (RQ1).
2. Focus Groups (FG) held at the end of the first two iterations of the course to facilitate critical discussion around the course that had just ended (RQ2). Semi-structured interviews were used to elicit students' views on: (1) the most valuable activity of the course; (2) the adopted learning strategies; (3) pros and cons of group work; (4) the course organization; and (5) the role of technologies. FGs were conducted by external moderators in order to promote students' spontaneous and open comments.

3.2.2. Data Analysis

Closed items of the CKP-q were interrogated to collect descriptive statistics. In terms of qualitative data (FG transcriptions), a content analysis made up of three stages was followed: (1) The answers were first read by two independent evaluators to extract preliminary categories based on the TLA DPs (collaboration, knowledge advancement, creativity, etc.); (2) each student response was then segmented into units of analysis, depending on the single DP correspondence. However, for each unit of analysis, student responses were assigned one category based on the general meaning that they expressed. This ensured that individual students were not counted multiple times for one category. (3) Each segment and its corresponding category were traced as positive or negative aspects and finally hierarchically ordered according to their recurrence in the different FG sessions.

Considered together, the tools make the Trialogical principles the very perspective from which to observe, analyze, and refine the course.

Table 2 shows participating students, tools, and data generated for each of the two iterations.

Table 2. Participants and data generated in the two iterations.

Iteration	Participants	Data Collection
a. y. 2015	55 (M: 16–29%, F: 39–71%)	CKP-q (N = 48–87.27%) FG (N = 24 participants. Participants were split across three focus groups.)
a. y. 2016	54 (M: 26–48%, F: 28–52%)	CKP-q (N = 45–83.33%) FG (N = 32 participants. Participants were split across four focus groups)

3.3. The TLA-Based Course Design

This research focused on higher education, specifically, on the Experimental Pedagogy course within the 3-year Bachelor of Psychology and Health course at Sapienza University of Rome (IT). The aim of the course is to provide fundamental knowledge about key learning theories and scholars, and to let students experience specific collaborative techniques and an educational use of modern technologies. Once graduated, in fact, these students may enter work-related contexts and roles such as School Psychologists or Educational Designers supporting Teachers in planning their courses and managing technology-enhanced learning techniques. Yet, their prior experience about digital tools and environments was limited; therefore, the course in Experimental Pedagogy provided them with several, repeated experiences through which to acquire an adequate familiarization with educational technologies.

The teacher of both the iterations is a pedagogical expert in the field of computer-supported collaborative learning. She decided to adopt TLA to structure activities that allow students to become active builders of their knowledge, collaboratively creating concrete artifacts and hypothesizing applications of the theories studied. The TLA-designed activities were, in fact, aimed at creating useful and meaningful products for future job prospects, so as to motivate students during the study of the discipline. Furthermore, the TLA reinforces the blended nature of the course because it is a framework capable of enhancing the blended approach at different levels:

i. Mixing of a variety of teaching strategies and methodologies;
ii. Flexible integration of digital tools;
iii. Cross-fertilization between the university context and the professional/external context.

The course lasts 10 weeks, is structured in three consecutive modules, and, as mentioned, follows a blended learning approach, since it alternates classroom lessons and online activities, as well as different learning strategies and methodologies, grounded in the TLA. Students (avg. age: 21) were divided into learning groups to discuss course topics (Learning and Instruction, Technology for Learning), collaboratively construct artifacts and, finally, to develop a real pedagogical scenario.

The teacher's decision to adopt TLA first entailed a re-design of the course, aimed at strengthening some aspects, as suggested by the DPs, and at deploying appropriate strategies and teaching techniques to support TLA introduction in the course. In Table 3, TLA DPs are shown with reference to the blended setting of the course.

As shown in the table, since the first iteration of the course, each TLA principle is applied through a strong integration of online and in-presence activities that alternate during the three modules of the course and are kept together by a solid planning and the use of specific strategies. Role Taking, for instance, is a technique that reinforces the integration between the classroom and the online platform, thanks to "bridge" roles such as the observer, who is asked to observe the in-presence activity, write down a report, and then upload it online in the group-dedicated web forum for his/her groupmates to comment on it.

Table 3. The Learning Design around TLA DPs.

Design Principle	Implementation in the Course	Blended Setting
DP1 Organize activities around shared objects	The meaningful and shared object around which the course is organized is students' documentation of a pedagogical scenario meant to be implemented at school or at university. Intermediate collaborative objects are: – a conceptual map on the figure of the "good teacher" – a PowerPoint presentation reporting the analysis of preschool children' spontaneous writings.	Artifacts' building–online Artifacts' sharing-in presence

Table 3. *Cont.*

Design Principle	Implementation in the Course	Blended Setting
DP2 Supporting integration of personal and collective agency and work	Students are divided into groups of 9 to 11 members and participate in discussion by bringing their own ideas about the topic to be discussed by the group. Through the first module discussion, key shared understandings are distilled and captured in a collaboratively built cognitive map. In the second module, students' personal and shared understandings are 'tested' through the common activity of analyzing collected writings. Interaction and interdependence are supported by the role-taking strategy. Four stable roles are assigned, in turn, to students in each module: social tutor, synthetizer, skeptic, and responsible for the collaborative artifact. In addition, during classroom collaborative activities, one student carries the role of critical observer.	Group discussions-online Collected writings' analysis-in-presence Role Taking-online and in-presence
DP3 Fostering long-term processes of knowledge advancement	The course is structured into three consecutive modules of approximately 4 weeks. Each module addresses a different part of the curriculum, and it is based on iterative activities of knowledge production and object creation. Knowledge advancement is reinforced through peer-review sessions during which each group is asked to look at the objects of two other groups and to provide constructive feedback. Later, each group works on improving their products, based on the feedback provided.	Peer-review sessions-in-presence Artifacts' revising-online
DP4 Emphasizing development and creativity through knowledge transformations and reflection	Different forms of knowledge and practices are involved in the course: from spontaneous discussions to the representation of concepts through conceptual maps; from reading and commenting on academic articles to knowledge building discussions; and from theoretical lessons to designing and reviewing concrete projects. Moreover, individual and collective reflection on the learning process is generated through: – group discussions of teacher's evaluation after each module – the observer's critical report of classroom collaborative activities.	Knowledge building discussions, academic articles–online Theoretical lessons, evaluation discussions–in presence Conceptual maps, project works, observer critical report–online and in presence
DP5 Promoting cross-fertilization	Real "school world" enters the learning contexts, leading students to experience genuine school practices. The creation of the pedagogical scenario is supported by a guiding template, which highlights the crucial aspects to keep in mind when planning a learning course (e.g., learning goals, evaluation, tools, etc.).	Learning course planning–online and in presence

Table 3. *Cont.*

Design Principle	Implementation in the Course	Blended Setting
DP6 Providing flexible tools for developing artifacts and practices	The course is based on blended collaborative knowledge-building activities, hosted in the Moodle platform (http://elearning.uniroma1.it, accessed on 23 September 2021). Each group has its own dedicated Moodle course to discuss, add external resources, upload documents, share collaborative products, and much more. Each course is linked to tools such as Padlet (for brainstorming activities), Google drawings (to create online conceptual maps), and Google documents (for the collaborative writing of the pedagogical scenario).	Digital tools–online and in presence

4. Results

In the following section, we describe the results of the analysis after each of the course iterations and articulate how these shaped and influenced the subsequent re-design.

4.1. First Iteration

To investigate which skills students perceived they developed at the end of each course iteration (RQ1), responses to the CKP questionnaire were analyzed (N = 48; 87.27%). As described earlier, the questionnaire comprised 27 closed-response items. For each item, students were asked to assign a score from 1 (not at all) to 5 (very much), answering the question "How much do you think you have developed the following knowledge–work skills?". Figure 1 illustrates the averages reached from each scale in the first course iteration:

Figure 1. CKP-q scales (first iteration).

Here, we can see that after the first iteration, students perceived they had consistently developed almost each of the skills grouped in the seven scales, especially those related to collaboration on collaboratively built artifacts ("shared objects") (Scale 1; avg. 4.09) and integration of individual and group work (Scale 2; avg. 3.90). Both these scales are anchored around the very blended nature of the course, that is, around the careful mix of activities and strategies that are carried out through a strong integration and online and in-presence, such as artifact building and revising or role taking.

The set of skills considered to be less developed (although still arguably developed to a good degree) is related to interdisciplinary collaboration and communication (Scale 6; avg. 3.12).

For a better understanding of the data collected through the CKP-q, we decided to also observe the individual items that obtained a score lower than 3.5 (Table 4), which is the threshold that we identified as the minimum desirable level.

Table 4. Items reporting the lowest average (first iteration).

Item	First Iteration
To ask questions relating to the practices of another field.	3.35
To present my expertise to representatives of another field.	3.02
To collaborate with representatives of other fields.	2.98

Only three items out of 27 reached an average lower than 3.5 and they are all included in Scale 6. This scale refers to cross fertilization of practices, that is, to the blended nature of the course in the sense of integration of university and beyond-university contexts.

The qualitative feedback collected through the FG allowed us to respond to RQ2, concerning strengths and areas of improvement to be considered in order to improve the course in its next edition. Specifically, through analysis of the transcripts, we highlighted three recurring aspects that refer to three macro-areas (Table 5).

Table 5. Most recurrent FG feedback (first iteration).

Improvement Area	Feedback
Course structure	Difficulty to connect Modules 2 (collecting/analyzing children's spontaneous writing) and 3 (developing a pedagogical scenario about collaborative use of technologies), also because of compressed timing
Learning strategies	For some roles, the contribution to the group work is not clear (e.g., for the critical observer)
Collaboration	Unequal levels of contribution and participation in the group

Once the data analysis was complete, the teacher began to adjust the course design, simultaneously considering the areas of skill perceived as less developed and the students' feedback on the less appreciated aspects of the course. In both cases, the teacher tried also to reinforce the blended nature of the course, at each of the considered levels. Table 6 reports the main changes the teacher adopted. To better show the link between the changes and the data, we (1) specified the scales corresponding to each DP and (2) numbered the changes made in response to the FG in a way corresponding to the suggestions themselves.

The main innovations introduced by the teacher during the re-design process mainly aimed to strengthen the skills related to cross-fertilization of practices and knowledge (DP5, Scale 5–6), which the CKP-q reported as not sufficiently developed and which refer to the blended nature of the course in the sense of integration between academic and external world. Additionally, innovations also aimed to improve course aspects related to timing, assignments, and collaboration within the groups. The revision of timing and contents in module 2 (changing the topic from "children's spontaneous writing" to "use of technologies in teaching") was also due to the desire to give more importance to the construction of the final shared object, thus reinforcing the TLA nature of the course.

Table 6. The course re-design (first iteration).

Design Principle	Changes Introduced in Response to CKP-q	Changes Introduced in Response of FG	Blended Setting
DP1			
DP2		1. Individual agency strengthened through an additional task introduced in module 2, preliminary to the collective discussion: the individual research and mapping of learning experiences using technology.	Online
DP3		1. Revised times and contents of module 2 to reinforce the advancement of knowledge: The analysis of children's spontaneous writing is replaced by the study of experiences of use of technologies in teaching, which becomes the basis for module 3.	In–presence and online
DP4		1. Critical-observer role modified: The observation grid focuses now on the whole module and not just on single classroom activities; it is completed online, thus becoming more easily usable by the group.	Online
DP5	(CKP scales 5–6) Introduction of teachers and school principals in the activities of Module 3, as external experts offering feedback to improve the pedagogical scenario, before its revision		Online
DP6			

4.2. Second Iteration

The answers (N = 45–83.33%) to the CKP-q collected after the second iteration of the course confirmed, and in some cases reinforced, the perception that knowledge–work skills were strongly developed (Figure 2). This time, the scales with the highest score were: Collaboration on shared object and Development through feedback (Scales 1 and 3–4.0). Interdisciplinary collaboration and communication (Scale 6–3.34), while remaining the one with a relatively lower score, recorded quite a substantial improvement compared to the first iteration (from 3.12 to 3.34).

With respect to the average of the individual items (Table 7), in the last places we now find the same three items on the sixth scale, but only two were below the minimum acceptable average (3.5), and are still improving compared to the first course iteration.

Figure 2. CKP-q scales (first and second iterations).

Table 7. Items reporting the lowest average (second iteration).

Item	Year 2015	Year 2016
To ask questions relating to the practices of another field.	3.35	3.53
To present my expertise to representatives of another field.	3.02	3.24
To collaborate with representatives of other fields.	2.98	3.24

Analysis of feedback collected through the FGs once again revealed three recurring critical elements (Table 8).

Table 8. Most recurrent FG feedback (second iteration).

Improvement Area	Feedback
Learning strategies	Not being able/confident in commenting on other groups' products Poor discussions mainly shaped as long monologue
Collaboration	Unequal level of contribution and participation in the group

Table 9 shows the re-design after the second year of the course.

The re-design after the second iteration of the course once again focused on Cross-fertilization (DP5-scales 5 and 6). In fact, while there was a trend of improvement, cross-fertilization continued to be less developed than the other scales. As for students' feedback, the teacher decided to focus also on Collaboration, which, as in the first iteration, seemed to be challenging for students. Some other significant changes were introduced to respond to students' feedback about the quality of the discussions and the limits perceived when being asked to provide colleagues with comments on their work. Once again, the blended nature of the course is reinforced through specific strategies and techniques purposely built as a bridge between the online and the in-presence setting. This is the case for the peer-review sessions starting online and then being completed online, through each group member's contribution.

Table 9. The course re-design (second iteration).

Design Principle	Changes Introduced in Response to CKP-q	Changes Introduced in Responses of FG	Blended Setting
DP1			
DP2		1 Added two new roles: researcher, scenario reviser 2. Self-Monitoring questionnaire (SM-q) introduced to promote a structured and ongoing reflection about one's own participation in and contribution to the group work 3. Provided specific assignments on how to constructively discuss, that is, by using explicit quotations and references to peer contributions in the Moodle Web forums	Online and in presence Online Online and in presence
DP3		1. Peer review session reinforced with two new assignments: (1) the groups build the criteria they then use to give feedback; (2) the groups clearly state how to improve their own product after seeing that of their colleagues	
DP4		1. Introduced teacher's formative evaluation of the maps through a classroom session, showing the changes between the first and second versions and the impact of given and received feedback	In presence
DP5	(CKP scales 5–6) Experts coming to class lessons to listen to group presentations. Students experiencing assessment practices.		In presence
DP6			

5. Discussion

The choice to apply TLA to this university course was derived from the teacher's desire to reinforce the blended nature of the course at various level, thus further promoting students' crucial knowledge–work skills. The subsequent course re-designs were, therefore, based on the attempt to make the course increasingly able to achieve this purpose. Courses, in fact, take time and consideration to develop effectively and even when positive results are achieved it is worth investigating how these can be maintained and/or strengthened over time.

To this end, we analyzed students' perceptions of the development of specific work skills and collected their feedback about the course during two subsequent iterations. In fact, it is only by considering both the optimal modalities for learning as well as the learners' needs, and the context, that a course can effectively be improved [19].

Based on these data, it seems that the progressive changes made in these areas have had a largely positive outcome. In relation to students' feedback, timing and collaboration seemed to be the recurring criticalities requiring ongoing refinement. On the one hand, as noted by the students themselves, timing is a limit strongly linked to context elements beyond the teacher's control: The third module of the course, the one perceived as a critical area, takes place during the examination period, and students feel the pressure of multiple assessment demands, confirming the importance of taking into account organizational factors as a key to successful implementation [20]. On the other hand, despite collaboration being reported as difficult and group participation as unequal, the related CKP-q scales (1, learning to collaborate on shared objects; 2, integrating efforts in collaborative learning) are constantly perceived as highly developed. These scales refer to the blended nature of the course based on a learning design that carefully selects and integrates strategies, techniques, and activities carried out between the online environment and the classroom physical context.

The Design principles of TLA have positively guided the planning and re-planning of the course, supporting positive outcomes in terms of knowledge–work skills. The key points of the curriculum design reside in the combined active and reflective nature of the course, which proposes the collaborative construction of meaningful objects to students and the continuous improvement of the objects themselves through recursive peer feedback activities. Each of these techniques, however, would be not sufficient without the adequate care of the teacher–student relationship. In the course described, in fact, the teacher took care to set up an environment based on mutual respect and collaboration: From the modelling offered to students who covered the role of tutor to that relating to peer feedback activities, each student had multiple indications and examples on how to be mutually supportive and able to recognize the value of the colleagues and him/herself primarily.

In summary, the results observed through the CKP-q confirmed the effectiveness of TLA application in a blended course as designed and re-designed. Most significantly, changes in specific DPs resulted in a perceived impact on skills developed by students. Additionally, the issues identified in one iteration were not repeated in the next, at least, not to the same degree, as for the case of the DP 5, referring to the blended aspect of cross fertilization, that students perceived as better implemented in the second iteration. Thus, it would appear to confirm that educational courses need to be developed over time to meet the needs of the learners and, in so doing, help teachers to refine their practice.

6. Conclusions

This research describes a teacher's process of designing and re-designing a university course in which the Trialogical Learning Approach was introduced as a theoretical basis for a blended course that involves students in concrete activities and genuine collaboration to generate knowledge and build significant artifacts while developing key knowledge–work competences.

The course re-design was founded on careful analysis of the impact of the course on students' perception of skill development and feedback on the course structure.

The results collected confirmed the validity of a similar approach to Learning Design:

1. The design was strongly anchored to a theoretical model as well as structured and formalized through templates of pedagogical scenarios, yet left teachers able to personalize the design principles' declinations;
2. Each course iteration was progressively and gradually developed based on the results, and the re-design also included the revision of the Impact Analysis Instruments;
3. Theoretical reflection continued to accompany all subsequent iterations.

The course design was, in fact, replicated in the following years with other students, confirming the positive aspects evidenced in the first two iterations. The course, in its current design, could be, however, transferred to other courses or contexts, as long as the Key issues defined by the TLA principles are kept, possibly maintaining those conditions we found as effective based on the data here presented: collaborative construction of useful and concrete objects; attention to the individual's agency within the group, also supported by specific techniques, such as the role-taking strategy; search for a continuous improvement of products and ideas, especially supported by peer feedback activities; supporting high connection and cross-fertilization between university studies and the world of work. Transferability will, of course, also depend on the possibilities of the context to make students use flexible technologies, which allow collaboration within small and large groups. We also note the teacher's willingness to go further than his/her known methods, often putting an extra effort in the course implementation.

However, we are aware of the limits of our research. First, the effectiveness of a learning course does not only reside in the participants' point of view, but must also be observed and, above all, take account of the intended learning outcomes. In addition, we are aware that our sample is small and culturally bounded to a specific context. Despite these limitations, this paper illustrates how DBR can be fruitfully used to refine and improve teaching and learning experiences in the context of a tertiary course, inspired by a specific theoretical construct. Our approach, moreover, highlights that engaging the students in a process of review, helps practitioners to refine module content and delivery more effectively and, in so doing, build in more robust opportunities for technology-based collaboration and learning.

Acting as designers and researchers, teachers can be empowered to both refine their practice and contribute to an enhanced understanding of learning theories such as TLA, a recent framework that, while still evolving, holds promise for educational research, and it seems extremely powerful in sustaining the blended nature of the future of higher education.

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education sciences

Article

Students' Self-Organization of the Learning Environment during a Blended Knowledge Creation Course

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Abstract: Learner-centered blended learning approaches, such as Knowledge Creation, emphasize the self-organizing characteristic of thought and action, and value the students' autonomy and self-regulation during the engagement in collaborative learning tasks. In blended contexts, the students need to organize their learning paths within a complex environment, including multiple online and offline learning spaces. This process of self-organization during courses based on the Knowledge Creation approach is currently an overlooked topic of research. The present case study is aimed at addressing this research gap by providing an in-depth understanding of the collaborative self-organization of a group of five undergraduate students participating in an interdisciplinary media design course. The course was designed according to the Knowledge Creation approach and was carried out before the start of the COVID-19 pandemic. The dialogical theory of the chronotope and the theory of cultural models constitute the main theoretical tools for the research. We used qualitative methods inspired by ethnography, including participant observation, in addition to the collection and analysis of audio-visual records, stimulated recall interviews, and learning diaries completed by the students. The findings show that the group self-organization changed across different phases of the collaborative task and involved the development of specific practices of self-organization. Cultural models associated with the task contributed to determine the students' choices related to self-organization.

Keywords: chronotope; higher education; cultural models; blended learning

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1. Introduction

Blended learning (BL) [1] is a commonly used label to denote a wide range of instructional designs involving the integration of online and face-to-face pedagogical activities [2]. BL has become increasingly popular during the past two decades and is currently considered to be a useful approach for post-pandemic education [3]. Because students' performance in BL courses appears to be affected by instructional design [4], a significant amount of the research on BL has examined the sequencing of online and offline activities, and developed multiple approaches and models aimed at optimizing the design of BL courses [5–8].

From a learner-centered perspective, BL is expected to allow students to take control of "the choices of what and when to blend" ([9], p. 2). For Masie ([10], p. 25), this is a natural process that can be observed when the students transform "training and instruction into learning". Thus, as the students engage in the learning activities, they may add new elements that are not included in the teacher design (e.g., finding additional readings or educational technologies on their own), ignore some other elements that they may not need (e.g., disregarding some of the templates or scaffolds provided by the teachers), and mix their self-initiated activities and the teachers' design elements in personal ways.

Among the approaches that emphasize the learner-centered nature of learning, Knowledge Creation (KC) [11] and Knowledge Building (KB) [12] specifically highlight the self-organizing characteristic of thought and action [13]. Based on a series of design principles [12,14], KB and KC deliberately seek to maximize the "intelligence operative among the students in proportion to the intelligence contributed by the teacher and the teacher's tools" ([12], p. 753). Consequently, in KB and KC, learners are typically afforded a relatively high degree of autonomy concerning the organization of the learning process.

Some empirical evidence seems to suggest that the autonomy of learners constitutes an important factor for academic achievement [2,15], thus providing empirical grounds for this kind of learner-centered approach to BL. From this perspective, learner-centered BL has a high potential to provide the flexibility, independence, and responsibility, in addition to supporting the metacognitive processes, necessary for the development of the "self-determined learner" [16].

When the learning environment and the learning task offer a high degree of autonomy, self-regulation becomes an important factor for success [17]. Self-regulation is particularly relevant in BL—compared with either face-to-face instruction or online education—because the self-regulatory abilities of learners are challenged by the integration of online and offline activities [2].

In addition, in learner-centered BL, the students may face challenges related to time management and learning environment management, which are "self-regulatory attributes" included in social cognitive models of self-regulation [15,18,19]. Coping with complex and unstructured learning environments, including both face-to-face and online activities, may not be a trivial task, particularly for students who do not have previous experience with learner-centered BL.

A further level of complexity that may characterize some learner-centered approaches is the collaborative nature of learning tasks, which implies that students do not only have to individually arrange the environment in ways that "make learning easier" [20], but also to coordinate with their peers and reach an agreement about the tools to be used, the places to meet, and the schedule of the collaborative task. Although the sequential organization of activity has been considered to be an aspect of interaction that plays a significant role both in collaborative learning and in BL [21–23], little is currently known about the students' self-organization during collaborative KC activities.

The arguments discussed above demonstrate the importance of examining students' self-organization during courses involving a high degree of students' autonomy, which is currently an overlooked topic of research. In this study, we contributed to addressing this research gap by exploring how a group of students diachronically self-organized their own collaborative activity while engaging in an interdisciplinary course based on the KC approach. Because the students had a high degree of autonomy during this course, this was considered by the researchers to be a suitable research context for a qualitative case study [24] on the students' self-organization.

To obtain a theoretically grounded understanding of this process, we adopted the dialogical notion of the chronotope [25], which allowed a socio-cultural examination of space (in terms of the organization of the learning environment) and time (in terms of temporal patterns of self-organization), and the theory of cultural models [26], which emphasizes the important role played by the assumptions and meanings that people associate with particular settings and recurring events, that are tacit and taken for granted. The reason for combining these theoretical perspectives is that we consider them complementary to the investigation of self-organization in collaborative settings. In the following, we briefly introduce these theoretical concepts, highlighting their relevance for the theoretical framing of the present study.

The chronotope has been used in education as a conceptual tool contributing to the examination of patterns of management of space–time in technology-mediated learning [27,28], allowing an understanding of how spatial and temporal patterns of organization of activity are constructed in dialogical interaction. According to this conceptualization, space and time are considered social constructions that are dynamically negotiated in dialogical interaction by the participants during any educational situation [29].

In this article, the chronotope is adopted as an analytical tool contributing to identify patterns related to the students' self-organization of the learning environment in both the spatial and the temporal dimensions. This notion emphasizes the interdependency between space and time, suggesting that the isolated analysis of either temporal or spatial patterns leads to a loss of in-depth insights about the ongoing learning processes. For example, when analyzing information on the level of the whole course, temporal information about students' engagement with the learning environment is lost [30].

Chronotopic analysis encompasses the examination of both the discursive construction of space–time that emerges from dialogic interaction [31], and the material-embodied processes through which learners enact space–time configurations and project structure on the learning environment. Concerning the spatial dimension, the analytic interest of the present investigation is on the virtual, material, social, and semiotic learning spaces that the students choose to inhabit, and on how the students arrange these multifaceted spaces as they carry out the collaborative KC activity. Concerning the temporal dimension, the analysis focuses on the diachronic development of the spatial configurations and on the students' collaborative negotiation of the schedule of the activity.

The theory of cultural models [26] has been used in educational research to examine a variety of topics, including literacy practices [32], students' achievement [33], differences in meanings and practices of education among diverse ethnic groups [34], and teachers' implicit theories on students' learning and teaching practice [35]. In the present study, the analytic focus was on the so called "task models" [35], which are models that the students may use to make sense of the task. These models are expected to provide strategies for addressing the task that they represent. Scripts [36] can be considered to be a specific type of task model that is often involved in students' responses to instructional tasks. The examination of cultural models is significant for learner-centered approaches to BL, because these approaches value the students' perspectives on educational processes.

Cultural models are likely to include assumptions and expectations about spatial and temporal relations, which may guide the students' sensemaking and self-regulation, particularly when dealing with complex and unstructured learning environments that do not provide clear-cut temporal and spatial boundaries assigned by the teacher or instructional designer [37]. However, to the best of our knowledge, the literature is currently lacking studies addressing this dimension of cultural models in research on BL.

The combination of the notion of the chronotope with the theory of cultural models allows emphasis to be placed on the strict interconnections between the students' culturally situated sensemaking about educational activities, and their material-embodied experiences of the space–time frameworks in which learning takes place. Research shows that the features of learning environments are encoded by people based mainly on the physical interaction with the world, and that such embodied experience of the world is combined with pre-existing knowledge and memories [38]. Thus, although the theory of cultural models assists us in examining how the implicit assumptions and theories may mediate the students' self-organization process, its combination with the concept of the chronotope provides insights into the close interconnection between these cultural assumptions and the learners' material-embodied experience of space–time. In this manner, the theory of cultural models is adopted in this context to enrich the findings of chronotopic research.

In sum, the aim of this explorative case study was to investigate how a group of students self-organizes its collaborative activity and arranges the learning environment during a learner-centered BL course. As discussed above, learner-centered BL courses may involve complex and relatively unstructured learning environments that challenge the students' self-regulation, particularly in terms of management of the learning environment and management of time. In particular, the course analyzed in this study allowed the students to autonomously define their own learning environment (in terms of choosing the places, the technological tools, and the learning materials to be used during the accomplishment of the collaborative task). The qualitative analysis, inspired by the theory of the chronotope and the theory of cultural models, was aimed at gaining an in-depth understanding of the perspective of the students on their self-organization as they diachronically selected and arranged the virtual and material learning spaces. In addition, we explored the expectations and assumptions related to the learning environment and the space–time organization of the course. The research questions guiding the analysis are summarized as follows:

- How do the students self-organize the space–times of the group collaboration across different phases of the BL course?
- Which practices of self-organization do the students develop during the course?
- How do the students' cultural models affect their self-organization?

2. Materials and Methods

2.1. Research Context and Participants

The present case study is part of a larger research project involving two groups of students attending an interdisciplinary media design course held at Metropolia University of Applied Sciences in Helsinki before the start of the COVID-19 pandemic. The course was designed according to the KC approach, which emphasizes tasks involving the creation and progressive refinement of tangible shared objects such as models, products, and prototypes. In KC, work is advanced through cycles of collaborative planning, brainstorming, receiving feedback, presenting, and delivering/publishing [14]. In addition, as discussed above, KC learning environments are expected to provide flexible tools for developing artefacts and practices that the students can self-organize with a high degree of autonomy.

At the start of the course, representatives of companies presented business problems to the students. The students were invited to choose one business problem and were split into groups based on their preferences. Each group worked for 16 weeks at the development of a product or service addressing the chosen problem. As intermediate tasks, each week they were invited to develop artifacts (business plan, sales pitch, etc.) that would be assessed by teachers. The students worked together for 10 h per week. The university provided a rich set of possible environments for collaboration, and the groups of students could freely book one of these rooms depending on their current needs. Each learning environment was characterized by a different technological environment involving smart-boards, desktop computers, tablets, notebooks, etc. Some of the spaces required advance booking. For example, the students could book a room (which could simultaneously host up to four groups), in which one group per time could use a smartboard and connected tablets; a smaller room that could host only one group, equipped with a round table, chairs, and a desktop computer; a computer laboratory equipped with 24 workstations; and other regular rooms that could simultaneously host two or three groups, equipped with desks, chairs, and a blackboard or a whiteboard. At times, groups also worked in subgroups located in different locations within or outside the university campus. Before the start of the data collection, each participant completed a survey to gather background information and signed an informed consent.

Of the two groups participating in the research project, one was selected for this study because only the data collected for this group allowed a comprehensive analysis of the students' self-organization. In particular, only the students of this group agreed to fill in learning diaries describing all the learning activities that each student carried out throughout the whole course, which were crucial for the conducted analysis. This group had five members, three of them Finnish (Ivy, Lenny, and Rita), one Dutch (Jack), and one South African (Carl). Because this was an interdisciplinary course, students came from different bachelor's degree programs: marketing, nursing, media engineering, industrial management, and IT studies. The observed group worked on a business problem presented by a representative of an international humanitarian institution; specifically, this problem related to the difficulty of convincing people to wash their hands carefully and frequently in order to prevent the spread of contagious diseases.

2.2. Data Collection

For the data collection, we used qualitative methods inspired by ethnography [39]. We primarily used participant observation, with audio and video recordings of a sample of collaborative activities carried out at the university premises. In addition, the participants were asked to fill in daily individual diaries briefly describing all the activities that they carried out for this course, including those not recorded by the researchers. In the diaries, the students specified for each activity carried out: (1) the physical location; (2) the technological tools and artifacts used; (3) the date and time; and (4) the people involved in the activity that were present in the same location at the same time. The diaries were filled in by four of the five participants of the group.

To follow the potential transformation of the patterns of self-organization in different phases of the course, we agreed with the participants that teamwork would be recorded for 2 weeks at the beginning of the course, 2 weeks in the middle of the course, and 2 weeks at the end. The participant observation was carried out by two researchers, one of whom handled the camera and the other who took field notes on the general impressions of the ongoing collaboration. Furthermore, the researchers took field notes during the observation of the teamwork and collected documentation concerning the observed activities. Finally, two video-stimulated recall interviews were conducted to "elicit participant's perspective on what was happening" during the recorded interaction ([40], p. 85).

2.3. Data Analysis

A qualitative case study methodology [41] was adopted for this study. The analysis was organized in four steps aimed at capturing the complexity of the studied case [42] (Figure 1).

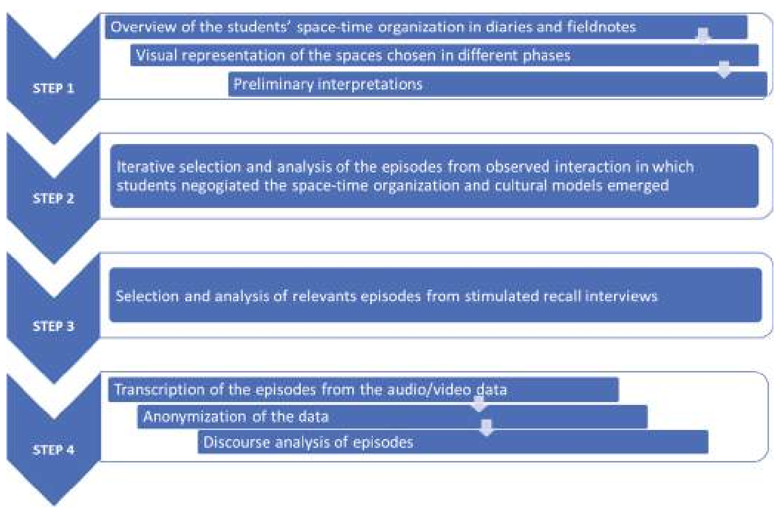

Figure 1. The four steps of the qualitative analysis.

First, the diaries and the researchers' fieldnotes were used to create an overview of the students' space–time organization during the course. To examine self-organization, it is fruitful to think in terms of the emergence of multiple heterogeneous and often overlapping physical, symbolic, virtual, and social spaces [43]. For example, physical spaces such as classrooms and laboratories may overlap with socially organized spaces involving intimate, social, and public zones, and with multiple symbolic/virtual spaces of books, blackboards, computers, etc. Tables and visual representations summarizing the virtual, social, and material spaces chosen by the students in different phases of the collaboration were developed. During this step, the researchers deleted references to proprietary software, using the generic label of the technological tool mentioned (e.g., spreadsheet, word processor, programming software). Based on the analysis carried out in this first step, the researchers developed preliminary interpretations that were progressively refined during the following steps.

The second step involved the qualitative examination of the video data [44], which consisted in the iterative selection and analysis of the episodes in which the students negotiated the space–time organization of the activity within the group and the episodes in which it was possible to detect the students' cultural models.

The third step involved the analysis of the stimulated recall interviews, which was aimed at developing an in-depth understanding of the students' perspective on their self-organization. The analysis of the interviews involved the selection and analysis of all the episodes in which the students (1) commented some videoclips that the researchers had selected during the second step of the analysis, and/or (2) reported their own assumptions and expectations (espoused cultural models) related to the spatial and temporal organization of the course.

Finally, the selected episodes from both the interviews and the observed interaction were transcribed and qualitatively analyzed. During this step, the researchers anonymized the data using nicknames. The students' talk and embodied actions were interpreted to answer the research questions guiding the analysis. Discourse analysis [45] was used to infer space–time relations from the discourse by considering linguistic features such as the tense, aspect, and modality of verbs; adverbs; conjunctions that marked temporal relations; and phrases that marked location. Some gestures, particularly deictic gestures such as pointing, allowed enrichment of the researchers' interpretations of how participants were defining space and time. In the analysis below, we do not report all of the episodes that were detected during the analysis. Rather, we first present an overview of the main patterns of space–time organizations that were identified, and subsequently discuss a number of excerpts that illustrate aspects of the process of space–time organization of the ongoing activity, including the role played by cultural models in this process.

3. Results

The findings are organized in three subsections. The first subsection addresses research question 1 and provides an overview of the space–time organization of the whole course and a discussion of how it changed across different phases of the collaborative project realized by the students. The second subsection addresses research question 2 and examines the process through which the students arranged specific space–time contexts and collaborative practices that contributed to improve their self-organization and coordination within the group. The third section addresses research question 3, discussing the role that the students' cultural models played in the process of self-organization.

3.1. Overview of the Space-Time Organization across the Whole Course

Table 1 summarizes how the use of different social, virtual, and physical spaces chosen by the students changed across the different phases of the course. In the table, the physical and virtual spaces are listed in order of frequency, from the most frequently mentioned in the students' diaries to the least frequent. Spaces that were mentioned only occasionally in the diaries are excluded from the table. We clarify that the students appear to have described in the diaries all the sessions of work on the project, with the exception of those that took place at home. Indeed, during the participant observation, the researchers noticed that some students contributed to a few tasks from home, particularly at the end of the course, but the sessions of individual work when these tasks were accomplished were absent from the diaries. The description of the other activities present in the diaries is consistent with the researchers' observations. Thus, we infer that the students did not consider individual work from home to be relevant for the diaries.

Table 1. Overview of the activities and main material, social, and virtual spaces depicted in the diaries.

Phase	Main Activities	Physical Spaces	Social Spaces	Virtual Spaces
First phase	Brainstorming, mind map of the project idea, preliminary project plan, user story, steering group meetings (SGM)	Mostly sitting in circle/semicircle in classrooms (Figure 1). Usage of computers/laptops, pen and paper, interactive whiteboard, tablets, post-it, photo-camera, whiteboard.	Mainly whole group activities in rooms shared with other groups.	Office suite (word processor, spreadsheet), online mind map tool, shared online folder, web-browser, graphic editor
Second phase	User story, programming, website design, information findings, sales pitch, test plan, midterm presentation, SGM	Primarily use of a private room in the library (Figure 2), computers/laptops, printer, video projector, photo-camera	Growing amount of individual work and/or collaboration in subgroups (2–3 members per subgroup), often carried out in a private space reserved for the group or a subgroup.	Shared online folder, web-browser, office suite (presentation software, word processor), programming software, graphic editor, web browser.
Third phase	Programming, website design, updating and finalizing documentation (e.g., project plan); marketing plan; financial plan; sales pitch; catch up/to do meetings with team; SGM	Shifting between the private room and the computer lab (Figure 3), individual work using computers/laptops, pen, and paper	Mostly individual work or collaboration in subgroups, weekly short briefings with whole group	Office suite (word processor presentation software), shared online folder, programming software, graphic editor.

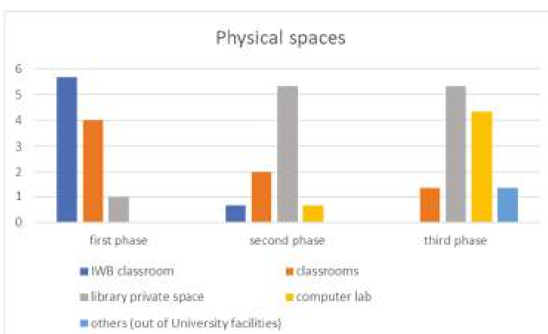

Figure 2. Physical spaces chosen by the students during the different phases of the course.

Figure 3. Primary configurations of participation during the first phase of the course.

Figure 2 represents the use of the different physical spaces during the course. In particular, the figure shows the average number of sessions that each student spent in each physical space. The figure was created based on the students' mentions of each space in the learning diaries. Table 1 and Figure 1 show that the three phases of the course were characterized by different patterns of self-organization.

During the first phase, the students mainly engaged in whole group sessions and tended to arrange their learning space sitting in circles or semicircles in classrooms shared with other groups. Typically, two or three groups shared these classrooms, each group arranging its own learning space in a corner of the room by moving chairs and desks (Figure 2). Although face-to-face conversations were the primary means of communication within the group, often oral communication was enriched by means of technological tools. For example, on several occasions the group used the interactive whiteboard that was available in one of the classrooms to project notes or contents relevant for the ongoing conversation, or an online tool allowing them to create a shared mind map to summarize the decisions of the group. In this way, physical, virtual, and social spaces were interwoven in a dynamic manner. During this phase, the students often chose to work in a classroom where they could book an interactive smartboard or in other classrooms where they could easily move the chairs and desks to arrange a suitable learning environment for the teamwork using their own laptops (Figure 3).

The figure shows that on average, during the first phase of the course, each student spent 5.7 sessions of work in the classroom with the interactive whiteboard and four sessions in other classrooms. During this phase, particularly during the first and the second weeks of the course, the participants explored the various tools available in the learning space, including the tablets provided by the teachers and a whiteboard available in one of the rooms, on which the students attached Post-its with ideas for the development of the project. In addition, they set up a shared online folder for sharing digital documents within the group.

During the second phase of the course, a growing amount of individual work and the creation of subgroups were detected. The students frequently booked a private room in the university library, which was often used by one of the subgroups composed of two members (Lenny and Jack), who worked collaboratively on the design of the website and the programming of the interactive content. At times, this room was also used by some of the students for individual work (Figure 4). Other students went to different classrooms or to the computer laboratory to carry out the subtasks assigned to them. Concerning the virtual spaces, in this phase the students ceased to use the online mind map tool, and some of them started systematically using domain specific software (especially programming software and graphic editors), whereas others used web search engines to find useful materials for the project. During this phase, face-to-face interaction involving the whole group became sporadic, and the students quite often worked from different locations. They used instant messaging or phone calls to communicate with each other, and the shared online folder for monitoring the work done by their colleagues and sharing documentation within the group. To conclude, in this phase, it was possible to observe how students decided to "blend" the collaborative activity, integrating face-to-face meetings and online activities that were carried out individually or in subgroups from different locations within the university campus. Online activity was monitored by means of the shared online folder.

Figure 4. Primary configuration of participation during the second phase of the course.

Finally, during the third phase, the students often chose to work from the private space in the university library or the computer lab, where they carried out individual work. During this phase, in some moments all of the members of the group decided to remain in the same room, even if they were carrying out individual work. At times they split into subgroups working from different locations, similarly to the behavior during the second phase. Figure 5 shows how the arrangement of desks in the computer lab forced the students to stand when they had to communicate with one of their peers. Nevertheless, on average, more than four sessions of work on the project were spent by each student in this room. This is probably connected to the fact that oral communication among the whole group was absent for long periods of time, and, more generally, social interaction within the group decreased. Nevertheless, during this phase, every day the students organized short whole-group meetings held at the private space in the library to coordinate and make decisions relevant for the realization of the project. These meetings were described by the students as "catch-up meetings" or "to-do meetings", suggesting that they felt the need to orchestrate a specific space–time for coordination because most of the time they engaged in individual subtasks with a low level of communication. In this phase, the online shared folder was used as a tool for monitoring the work undertaken by their colleagues and sharing documentation within the group, similarly to what happened in phase 2. Apparently in phase 3, however, this was not a sufficient means for coordination and the students developed the practice of "catch-up meetings" to enhance coordination. The use of the shared folder as a tool for monitoring the contribution of their peers is particularly interesting for the aims of this study; therefore, this is discussed in the following section.

Figure 5. Primary configuration of participation during the third phase of the course.

3.2. Arranging Physical and Virtual Space–Times for Self-Organization

In this section, we discuss how self-organization involved the development of specific group practices involving both physical and virtual space–times. First, in the video data from the observed interaction of group work, we identified 19 episodes in which a shared online folder was used for purposes associated with self-organization. This folder was used for monitoring the state of advancement of the task and/or for the coordination of individual efforts. Excerpt 1 provides an illustrative example of these episodes.
Excerpt 1: observed interaction; third phase of the course

> Ivy: why didn't Lenny ... yesterday ... ehhh did he do the second test meeting ... he did not put any documentation in the shared folder
>
> Carl: but he did it [the test] yesterday
>
> Ivy: I told him that before the presentation we need the second test done

In this excerpt, we infer from Ivy's speech that she used the shared folder to monitor Lenny's work on the subtask that was previously assigned to him by the group. Indeed, Lenny was expected to carry out the testing of the website that they were designing, which involved meeting a group of potential users of the site and collecting data on their usage. In several cases such as this one, the students checked the status of documents within the shared folder and inferred from it what their peers had been doing and which subtasks still needed to be completed. Because the researchers observed that this shared folder had

become an important tool for the students' self-organization, a question was asked during the final interview to gather the students' perspective on its usage (Excerpt 2):
Excerpt 2: final stimulated recall interview

Researcher: talking about the shared online folder ... how would you comment on the use that you have done of the folder, what was it useful for

Jack: just have any file from anyone in your computer

Ivy: and you can update it and anyone can see and it's all there you don´t have to worry where was it and where did you put it and who´s saving the documents or whatever

Jack: I open my laptop in the morning and then I see they start updating some presentations

Ivy: who´s doing what

Carl: forty files have been updated oopps

Jack: and then you just gotta check it out or not whenever you want but you know [if] somebody was working on it

[...]

Carl: and I think it is a good way to keep track because we didn´t have the (.) the space so so I think dropbox was our virtual space

Ivy: space yah

Carl: where we could

Ivy: save

Carl: at least store stuff there we're been working on ...

The answers provided by the students during the interview confirm that the shared folder was important for the process of self-organization for several reasons. First, for the students, this online space also allowed the placement of documentation such that it could be found more easily ("you don´t have to worry, where was it and where did you put it"). Second, the folder allows the participants to see "who's doing what" ("I open my laptop in the morning and then I see they start updating some presentations"; "you know if somebody was working on it"). Third, the online shared space appears to Carl to be a replacement for a stable physical space that they tried to find at the beginning of the course. Indeed, during the first phase of the collaborative task, the group explored the different physical environments available at the university campus and realized that they needed a stable and private place, where they could leave artifacts useful for the "project planning". Excerpt 3 is taken from the final interview and allows an examination of the students' perspective on this aspect of their self-organization.
Excerpt 3: final stimulated-recall interview

J: I think it´s a shame that in the start we tried to have our own space to work at so we had this whiteboard up there with everything where you can see the project planning but we tried to do it for two weeks and then we couldn´t keep the board for ourselves ... the all thing skipped and then we started wandering around the school

C: looking for a place to settle

J: yah I think that was a bad thing for the project because that that keeps the focus ... where should we work now? instead of just go to the place open your laptop or whatever

C: and have all the stuff

J: and you can leave your ideas on the table and come back and start again instead of piling up

[...]

J: the availability of the laptop and the ipads is cool to just have them . . . but if it´s not your own for a period of time then you never gonna do anything on it because you don´t wanna

I: yah you don´t save the documents

J: you don´t wanna save it on there because somebody else is gonna throw it away or whatever and next time you pick up the laptop somebody made a whole different background and a mess on the desktop so

J: and if the ipad is not really yours to you then you never gonna use it fully just for the browsers on the internet and then yah well then it stops after that

In this excerpt, one of the students explained that a major need of the group was to find a place that could provide stability to their iterative efforts throughout the whole process ("find a place to settle"). It appears that, for the accomplishment of the long-term task of developing the project, the students needed a stable space across the multiple situations and tasks encountered ("because that keeps the focus"). In particular, they needed a place to leave artifacts without the fear that other people could "throw them away". This was a recurring theme mentioned by most of the students during the second interview. Based on these premises, the students developed alternative solutions, such as using the shared folder and creating a recurring daily practice of "catch-up" meetings to satisfy their organizational need.

3.3. Space–Time Organization and Cultural Models

In this section, we use some excerpts from the observed interaction and from the video-stimulated group interviews to provide an in-depth discussion of the process through which cultural models were involved in the students' collective self-organization of space–time. This section aims to answer the second research question.

Excerpt 4 was taken from the second week of the course, during a session in which the students were collectively working on the profiling of the user group; that is, they defined the ideal type of user that was expected to use the website created during the course.

Excerpt 4: recorded interaction, first phase of the course

Jack: ok (.) ((pointing to Ivy)) put up a fat title of different types of users and we're gonna draw out just a list of different types of users

Lenny: yah

Carl: I want to do a mind map. I like the mind maps

Jack: we can do a mind map . . .

Lenny: yah we could . . .

Ivy: no not always the mind map

Jack: it's it's very

Carl: ok, well, so user groups are gonna be kids . . .

In Excerpt 4, Carl proposes to also use the mind map for the task of choosing the user group, to which Lenny and Jack appear to agree, but Ivy argues that they should not always use the mind map. The background needed for interpreting this excerpt is that, during the previous sessions of collaboration, the group had made intense use of mind map tools for representing the main ideas connected with the project. Carl and Jack appear to be willing to create a new mind map for the ongoing task, but they immediately accept Ivy's objection and start working on the task, dropping the idea of the mind map. A few minutes after this clip Jack said that he felt the need to draw something and started drawing a schema of the age groups that they were discussing on the smartboard. In our interpretation, when he proposed to create a mind map, Carl voiced the need of a visual representation for advancing the collective discussion. Although Carl's proposal was not accepted, later Jack re-voiced the same need when he started drawing on the smartboard. This excerpt shows that the participants may not provide clear explicit arguments when they make decisions about the technological tools (and visualization techniques) to be used for advancing the collaborative task. The data show that during the video-recorded sessions, the dialogical interaction around this topic tends to be concise and it is difficult for an external observer to understand the rationale behind the group's choices on self-organization. This finding suggests that the process of self-organization includes implicit assumptions that are not clearly voiced by the participants.

Because the decision making about the tools to be used for collaboration was of analytical interest, the researcher showed the videoclip containing this interaction to the students and asked them to comment on it. Excerpt 5 contains part of the students' reactions to the projection of the videoclip. The participants discussed their perspective on the use of the mind map during the project and all the participants appeared to be convinced that the mind map was not the right tool in that moment.

Excerpt 5: first stimulated recall interview

Lenny: I kind can't explain why but . . .

Ivy: yep it's hard to explain but but mind map is is not the right tool

Carl: I thi I think the mind map is what you use to are starting to create something

Ivy: yah and you are changing ideas

Carl: and watching you have your basic flow

Ivy: yah

Carl: you actually you don't make a mind map for when you have certain points you wanna portray because what's the point then you just have them

Ivy: when you have a clear task you have to do it I I think mind map is not appropriated

In our interpretation, Excerpt 5 reveals assumptions that the students have developed concerning the relationship between the temporal structure of the task and the appropriate tools to be used. First, Lenny and Ivy state that it is difficult to explain the reasons behind their choice, confirming that implicit cognitive processes may have been in place when making this decision. Subsequently, Carl links the use of the mind map tools to a specific phase of the collaboration when one is "starting" to create something. Then, Ivy adds that the mind map is good when there are changing ideas, whereas the mind map is not appropriate when they have a clear task. Carl also refers to the fact that, by using the mind map (in previous sessions of collaboration), they could watch their ideas as they were emerging, and that such a means of working allowed them to reach what he calls a basic flow. Although he had initially proposed the use of the mind map in Excerpt 1, during the interview Carl appeared to be convinced that, in the case shown in the videoclip, the mind map was not the right tool because they already had a "list of points". The analysis of the data from phases two and three of the course confirms that the students no longer used the mind map tools that were used at the beginning of the course, confirming that the cultural model they espoused during the interview is compatible with their enacted self-organization.

4. Discussion

In this study, we examined the students' self-organization of space–time during a Knowledge Creation course and the role played by cultural models in this process. In this section, we discuss the findings by connecting them to the research questions that guided the analysis.

To answer research question 1, the learning environment of knowledge creation was examined in terms of a diachronic sequence of space–times that the students dynamically arranged throughout the different phases of the BL course. We showed how different physical environments and virtual spaces, and different configurations of the social space, were relevant during each phase of the task. In particular, the initial phase of the activity was characterized by oral discussions mediated by shared visual representations such as concept maps, while during the second and third phase, a progressive increase in individual work often mediated by domain specific software (such as programming software) was observed. Across the three phases of the course, the group members contributed to the collective task from different physical spaces, thus “blending” their learning experience and alternating online and offline activities according to their own preferences and situational needs. In addition, the analysis shows that the students deliberately sought to find a stable place for the collaborative activity. This need for stability can be discussed in terms of embodied cognition. As brilliantly discussed by Kirsch [46], people tend to encode information in space, which works as an aid for thinking and lowers the cognitive load of complex tasks. Due to not being able to “leave” artifacts in a stable, physical learning space, which would work as a mediating tool for their sustained activity across several months, the students had the feeling of being lost, of wandering around the school, and of not being effective in their collaboration. This need was at least partially fulfilled through the introduction of the practices of space–time organization that were identified, which are discussed below.

The analysis conducted to answer research question 2 allowed discussion of how the students socially negotiated specific practices (and associated space–time frames) for self-organization that contributed to satisfy their need for stability. In our interpretation, these practices provided a stable anchor for the self-organization of the group and allowed discussion of how physical and virtual space–times were flexibly used for self-organization. The space–time configurations in which these practices took place were intertwined with on-task space–times, and they can be considered to be complementary to the joint problem space (JPS) theorized by Teasley and Rochelle [47,48]. The JPS is a concept that enables examination of how learners collaboratively make sense of a problem-solving task, and of the content knowledge and procedures needed for finding a solution, thus developing a shared understanding of the problem assigned by the teacher. On the contrary, the joint organizational space–times (JOSTs) detected in the present investigation are related to the students’ management of complex learning environments in situations in which they face problems related to the organization of the collaborative activity. In particular, the group introduced daily “catch-up meetings” and used a shared online folder for the “monitoring” [49] of the task and the “coordination” of individual efforts, especially when working from different places. The development of these practices of self-organization is not immediate. Indeed, the data show that this was a demanding process for the group, confirming previous research suggesting that time management may constitute a significant challenge for students in blended learning contexts [50]. In addition to time management, based on the analysis of this case, we also argue that the management of unstructured and technologically rich environments may be seen both as a resource and as a challenge for the students. The students can perceive the multiple physical environments and virtual spaces as resources that can be flexibly and autonomously integrated in creative configurations of online and offline participation. This is in line with previous research showing that adult learners tend to value course designs when they contain multiple options, self-direction, and variety [51]. Conversely, such rich and unstructured learning environments can require sustained efforts across extended periods, because the students need to iteratively reorganize their learning environment based on the evolving needs of the group.

Overall, these findings can be interpreted by adapting and extending the scope of the concept of interaction space that has been used in the context of intelligent learning environments by Dillenbourg and colleagues [52]. Although the present study takes place in a radically different context, the interaction space has been conceptualized in terms of a sequence of subspaces called microworlds, thus accounting for the temporal development of learning activities which is crucial for the present investigation. According to this theoretical perspective, different phases of a learning course can be described in terms of the sequence of interaction spaces relevant at different times during the learning activity, which involved both spaces for representation (e.g., the concept maps) and spaces for (inter)action (e.g., the design and programming of the website). Nevertheless, although previous research on the modelling of interaction spaces has been aimed at improving the design of learning environments by teachers and instructional designers, the present investigation shifts the focus onto the active role that learners can play in selecting and arranging the sequence of space–times that characterizes the collaboration in blended learning contexts. Accordingly, the investigation has allowed the detection and analysis of the space–time frames that the students arranged specifically for the self-organization of the activity. Thus, according to the chronotopic approach proposed here, the analytic focus is on how the space–time of interaction is socially arranged by the participants during the activity, rather than on how it is structured in advance by the teacher. It is not expected that all the groups of students engaging in Knowledge Creation will enact the same sequence of space–time relations observed in this group. Rather, it is hypothesized that the students may develop a set of self-organization skills, related to the iterative development of collaborative practices of self-organization, which are currently under investigated. These skills are not only relevant for the successful implementation of the knowledge creation activities discussed in this investigation. Contrarily, there is a growing awareness that the development of this type of self-organization skill is to be considered as an expected educational outcome of high societal significance. A recent review study commissioned by the European Commission on Key Competences for European Citizenship showed that skills connected to self-organization "in various forms are included in several frameworks, either as a separate skill or as part of social and civic competences" ([53], p. 18). Scientific knowledge about how students self-organize Knowledge Creation activities may be used by teachers to support the students in this aspect of the learning process. Future research in this field may uncover further details about how the students can learn to collaboratively generate effective practices of self-organization, and discuss strategies to promote the learning of such skills, which may be based on the analysis of cultural models such as the ones discussed below.

Finally, the findings associated with research question 3 allowed discussion of how the students built on "cultural models" that included assumptions regarding the space–time frames of the task when they self-organized their collaboration. The analysis of the two excerpts presented above illustrated that processes of self-organization are often implicit and allowed discussion of how the task models elicited during the interview may play an invisible form of mediation that silently guides the students' self-organization. In particular, we emphasize how the students' task models may involve specific assumptions about the space–time organization of learning tasks, for example, expecting that the creation of mind maps is appropriate only at the beginning of a Knowledge Creation course. We claim that these representations of space–time associated with cultural models are important elements of self-organization that are not yet addressed in the literature on Knowledge Creation. Our analysis shows that, at times, the students developed divergent ideas about the temporal development of the collaborative project and about the virtual/material spaces that were relevant in the different phases of the course, also based on their professional background. Students and teachers may be unaware of these assumptions and their implications for learning. Thus, developing scientific knowledge of the students' choices, challenges, and assumptions concerning the organization of the space–time of Knowledge Creation can help teachers to provide assistance and facilitation, and allow students to further develop their skills as "reflective, self-directed, self-regulating and, indeed, self-determined learners" ([9], pp. 12, 16). Our data show that throughout the Knowledge Creation process, the students may need to develop different arrangements of material and virtual tools, in addition to different configurations of online and offline participation depending on the diachronic development of the "long-term processes of knowledge advancement with shared objects" [14] that characterize KC.

The explorative nature of this case study does not allow generalization of the findings to different groups and different courses. However, the richness of the data from this case study allowed us to illustrate relevant aspects of student self-organization that can provide directions for future research in this rather unexplored field.

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Article

Knowledge Building in Online Mode: Insights and Reflections

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Abstract: It seems certain that blended learning will be on the rise in higher education, with in-person meetings increasingly precious time, and online synchronous and asynchronous sessions used to complement them. This paper examines Knowledge Building in two graduate courses conducted during the COVID-19 pandemic. There were no in-person sessions; rather, synchronous Zoom sessions were combined with asynchronous work in a knowledge building environment–Knowledge Forum. Knowledge Forum is designed to make transparent and accessible means by which deep understanding and sustained creative work proceed. Accordingly, for example, rise-above notes and view rearrangement support synthesis and explanatory coherence, epistemic markers support knowledge-advancing discourse, and analytics support self-and group-monitoring of progress as work proceeds. In this report, we focus on these aspects of Knowledge Building, using a subset of analytics to enhance understanding of key concepts and design of principles-based practices to advance education for knowledge creation. Overall, we aimed to have students take collective responsibility for advancing community knowledge, rather than focus exclusively on individual achievement. As we reflect on our experiences and challenges, we attempt to answer the following questions: Do courses that introduce Knowledge Building in higher education need an in-person or synchronous component? In what ways can we leverage in-class time and Knowledge Forum work to engage students in more advanced knowledge creation? We conclude that synchronous and asynchronous Knowledge Building can be combined in powerful new ways to provide students with more design time and deeper engagement with content and peers.

Keywords: knowledge building; knowledge creation; Knowledge Forum; design thinking; higher education

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1. Introduction

Due to the COVID-19 pandemic, in March 2020 higher education institutions in Canada swiftly shifted to emergency remote learning. Typically, online video conferencing replaced face-to-face interactions, with classes meeting at the same time as scheduled originally. As it became known that all courses were to be delivered online in the following Fall and Spring terms, instructors and course designers invested more time analyzing course content, goals, and structure in light of online requirements [1] and the need to engage students without face-to-face interaction.

In this paper, we reflect on our experience designing and delivering two courses to introduce students to Knowledge Building theory, pedagogy, and technology at a large post-secondary institution in Canada. Knowledge Building is an extensively researched innovative pedagogical approach that addresses the need for schools to be restructured as knowledge-creating organizations [2,3]. Two courses are offered to students enrolled in masters and PhD programs to introduce the key principles and concepts of Knowledge Building. Both courses involve students working as a community in design mode [4] to build on each other's design work and advance community knowledge.

In both courses, individuals come together to tackle problems of understanding related to education for knowledge creation and to consider implications for their areas of expertise. We examine how ideas transform and become integrated across different community views created by students. There was not one stream of information, but different advances based on diverse student interests, complemented by efforts on the part of instructors and students to establish increasingly coherent community knowledge. In this paper, we discuss how ideas are articulated and progressively refined through multiple course components.

Changing course arrangements at a time when many students are experiencing social and emotional stress and turbulence is challenging. Bringing students together as a community to engage in collaborative and progressive design work, with students taking collective responsibility for community knowledge, represents yet another level of difficulty. Not only must knowledge building principles and concepts be integrated into students' professional and personal learning trajectories, but the community must come together to envision education restructured as a knowledge-creating enterprise.

The goal of this paper is to highlight ideas implemented to engage students in principles-based, idea-centred design to advance a common objective and enable students to take greater responsibility for collective achievements. We reflect on our experience as course designers within the broader context of a Knowledge Building Research International team that looks to improve Knowledge Building courses: Do courses that introduce Knowledge Building require an in-person or synchronous component? In what ways can we leverage synchronous class time and asynchronous Knowledge Forum work to engage students in more advanced knowledge creation? Our collective goal is to establish a global network of research-based courses to advance education for knowledge creation.

2. Knowledge Building

Knowledge Building aims to engage students directly in the means by which knowledge in the world is advanced. It is akin to knowledge creation as practiced in research laboratories and other frontier-advancing organizations, amplified by a concern for educational benefit to the participants and to society. It focuses on the growing need for students to work creatively with ideas and to see themselves as active contributors in advancing community knowledge [5]. The essence of Knowledge Building is the production and continuous improvement of ideas to advance community knowledge [6]. Knowledge building discourse happens in "design-mode" [7,8], where the main concern is with the "usefulness, adequacy, improvability, and developmental potential of ideas" [7] (p. 57). It is facilitated by Knowledge Forum (KF), the technology designed to promote advanced knowledge work. Twelve principles convey the theoretical framework and workings of knowledge-creating communities [9,10]; the principles (indicated in italics throughout the text) are described below.

Knowledge Building is premised on the idea that each student is a legitimate contributor in the creation of authentic, creative knowledge work, and that "the state of knowledge in the classroom is an emergent distributed phenomenon that cannot be found in any one student's mind" [11] (p. 399). In keeping with Vygotsky's (1978) [12] theories of social constructivism and sociocultural learning, Knowledge Building accentuates the role of social interaction and collective responsibility. Additionally, it represents a complex systems account of new knowledge [13,14] and knowledge creation as an observable form of cultural practice and progressive enterprise [15]. It is distinguished by its emphasis on "deep constructivism"—on engaging students intentionally in taking *collective responsibility for advancing community knowledge* and exercising *epistemic agency* as they take charge of goals, designs, and progress evaluations normally handled exclusively by the teacher [6]. Design and innovation are central to Knowledge Building. As elaborated in knowledge building principles below, collaborative creation and advancement of public community knowledge requires *idea improvement*, *Knowledge Building discourse* as collaborative problem solving, and *constructive use of authoritative resources* to support ever-deepening understanding and emergence of new ideas and artifacts [5]. At the very heart of Knowledge Building is sustained creative work requiring interdisciplinary understanding that goes deep into complex, real-world problems and creates coherence and solutions, as in knowledge-creating organizations. In education contexts there is added emphasis on the well-being of contributors and innovation for public good.

Scardamalia [9,10] articulates 12 knowledge building principles to incorporate in practice:

Real Ideas, Authentic Problems. Authentic knowledge problems arise from efforts to understand the world; students address problems that matter to them, with their ideas real building blocks in knowledge creation.

Improvable Ideas. Ideas are treated as improvable. Community members work continuously to improve the quality, coherence, and utility of ideas.

Idea Diversity. Idea diversity is essential to the development of knowledge advancement. To understand an idea is to understand the ideas that surround it, including those that stand in contrast to it. Idea diversity creates a rich environment for ideas to evolve.

Epistemic Agency. Community members set forth their ideas and negotiate a fit between personal ideas and the ideas of others, using contrasts to spark and sustain knowledge advancement rather than depending on others to chart the course. They set goals and plans, and deal with problems that are normally left to teachers, managers, or other educational designers.

Community Knowledge, Collective Responsibility. Community members share the responsibility for advancing community knowledge. Contributions to shared, top-level goals of the organization are prized and rewarded as much as individual achievements.

Democratizing Knowledge. All members are legitimate contributors to the shared goals of the community. All are empowered to engage in knowledge innovation, and all take pride in knowledge advances achieved by the group.

Symmetric Knowledge Advancement. Knowledge is advanced through cross-team interactions as different community members and communities with different expertise contribute to what is known and to available resources.

Pervasive Knowledge Building. Knowledge Building is not confined to particular occasions or subjects but pervades mental life—in and out of school.

Constructive Uses of Authoritative Sources. To know a discipline is to be in touch with the present state and growing edge of knowledge in the field. This requires respect for and critical analysis of what is known, going beyond given source material to extend understanding through authoritative and other data sources.

Knowledge Building Discourse. Knowledge is advanced through discourse aimed at idea improvement. Discourse results in more than the sharing of knowledge; the knowledge itself is refined and transformed through the discursive practices of the community—practices that have the advancement of knowledge as their explicit goal.

Embedded, Concurrent, and Transformative Assessment. Assessment is embedded in the day-to-day workings of the organization, with the community assessing progress and identifying problems as work proceeds; it is integral to the effort to advance knowledge.

Rise Above. Creative Knowledge Building entails working toward higher-level formulations of problems and solutions. It means working with diversity, complexity, and messiness, to move beyond current best practices to achieve new syntheses and improved outcomes.

3. Literature Review: Knowledge Building in Higher Education

Knowledge Building requires work in design mode, with innovation as a goal and self-organization and emergence as key characteristics [16]. To achieve this transformation, teachers who adopt Knowledge Building engage in design and exploration of new practices, assessing those practices in light of student benefits [17–19] They share stories of their own experiences and perspectives, bringing principles-based knowledge building into their practices and engaging in co-design with other professionals so that the "knowledge that is co-created is greater than the sum of each individual member's knowledge" [20] (p. 85). Assessment is part of the effort to advance knowledge; a knowledge building community needs to engage in its own internal assessment to identify problems as the work proceeds [21]. Previous studies examined implementation of Knowledge Building in graduate courses with prospective teachers and in other higher education contexts with students collectively advancing knowledge as they tackle educational problems, share perspectives, and generate new possibilities. To contextualize our research, we highlight previous studies with the stated goal of engaging graduate students as a knowledge building community.

Prior research has explored technology use, attitudes and perspectives, and pedagogical implementations of Knowledge Building—with results demonstrating its effectiveness as an innovative instructional approach [22]. For example, Gilbert and Driscoll [23] employed a case study methodology to explore how different instructional conditions promote a knowledge building community among 20 graduate students enrolled in one semester-long course at Florida State University. The conditions included (1) a collective and authentic goal (the design of a charter school), (2) students working in cooperative groups to achieve the goal, (3) self-selected readings to promote ownership, and (4) use of Construe, a technology to store and facilitate communication. The results showed that a task presented to students as authentic was not viewed by the students as authentic enough to foster collaborative work; the researchers suggested a shared vision might result in more collaboration. The researchers also determined that it is important to continuously track knowledge building to provide means of more support and feedback. As described in the sections below, in both of our courses we emphasized a shared vision to be refined or revised by students, in keeping with the *Real Ideas, Authentic Problems* principle, rather than a predetermined problem to be tackled. In addition, Knowledge Forum analytics are designed to enable continuous assessment of individual and community progress, in line with the *Embedded, Concurrent, and Transformative Assessment* principle. Another pedagogical implementation examined by Cesareni et al. [24] involved university students taking on scripted roles to foster discussions. The study was conducted over 15 weeks in a blended course with 143 students. The authors claimed that scripted roles can foster shared responsibility to advance the collective knowledge of the community. However, Bereiter and Scardamalia [25] raise concerns regarding teacher and researcher designed scripts that may reduce student agency, idea diversity, rise-above, and self-organization informed by embedded, concurrent, and transformative assessment. In the study to be reported, instead of scripted roles, we emphasize student agency in forming teams and responsibility for monitoring and advancing community knowledge to re-align work and team composition as work proceeds.

A case study by Chan and Van Aalst [17] reported on findings from two graduate teacher-education courses in Hong Kong and Canada. The authors examined how teachers engage in collaborative inquiry by focusing on how progressive discourse results in idea improvement, and how members share collective responsibility to advance the knowledge and understanding of the whole community. The first course involved 210 pre-service teachers divided into 11 groups working together to analyze case studies, pose new problems, and synthesize new ideas and understanding. Classes met synchronously once a week and students contributed asynchronously on Knowledge Forum. Analysis of contributions showed a high level of engagement and attempts to connect theory and practice. The second course involved joint work between six students in Hong Kong and six students in Canada, with similar promising results.

Another case study by Sing and Khine [26] looked at online interactions among 11 in-service teachers taking a module titled "Integrating Information Technology into School Curriculum" at a teacher training institute in Singapore. The students spent the first three weeks discussing theoretical issues, and the following four weeks designing IT-based lessons. Half the lessons were conducted in person and half online, with discourse taking place on Knowledge Forum. The results showed that although students formed an active community, there was no evidence of deep or sustained online interaction. The authors suggested finding ways to enable deeper interactions. Chai and Zhu [27] hypothesized that students who adopt knowledge building principles are more successful in forming as a knowledge building community. They analyzed online discourse, design artifacts, and reflections of 39 pre-service teachers and found that depth and breadth of principles-based analysis tended to distinguish high performance groups from groups with lower performance.

Hong et al. [28] examined how 24 teachers enrolled in the course "Integrating Theory and Practice in Teaching" at a university in Taiwan perceived the Knowledge Building theory and approach. Students used Knowledge Forum to engage in knowledge work about teaching theories and practices. The findings suggested that knowledge building discourse helped participants acquire informed understanding of Knowledge Building and to some extent shaped their views on its feasibility as a teaching approach. An earlier study by Chai and Merry [29] suggested that teachers working as a knowledge building community experienced similar changes in their views. Findings from the case study by Chai and Tan [30] also posited that engaging teachers in Knowledge Building leads to a deeper understanding about the pedagogy and suggested that teacher agency and adequate time are necessary factors for teachers to implement Knowledge Building in their teaching.

A more recent study examined the socio-cognitive dynamics of knowledge building discourse among 61 first-year Dutch Master of Education students in three consecutive courses [31]. The research focused on the concept of openness, which the authors defined in this context as the "cognitive, epistemic, and relational activities of community members as manifested in their discourse" (p. 168). Contributions to Knowledge Forum were analyzed based on (1) the cognitive dimension, which relates to the production and evaluation of knowledge, and (2) the social dimension, which relates to how the community members present themselves and communicate with others. The results showed that cognitive activities were key to advancing discourse, whereas social activities actually hindered discourse. In our courses, we aimed to support social dimensions to foster conceptual advances and to explore the possibility that student use of knowledge building analytics can help sustain thoughtful and intentional collaboration among community members as well as lead to deeper understanding of principles.

The above studies described knowledge building in teacher education courses; other studies examined knowledge building in other contexts of higher education such as in engineering [32] and healthcare [33]. In our study, we describe new approaches and designs developed to facilitate knowledge work among graduate students in an online mode. Cesareni et al. [24] argued that learning models like the Community of Inquiry [34] and Knowledge Building Communities [5,21,35] stress that the main purpose of online courses in higher education "is to build new knowledge" (p. 11) through a deep collaboration amongst community members. Yet, models differ in the way groups are formed and idea improvement is sustained. For example, the social configuration of group members in knowledge creating teams tends to be opportunistic and emergent rather than fixed by the instructor, with advantages as demonstrated by Zhang et al. [36], and sustained knowledge advances are marked by rotating leadership [37] and embedded, concurrent, and transformative assessment, as demonstrated in the present study.

4. Methods and Data Source

Novel designs and knowledge building analytics were used to facilitate productive knowledge work in two online courses. In this report, these courses are treated as case studies to explore opportunities and constraints in establishing knowledge building communities. The case study framework favours in-depth analysis of how and why a phenomenon occurs in a real-life investigation–in this case ways to combine synchronous class time and work on Knowledge Forum to engage students in more sustained knowledge advancement. The data sources for this study consisted of student discourse in the Knowledge Forum database, observations during the synchronous Zoom sessions, as well as students' self-assessment portfolios. There were two data sets for this study, one from each graduate course.

4.1. Knowledge Building Environment: Knowledge Forum

Knowledge Forum is a technology especially designed to support and sustain advanced knowledge work [10]. Members can contribute ideas in notes that consist of text or multimedia artifacts (e.g., drawings, videos, audio), connect ideas through citations and build-ons, and organize their design spaces—views. Ideas can be revisited, updated, and advanced at any time, with information from different sources integrated and combined to rise above and create better, more coherent designs, theories, and practices. Members also have access to knowledge building analytics to self-assess the state of their work and community knowledge. They can see how the community members and ideas are networked through their discourse within and across groups. In-class or synchronous discussions are sometimes dominated by certain students. We aim through visualizations of classroom dynamics and students self-intentioned efforts to engage all students productively in idea improvement.

4.1.1. Notes

Within Knowledge Forum, community members have the ability to create notes (Figure 1) to represent their ideas, theories, or challenges, and then build on and deepen thinking to generate new understandings and advance community knowledge [38]. The note editor allows for textual or visual elements such as images or video to be embedded in notes. The editor also contains note identification information, including a note title and keywords. One thing that differentiates this note editor from many others is the fact that scaffolds can be inserted (see the "Scaffolds" section below). In addition, notes have tabs that allow editors of the note to make changes, a read tab so that a reader can focus on the content of the note, history tab to convey its evolution, connection tab to indicate who has read, cited, or referenced the note, and other properties.

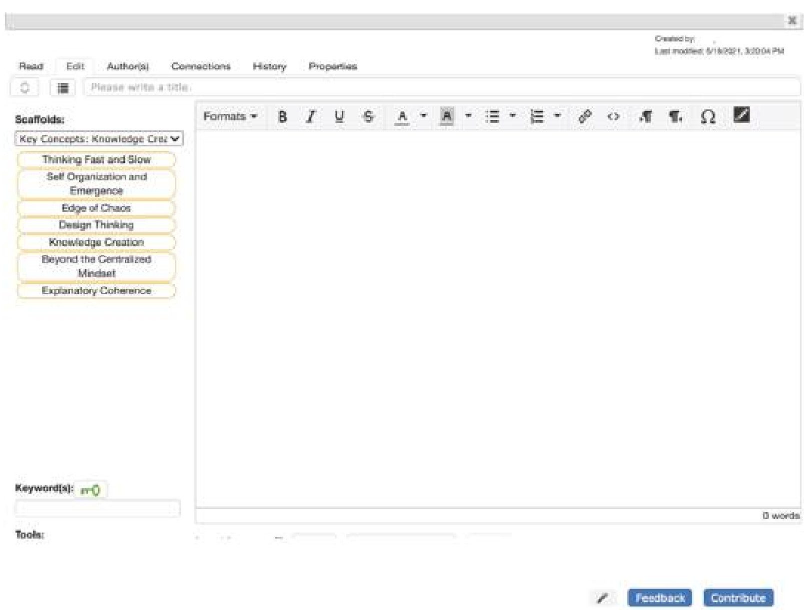

Figure 1. Knowledge Forum note features.

Community members can create "build-on" notes to each other's work. Build-ons are represented by arrows to show the connections between notes (Figure 2). Members can also cite other notes by copying the section they want to cite into a new note, which automatically inserts the copied text in the form of a quote. This provides a further link between notes and allows note authors to be recognized. Members can also co-author a note if there is an idea they want to promote jointly to the community.

Figure 2. A collection of Knowledge Forum notes illustrating build-on notes.

4.1.2. Views

Views are pages within Knowledge Forum that provide a backdrop for group notes. Views can be customized to reflect the needs of the community, whether that be graphical display, timeline, links to external content, or thematic organization. For example, in the two courses, separate views were created for small design groups to represent their work (Figures 3 and 4). In the first course, a separate view was created for each week to discuss the week's reading. Views can also be organized by participants, as in the second course where a separate personal journal view was created by each member. All views are accessible by the entire community to add and build on ideas or add additional content, unless the view creator specifies private view.

Figure 3. Example of a design group view from course 1.

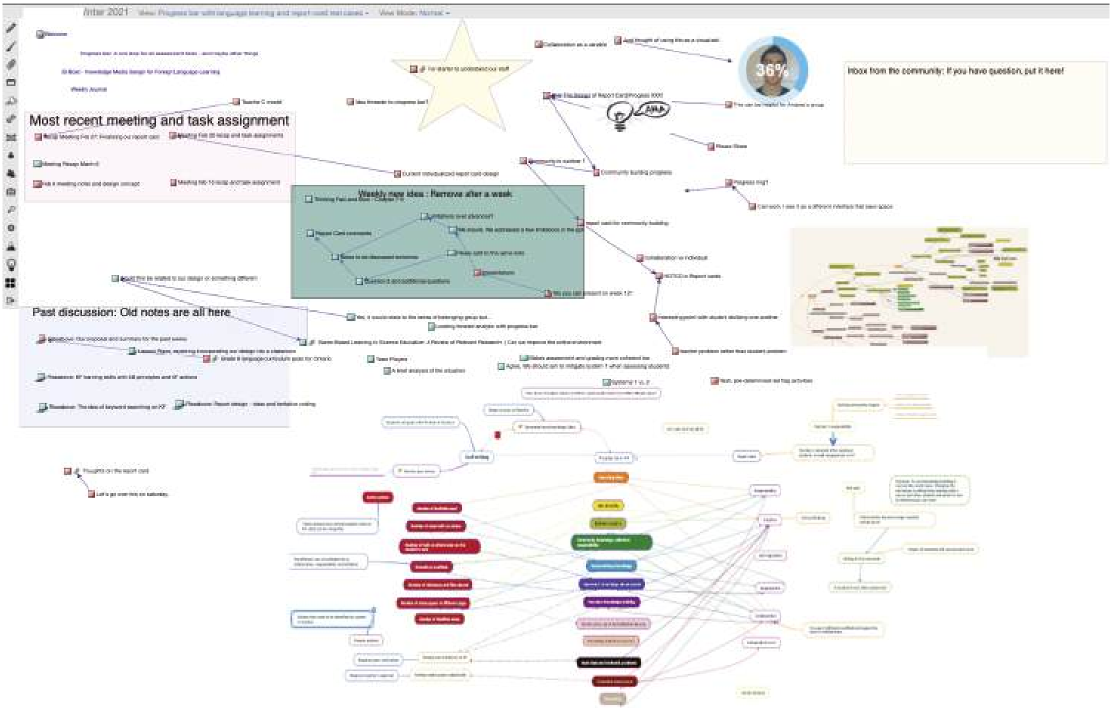

Figure 4. Example of a design group view from course 2.

4.1.3. Scaffolds

Epistemic markers are an important feature in Knowledge Forum as they facilitate forms of discourse underrepresented in school discourse but essential for Knowledge Building/knowledge creation. An example of such discourse is theory building. The theory building scaffold shown in Figure 5 has been used to engage students in theory talk from grade one to tertiary education. Scaffold supports–phrases such as “I need to understand” or “putting our knowledge together”—vary in difficulty. Students select a phrase by clicking on it; it is entered into the note for integration into their discourse. Studies in early elementary school, with the theory building scaffold available for use but not compulsory, led to phrases such as “my theory,” and “I need to understand” in students’ written discourse. By various reports these discourse forms were also found in classroom talk, conversation on the playground and at home. Significant educational advantages have been reported [39]. In addition to embedding powerful discourse moves into student work, scaffolds can be searched and analyzed to view patterns of use, helping students to monitor and adjust contributions as work proceeds and to exercise epistemic agency in advancement of community knowledge [10].

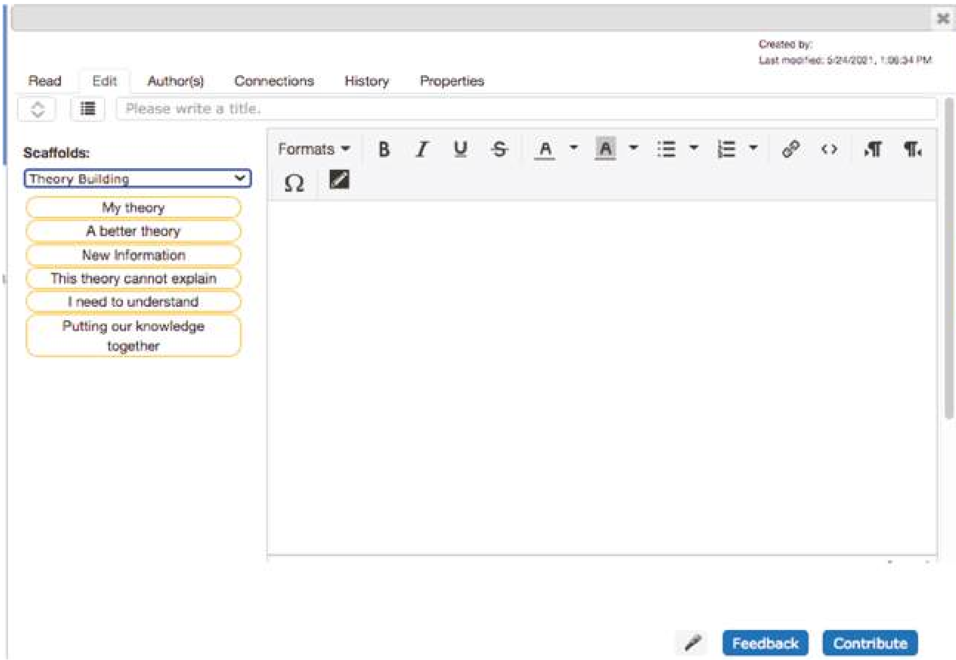

Figure 5. Knowledge Forum note with a "Theory Building" scaffold.

Knowledge Building/knowledge creation is advanced through the public life of ideas—ideas made explicit and available to others who can help advance them. Knowledge Forum is a multimedia environment allowing students to represent ideas in the form of text, audio, images, video, models—many representational forms. It gives ideas a life beyond the mind of the originator and beyond transient conversation. Students were asked to use meaningful titles to facilitate search and review and to engage individually and as a group in the curation of ideas and views so visitors to their view could easily understand their work. Knowledge Forum was used in both courses.

4.2. Context and Participants

4.2.1. Course 1: Introduction to Knowledge Building

This course introduces students to Knowledge Building through engaging them in teamwork to advance a shared, top-level goal: use knowledge building principles to advance practices in their field. Students operate as designers, conveying designs as artifacts in Knowledge Forum, with design iterations to improve practices through reading, discussion, and help of community members. The focus is not on a final product but use of knowledge building principles as design parameters and Knowledge Forum as a design space. There were 23 graduate students enrolled in this course, all new to Knowledge Building and with diverse educational backgrounds and professional practices. They were encouraged to explore knowledge building potential in their areas of interest, contributing notes, designing views, and using analytics to assess their contributions, both as individuals and as a community.

The course included 12 sessions delivered synchronously once a week in the Fall 2020 term. Initially, we designed the course so that four sessions were mandatory whole-group sessions, with the remaining sessions optional to allow for small group design time. But optional sessions that provided a mix of design time and interaction with peers and instructors were attended by all students. In the first session, students were asked to create a biography note on Knowledge Forum to share their educational background and interests and highlight an educational challenge they faced. Students were encouraged to build on each other's notes to explore diverse interests, find common interests, and form into small design groups. They were not required to join a team. Since contributions are entered into Knowledge Forum's community space, all work is in an important sense teamwork. Team membership can change at any time, with exchanges facilitated by team views. All students read knowledge building articles and used the "reading-of-the-week" view to explore issues of application related to their professional contexts.

Eventually 9 design groups were formed, each with their own view on Knowledge Forum (Figure 6). Students showcased their progress and designs in the last two synchronous sessions.

Figure 6. List of design views in course 1.

Weekly Course Readings

Students read two articles per week. A new Knowledge Forum view was created each week for students to engage in knowledge building discourse around concepts covered in the readings. A "Why Knowledge Building, Why Now?" scaffold was used to encourage students to identify problems of understanding, myths, misconceptions, and new possibilities they uncovered as they read articles.

Although students demonstrated a high level of engagement, as suggested by the number of notes posted in the reading views (Table 1), students commented that discussions in their reading views and design-group views were not tightly connected. We experimented with having students discuss readings within their different design groups. Under both conditions students focussed more on discussion of general educational issues than on implications of what they read to generate design iterations. Generating principles-based design iteration seemed to be an especially difficult challenge.

Table 1. Number of student notes in reading views.

View	Number of Student Notes
Reading view 1	87
Reading view 2	177
Reading view 3	144
Reading view 4	116
Reading view 5	164
Reading view 6	160
Reading view 7	122
Reading view 8	108
Reading view 9	83

Although students mostly worked within their own group, they explored the ideas of other groups and at times made connections and contributions. However, especially toward the end of the course, as they prepared for their design-group presentations to the class, they focused on their own ideas and connections to the shared course design goal. Next iterations of the course will need to provide better support for use of readings to inform design iterations and deeper integration of work within and across groups.

Synchronous Meetings

For the first session of the course, we built on the affordances of online learning to invite three panelists to address the question, "Why Knowledge Building, Why Now?" Panelists discussed their experiences with Knowledge Building and the expanded competencies and opportunities it affords in their various contexts. One panelist was an administrator of an Ontario-wide Leading Student Achievement initiative, another introduced Knowledge Building and Knowledge Forum to Inuit communities north of the Arctic Circle, and the third co-authored the Knowledge Building Gallery [40] based on work with teachers new to Knowledge Building. Their diverse experiences resonated well with students who came to the course with varied educational and professional backgrounds. The panelists conveyed their pleasure in starting students on their Knowledge Building journey and agreed to return for the last class. Given different locations of panelists, this rich conversation would not have been possible in a regular classroom setting. Students looked forward to presenting their work at the end of the class to these experienced professionals.

The rest of the synchronous sessions started with a whole-class discussion and time to discuss conceptual, design, or administrative issues, followed by use of the Zoom breakout room function to allow each design group to engage in focused design work. The instructor and two teaching assistants rotated between rooms, engaged as co-designers. After the breakout groups, the whole class came together again to provide updates of their work, learn more about each other's designs, and find points of intersect across groups.

Synchronous sessions with all students together in the main Zoom room were recorded, and links to the recordings were posted in a Knowledge Forum note on the course home page. Recordings were helpful for students who were not able to join the synchronous session during class time, and they also provide opportunity to re-listen to segments to continue discussion of an idea entered there, although we are not aware of anyone who accessed recordings for that purpose.

4.2.2. Course 2: Digital Media and Practices for a Knowledge Society

The second course did not require that students take the first; however all but one of the 9 students in the second course had taken the first. As in the first course, students worked in small teams to advance a shared top-level goal; in this course, co-design of knowledge practices and technologies to enable a realistic model of students advancing knowledge for public good [8]. Students were guided by seven concepts in the knowledge creation literature.

Thinking Fast and Slow. These are two systems that drive the way we think. System 1 is fast, intuitive, and emotional; System 2 is slower, more deliberative, and more logical [41].

Self-Organization and Emergence. Self-organization is a dynamic process by which system order arises without external control; emergence occurs when something new arises from the interaction between individual parts of a system [42].

Edge of Chaos. This is the transition space between order and disorder where creative thinking and radical innovation can happen [43,44].

Design Thinking. Creative knowledge work requires participation in design activities to produce and develop new ideas [45].

Knowledge Creation. Knowledge is created through the intentional and purposeful generation of ideas. Ideas are artefacts that have a public life and interact with one another; students engaged in design thinking to collaboratively advance their ideas [25].

Beyond the Centralized Mindset. In making sense of complex systems, people often assume centralized causes and controls—where a single leader makes all the decisions [46].

Knowledge Building requires thinking beyond–thinking of students as epistemic agents able to take collective responsibility for knowledge advancement [47].

Explanatory Coherence. Explanatory Coherence assumes that a theory is more coherent if there is sound reasoning and explanation for the theory and its underlying facts and propositions [48,49].

As with the first course, students were asked to enter a biography note to introduce themselves, an educational challenge they faced, and how they believed education can be improved. As many students already knew each other, several students built on each other's notes with statements like "Nice to see you again" or "Looking forward to work with you again." Students were also asked to form design groups based on their common interests. As most students were familiar with each other's work, three groups were formed right after the first class, one of which was a continuation of a design idea advanced in course 1.

This course spanned 13 weeks in the Winter 2021 term, with 11 classes. No classes were held weeks 10 and 11; rather, small groups self-organized meetings and in the last two sessions, groups presented their designs. We followed the same flow for synchronous classes as the first course: full class discussion, followed by Zoom breakout rooms for small-group design work, followed by a full class discussion of designs and issues arising from readings. There was no panel discussion in this course.

Weekly Course Readings

Instead of determining fixed weekly readings for all students in the class, we attached to the syllabus a list of articles and videos that address the seven knowledge creation key concepts. As with the first course, the expectation was for students to review two articles per week and provide commentary on Knowledge Forum on how these articles convey and support conceptual and design advances. Students were asked to use the "Key Concepts" and "Constructive Use of Authoritative Resources" scaffold to explore concepts (Figures 7 and 8).

Figure 7. Key Concepts scaffold.

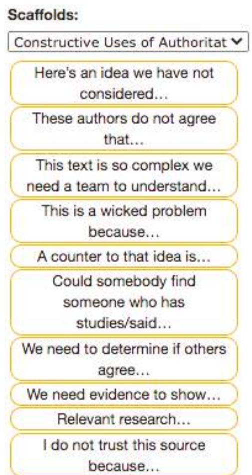

Figure 8. Constructive Uses of Authoritative Sources scaffold.

In addition to design views, students were asked to create personal views to serve as their public journal space. Students were to add citations to the literature and commentaries to convey coverage of readings spanning all concepts. With the help of view rearrangement (description provided below), students were able to find notes that addressed the concept(s) they wished to discuss or learn more about.

5. Results

5.1. Assessment and Existing Analytics

In both courses, students submitted three portfolios—three checkpoints—to assess their contributions to community goals. As discussed below, we encouraged students to use data from idea building, scaffold growth, and key concepts analytics. At each checkpoint students received feedback and suggestions regarding promising directions.

5.1.1. Idea Building

The idea-building analytic (Figure 9) provides a social network view of level of connectedness between community members. Each circle represents a different student. The image in Figure 9 taken toward the end of the course indicates all students were connected at some level. The larger the circle the greater the number of connections, with arrow indicating direction of connection. Students can determine where they need to contribute more; for example, they can intentionally build on a note of someone new, producing an arrow out and enlarging their sphere of connectedness. As members read, reference, and build on other notes, they are better positioned to take collective responsibility for community knowledge. Is it possible to engage everyone? Democratizing knowledge suggests we should try. Qualitative accounts of efforts toward that end are provided by students in their portfolios.

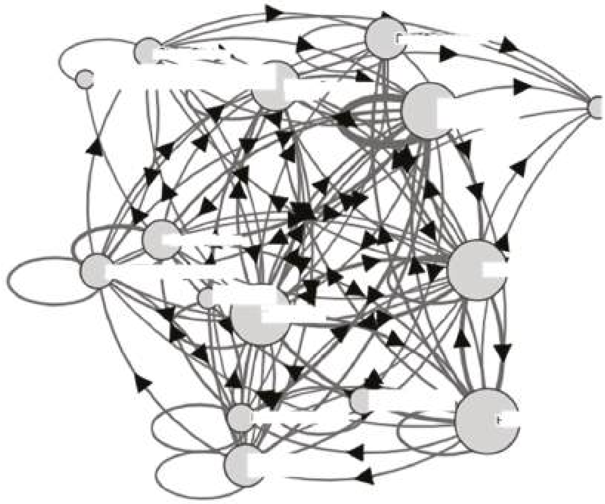

Figure 9. Idea building in course 1.

The following is a student's qualitative account of personal idea-building results submitted as part of the portfolio self-assessment (Figure 10).

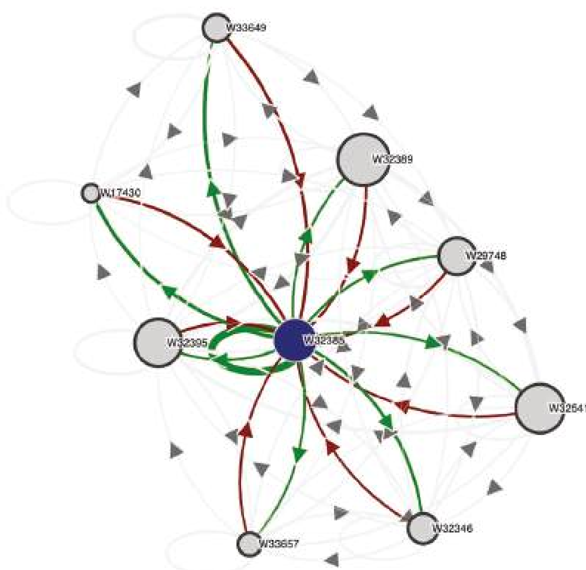

Figure 10. Example of student idea-building portfolio self-assessment in course 2.

> *"Much of my work since the last portfolio has been done live with my group. Notes for these meetings were made under the authorship of our group ("Sense of Belonging") to allow the other members to edit as needed. I'm not sure how group-authored notes are reflected in the analytics.*
>
> *I have admittedly fallen behind keeping up with the other groups' design projects over the course of the last month of the class. I do see areas in which my work intersects with that of the other two groups. The "Enhanced KB Community Engagement" group's work on*

norms of engagement directly relates to my ideas about community norms. Their work is more focused on using KF, but I believe both our theories would be enhanced by sharing ideas. The progress bar group's work is aimed directly at increasing engagement."

The student reflected on pattern of contribution within their small group and with other small groups.

5.1.2. Scaffold Growth

The scaffold growth analytic shows epistemic discourse moves based on the frequency of use of Knowledge Forum scaffold supports such as "My Theory," "I Need to Understand," etc. Through reviewing patterns of use, students gain a meta-level perspective on their contributions, allowing them to monitor the type of discursive moves that they are—or are not—making at any given time. Informal analysis suggests students tend to avoid difficult scaffolds and concepts. In the second course we ran the scaffold growth for the whole class to determine student engagement with the different key concepts (Figure 11). We found that students were more comfortable discussing and bringing forward ideas related to "Thinking Fast and Slow" and "Design Thinking," but were less engaged with "Beyond the Centralized Mindset" and "Explanatory Coherence."

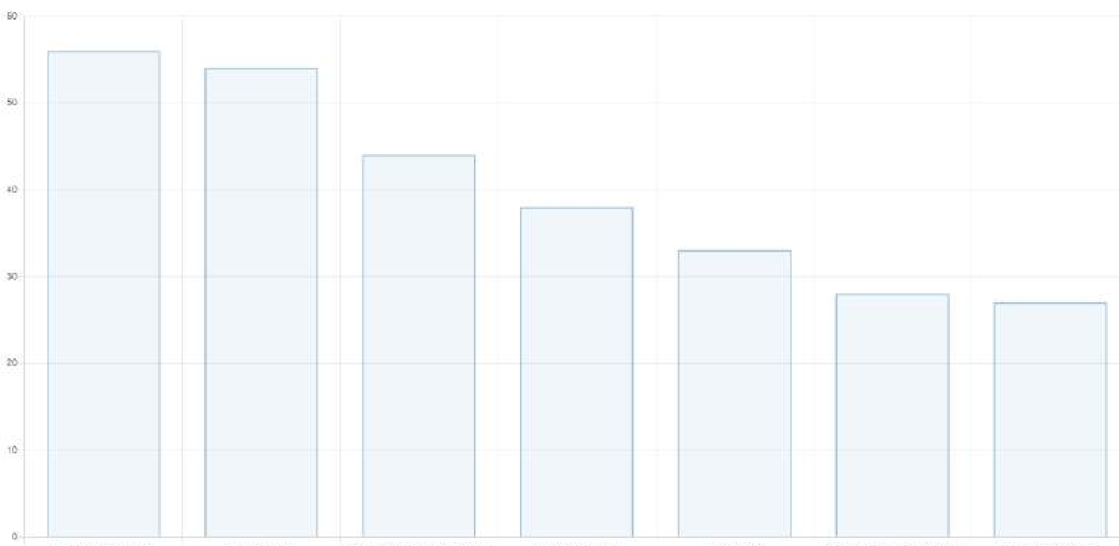

Figure 11. Key Concepts scaffold growth in course 2.

Research indicates that viewing such results leads to productive discussion and more intentional integration of less frequently used concepts and discourse moves [50].

One student reflected on the use of this analytic in their portfolio by comparing the results of two consecutive months:

"I have been endeavoring to advance a shared vision, which could be proved by the growth in the 'we' scaffolds. The following bar charts were retrieved from KF on February 1 and March 1 separately. Last month, most of my notes were built around individual work and understanding. For example, scaffolds such as 'I need to understand', 'my theory', 'an educational practice I would like to improve' were most frequently in February, and the words 'I' and 'my' would be more likely related to isolated, individual work. This month, however, there was an obvious increase in the number of scaffolds with a 'we' thinking, such as 'our design', 'here's an idea we have not considered', 'we need to determine if others agree', and etc. I have also been using the learning analytics embedded in KF to

review my notes, scaffold my understanding of KB, and support my design, which can be proved by the total number and type of scaffolds I used in the month. The data indicated my efforts toward integrating design thinking into my research work toward the top goal of the community."

5.1.3. Key Concepts

In the first course, the key concepts are the 12 Knowledge Building principles, and in the second course they are foundational concepts in the knowledge creation literature. The Key Concepts analytic is customizable to allow focus on concepts in any domain. Once concepts are identified it produces on demand a list of terms or phrases and title of the note(s) that contain these terms for each student (Figure 12). Hovering over the title shows the excerpt of the note that contains the term or phrase, and clicking the title opens the note in full. Thus, it is possible to see how frequently and in what contexts key concepts are in students' productive vocabulary.

Real Ideas , Authentic Problems	Our Design Challenge
Improvable Ideas	Meeting Minutes- October 4/5 2nd meeting - Oct 7 Our Design Challenge
Idea Diversity	Big and small Concurrent, Embedded and Transformative Assessment Share your Ideas! Our Design Challenge
Rise Above	Role of the moderator Community Rise Above- Scaffolds Motivation Concurrent, Embedded and Transformative Assessment Confidence Rise above challenge In a Pandemic Our Design Challenge Unlock scaffolds Building the Covid-19 Model
Epistemic Agency	Cutting Eduge Rise Above- Scaffolds Concurrent, Embedded and Transformative Assessment
Collective Responsibility for Community Knowledge	
Democratizing Knowledge	
Symmetric Knowledge Advancement	Our Design Challenge
Pervasive Knowledge Building	
Constructive Uses of Authoritative Sources	
Knowledge Building Discourse	Buy In Factor Our Design Challenge Re: Questions to advance design challenge Mobile phone + applications Need to go through
Embedded, Concurrent and Transformative Assessment	

Figure 12. Key Concepts for one student in course 1.

5.2. Metadiscourse

In order to exercise collective responsibility for knowledge advances students need the "big picture" of community knowledge as represented in their local community and authoritative sources. To apply principles, they need to work with them in design mode. To facilitate such work embedded scaffolds and view rearrangement were implemented.

5.2.1. Embedded Scaffolds

Embedded scaffolds allow users to apply multiple supports without need to toggle between scaffolds. Thus, for example, to encourage more principles-based design iterations we yoked the knowledge building principles scaffold with a "design mode" scaffold (see Figure 13). We aim to support demanding conceptual work suggested by design-mode items such as "A new idea that combines other ideas," "A new understanding," "A better example," and "A better design."

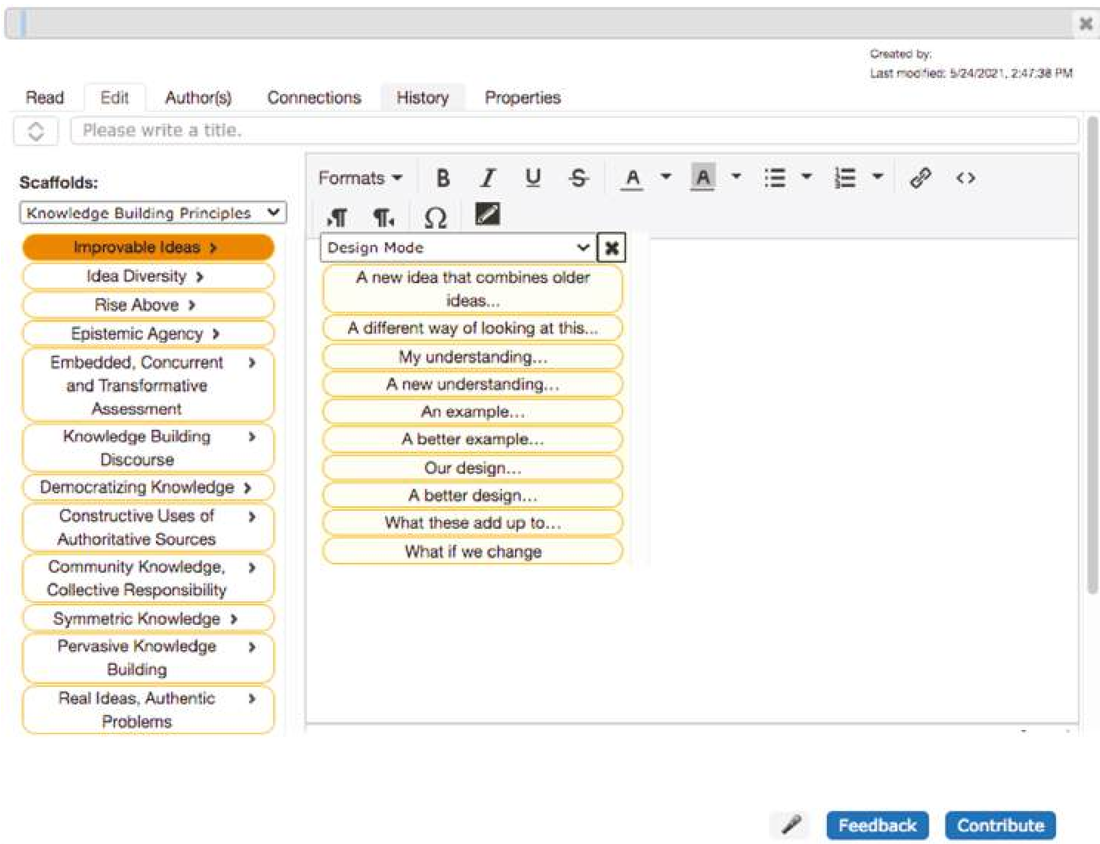

Figure 13. Embedded scaffolds: knowledge building principles scaffold yoked to design mode scaffold.

5.2.2. View Rearrangement

View rearrangement allows users to display only those notes that use specific scaffolds/epistemic markers. As shown in Figure 14, the user selected for display all notes containing "Epistemic Agency"; "Real Ideas, Authentic Problems"; and "Knowledge Building Discourse" scaffolds. The title of each note containing these epistemic markers is displayed and users can click on the note icon to read the full note.

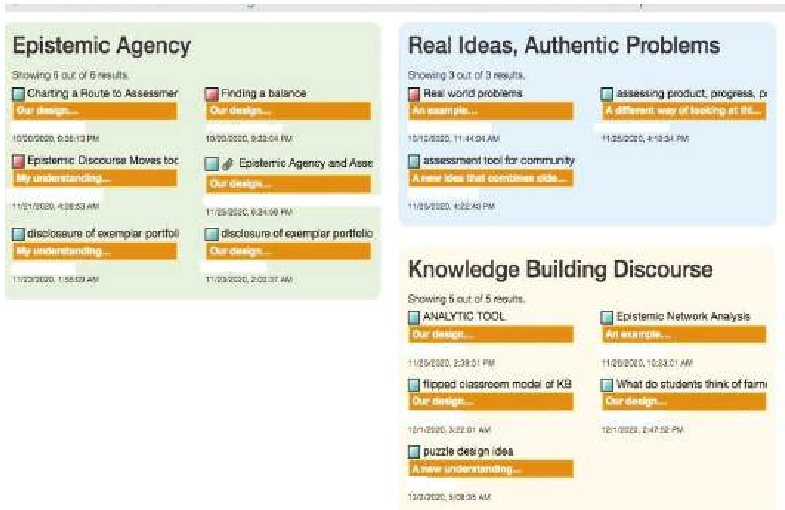

Figure 14. View rearrangement showing the subset of notes that used the "Epistemic Agency"; "Real Ideas, Authentic Problems"; and "Knowledge Building Discourse" scaffolds.

In the second course, students who were in the first course and had prior experience using view rearrangement seemed to use it more intentionally. For example, one student noted, after re-arranging her notes to see use of key concepts

> *"For the next few weeks, I will aim to learn more about knowledge creation, explanatory coherence and edge of chaos. Most of the notes lie in design thinking and beyond the centralized mindset. This could be the evidence that I am engaging in the design mode for the past month. I also consider myself having some sense of thinking fast and slow."*

View rearrangement enables students to focus on contributions with particular scaffolds, reducing cognitive load associated with varied artefacts presented in a view. For example, students can view all notes containing "Putting Our Knowledge Together" or "A Better Design."

6. Discussion and Reflections

Our reflections on the two questions posed at the beginning of this paper are based on student interactions observed during synchronous Zoom sessions, discussions on Knowledge Forum, and student written portfolios.

Bates's [51] "law of equal substitution" is based on the assumption that coursework can be taught just as well online or in face-to-face mode. We examined two courses in which in-person meetings were impossible due to COVID-19 restrictions. As course instructors we explored new ways of advancing community knowledge through student engagement within and outside designated classroom time. We provided many and varied opportunities for students to generate and build on ideas and work with each other. For example, students contributed ideas to Knowledge Forum community spaces so that contributions were available for all class members to read and build on; students shared ideas with the entire class at weekly meeting, both before and after small-team breakout sessions; team members organized sessions anytime they wished and used supportive technology such as chat or WhatsApp, with summaries then recorded in Knowledge Forum; instructors recorded synchronous Zoom sessions and made them available for review and ongoing work in Knowledge Forum; and students used Knowledge Forum analytics to inform their work as it proceeded. Additionally, students received feedback from peers and instructors across these various contexts and discussions were not confined to linear, one person after another sharing of ideas or strict in-person defined periods of time; rather, there was anytime, anywhere access to the community knowledge space and analytics. Shy students and those less inclined to share in groups reported that different formats helped them; students also reported that they met in small groups outside of the allotted class time to formulate ideas and use analytics to assist in refining their work and conveying newly formulated ideas.

Question 1: Do courses that introduce Knowledge Building require an in-person or synchronous component?

Knowledge Building is interactive and dynamic by nature. The weekly Zoom sessions allowed students to work collaboratively in real time. Immediate feedback helped students refine their understanding of Knowledge Building and engage in design thinking and idea improvement. Synchronous sessions helped teams learn about designs of other teams, making it easier to gain an overview of work posted in various design spaces in Knowledge Forum. Almost all students had their cameras turned on during Zoom sessions, providing opportunity to see each other and helping to create a sense of community. Social interactions during synchronous whole-group and small-group Zoom sessions were interleaved with design time during asynchronous Knowledge Forum interactions and provided many opportunities for instructors to interact. Most student groups reported meeting synchronously outside class time, accentuating the need for synchronous time for collaborative design. In the first course, one student posted a note on Knowledge Forum with the title "SHOUT OUT TO EVERYONE!!!!," inviting students to create a WhatsApp group and meet through Zoom to foster more conversation.

> *"If anyone needs some connecting, let's make it happen. We can create a what's app group to check in on each other and meet through zoom if necessary—even just to exchange thoughts and interact in a different, more personal way. I know we're nearing the end of the course but it's never too late! You can find me (...) on What's App and contact me whenever. If not, leave a note in my portfolio and we'll figure it out"*

Question 2: In what ways can we leverage in-class time and Knowledge Forum work to engage students in more advanced knowledge creation?

Synchronous class time enables class-wide discussions, creates a sense of community, and is useful for interchanges across design groups. In future course iterations we plan to provide more time for groups to work together and for breakout groups, combining small-group design teams to facilitate more exchange of ideas.

In an attempt to make a connection across groups, one student noted that their Knowledge Forum interface recommendations connected with ideas of two other groups, one focused on norms of engagement and another on a progress bar to encourage more student engagement. The student noted that integrating all ideas would provide better results.

> *"We want to tie our interface changes to tie it to the group of sense of belonging—by co-creating norms of engagement would allow for ways of impaction through classroom expectations and to change how the student and teacher relationship allow for goals of the community, and authentic problems to be addressed. Having consequential results. To also add it to another group of transformative assessment they put together the tools created to all for more norms of engagement, but students as now the centre as idea creators—to allow for new ways to intersect, and with cutting edge of their fields. We also used the other group's creation of a 'progress bar' to have others try their design idea and other groups attempted to ask how it motivated their ideas."*

In future iterations, we will experiment with different patterns of information flow [19], rotating leadership [37,52], and embedded scaffold/view rearrangement with greater focus on cross-group work (e.g., we will include scaffolds such as "Putting Our Designs Together" or "Your Idea Helps My Design").

Asynchronous work on Knowledge Forum is especially helpful for establishing objects of discourse that represent the interests of all students and that set the stage for knowledge creation. Ideas need a life beyond the mind of the creator and impermanence of conversation. Modern media make it easy to record conversations, but then who will listen to all those recordings? Knowledge Forum brings the following advantages to course work: intentional efforts to enter ideas into the public domain for sustained improvement, priority given to powerful discourse moves, accessibility of promising ideas, self-and group-assessment as work proceeds, and increased chances of engaging others in building on ideas for public good. Of course, the large number of notes students generate can be overwhelming; accordingly, we introduced embedded scaffolds and view rearrangement to make it easier to bring promising ideas into focus. Accessible, recorded ideas also allowed students to showcase and self-assess their work at critical reflection moments such as writing portfolios, aided by analytics to help them see gaps and inform next steps.

7. Limitations

This study describes efforts to engage students in productive knowledge building in two courses delivered fully online. One limitation is sample size, as both courses were relatively small, and both courses were conducted at the same institution. To ensure a more representative distribution of students and more generalizable results, the course design needs to be tested in different contexts with a larger sample size. Additionally, while we describe studies that explored the implementation of Knowledge Building in other graduate courses, the pandemic context is unique. While a great deal of additional research is needed, the work reported provides a starting point for combining synchronous and asynchronous Knowledge Building and for future work to analyze temporal changes and contributions of community members over extended periods of time.

8. Future Direction

Enhancements of Knowledge Forum reported in this paper allow community members to find ideas at points of intersection of different interests and designs within the community. Additional visualizations are under development so that students are better able to view the evolution of thought in the community. For the next iteration of the course, we aim to extend this work across communities. We will experiment with a public layer of the community space through which ideas are accessible to the Knowledge Building International community. Through sophisticated data mining and analytic techniques, we will experiment with a searchable metaspace to view ideas on various knowledge-for-public-good trajectories. Through such work we anticipate deeper engagement with course content and more sustained knowledge work that extends beyond course limits of time and space.

To further sustain Knowledge Building efforts, we are designing an international Knowledge Building program to engage researchers, practitioners, administrators, engineers in collaborative design and innovation. The goal is to bridge the gap between what happens in the classroom with what happens in the world beyond, to better address the complexity of problems in the global society.

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Blending Academic and Professional Learning in a University Course for Future E-learning Specialists: The Perspective of Company Tutors

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Abstract: Blended learning usually refers to the combination of online/offline instructional methods. In this paper, we describe a university course in "E-learning Psychology" designed to blend not only modes of teaching, tools, and media, but also learning contexts; specifically, academic and professional contexts. To achieve an effective blend of learning contexts, students were monitored by academic and company tutors through an instant messaging app (WhatsApp). The unique contribution of the company tutor to the blending of academic and professional contexts is explored. By qualitatively analyzing (i) process data (four WhatsApp log chats) and (ii) self-report data (interviews with six company tutors), we found that the company tutor contributed to both the traditional blended dimension (mixing online and offline) and to the blend of the academic and professional contexts. When company tutors participated in the chat, students moved from an organizational dynamic, featuring chats monitored by only the academic tutor, toward a more collaborative and reflective dynamic. The company tutors considered the opportunity to blend academic and professional contexts as the best aspect of the course for both themselves as educators/company representatives, and for the students. This paper offers insights into the ongoing discussion about what blended is—or should be—and the role of company tutors in blending educational contexts.

Keywords: blended learning; company tutors; instant messaging; university students; group dynamics

1. Introduction

Currently, the term 'blended' in relation to teaching and learning is used with increasing frequency. This trend could be attributed to educators and education systems exploring ways of working post-lockdown, after the imposed introduction of distance learning. Globally, all sectors of education have faced several waves of remote teaching to support educational continuity without face-to-face teaching. We have, therefore, witnessed an unprecedented use of digital technologies as a result of remote learning. But now many are starting to wonder what will remain of this digital experience. Will the platforms that we have begun to know—and perhaps even appreciate—be totally abandoned? Or, having developed digital skills, will teachers and students try to capitalize on them?

Those who favor this second possibility tend to invoke the blended learning approach [1]. Even before the imperative of distance education, blended learning was considered one of the top 10 trends to emerge in the knowledge delivery industry [2]. This occurs for many reasons. For instance, blended learning is considered to support inclusive education [3], sustain student motivation and self-efficacy [4,5], improve student learning [6], and promote innovation [7]. Given the renewed contemporary relevance of Blended Learning (BL), a clear definition is needed. In this paper, we first discuss a few different ways of conceiving BL and subsequently, we articulate our position. Finally, we present an experience where our view of BL has been implemented in a university course with the support of an instant messaging tool, namely WhatsApp.

2. Theoretical Framework

'Blended' means 'mixed', so the concept of BL clearly involves the idea of taking different elements and putting them together to create something new that is greater than the simple sum of its parts. When applied to educational contexts, 'blended' mainly refers to mixing online and offline—face-to-face and digitally mediated teaching and learning. However, simply using elements of both online and offline learning is not necessarily Blended Learning (BL) [8,9]. For example, duplicating the same lesson face-to-face and remotely, either in real time or with the use of recordings, cannot be considered as BL. Rather, true BL is achieved when the online and offline elements integrate and enhance each other. If the educational offer remains unchanged in the two situations, there will be a mere substitution of activities and materials, just available in two different venues [10]. This cannot be called BL and often it generates confusion in students and difficulties for teachers in managing the educational experience.

Graham et al. [11] contend that genuine and effective BL requires a combination of different teaching and learning modes in addition to the mix of online and offline—from explicit teaching to different collaborative learning strategies. Further, a variety of technology is needed to deliver information and curricular content as well as to support different types of interaction.

Therefore, three elements are needed to achieve genuine BL [11]:

a. a combination of online and physical presence. This is the most popular conception of BL [12];
b. a combination of delivery tools or media used to provide information and to support interaction. Based on the increasing number of platforms, software and media available, this element is currently gaining great attention. Importantly, combining digital tools also require teachers and learners to accept various technologies [13];
c. a combination of different methods of instruction and teaching/learning. This is the most difficult aspect to realize because it implies that teachers and course designers should have a robust knowledge of the various educational strategies and that they understand which one is the best according to the affordance of the situation and to the specific learning goals [14]. Pedagogical knowledge is necessary to satisfy this requirement, and instructors do not always have it.

To synthesize the different models of BL we report in Table 1 a synthesis proposed by Galvis [15]:

Table 1. Overview of BL modes.

Dimensions of the Blend, Singh, 2003 [12]	Dimensions of the Blend, Galvis, 2018 [15]
Offline (face-to-face) and *online* (virtual) learning environments	*Spaces* (face-to-face, online, autonomous) and *time* (synchronous, asynchronous) for student-teacher-content *interaction*
Self-paced (learned controlled) *and live*, *collaborative learning* (among many learners)	*Pedagogy* (conventional, inverted) and *locus of control* (teacher, students, group)
Structured (formal) and *unstructured* (informal) learning	*Media* to attain knowledge (expository, active, interactive media)
Custom content (adaptive, flexible) and *off-the-shelf content* (generic)	*Learning experiences* (formal, non-formal, informal)
Learning (before a new job-task), *practice* (using job-tasks or simulation models), and *performance support* (Just-in-time coaching)	*Learning environments* (personal/networked, at work/at home, virtual classroom/physical classroom)

Source: Supporting decision-making processes on blended learning in higher education: Literature and good practices review [15].

BL has become particularly common in Higher Education (HE) [16]. The specificities of BL at this level of education can be classified into four macro-groups of concepts [17]. The first is *Social perspective*, which encompasses reconfiguration of space, time, and responsibility, individualization of education and promotion of educational equality [18]. The second is *Pedagogical perspective*, which proposes different teaching approaches based on several learning theories, included Community of Inquiry, Activity Theory, Project Based

Learning, Constructivism [19]. The third is *Technological perspective,* which focuses on the choice of tools and infrastructures based on specific teaching, learning and management purposes. Finally, *Organizational perspective* deals with the institutional factors supporting the adoption of a BL strategy.

Furthermore, BL in HE is not limited to the formal classroom (face-to-face and virtual classrooms) but also encompasses activities in additional learning spaces. Indeed, one of the affordances provided by digital technologies is the expansion and continuity of space–time in the learning environment [15]. According to Rossett and Frazee [20], BL occurs in formal (e.g., classroom), non-formal (e.g., work, communities of practice) and informal learning environments (e.g., media, websites), building on the strengths of each context. Moreover, Rossett and Frazee [20] highlight the facilitating roles of both humans (e.g., tutors) and digital technologies in education.

How to effectively blend different contexts has, to date, not been adequately interrogated. As such, this paper contributes to expand this scholarship by exploring another dimension of blending; namely, blending not only online and offline modes but different contexts and learning environments [21]. We suggest that effectively blending different contexts is challenging but necessary to support a more comprehensive and nuanced conception of contemporary BL.

A variety of contexts can be blended depending on the desired outcomes. For example, different levels of education can be blended creating a situation where students from, for instance, the final year of primary school collaborate with students from the first year of secondary education. In the present paper, we describe how university courses can blend with workplaces. We argue that blending educational and professional contexts in ways that are meaningful for the course, provides opportunities for students to practice what they have learned. Further, students' professional agency can be empowered by supporting the shift from being 'a student' to being 'a professional' [22,23]. Learning may also gain a playful and informal dimension [24], and learning strategies typical in non-school contexts can be imported into formal learning [25].

We contend that blending contexts enriches learning and that the extra support needed to develop an appropriate course architecture to incorporate this dimension is worth the investment of time. Our proposal is to have this element—mixing of contexts—included in the definition of BL alongside the already accepted element of mixing online and offline modes. To support our proposal, we present research that mixes both online and offline learning as well as contexts by mixing a university context with a professional context.

3. The Research

3.1. The Context of the Research

The educational context in this research is an "E-learning Psychology" course at the University of Bari (Italy). The course is part of a master's degree aimed at preparing experts in human resources. This course has already operated in a blended format (i.e., online and offline) for more than 10 years [26]. The blending with professional contexts emerged progressively throughout the various iterations and has been crucial to the success of the course. The professional context this course blends with the university context is the job market connected to e-learning; this is particularly relevant for the future employment of course participants. As such, e-learning companies are invited to join the course and, over the past decade, have become increasingly involved in the course design, offering suggestions about the syllabus and helping instructors to enhance the practical aspects of the course by sharing their professional expertise. The connection between this course and the e-learning companies has become a flagship for the entire program. Figure 1 provides an overview of the course structure.

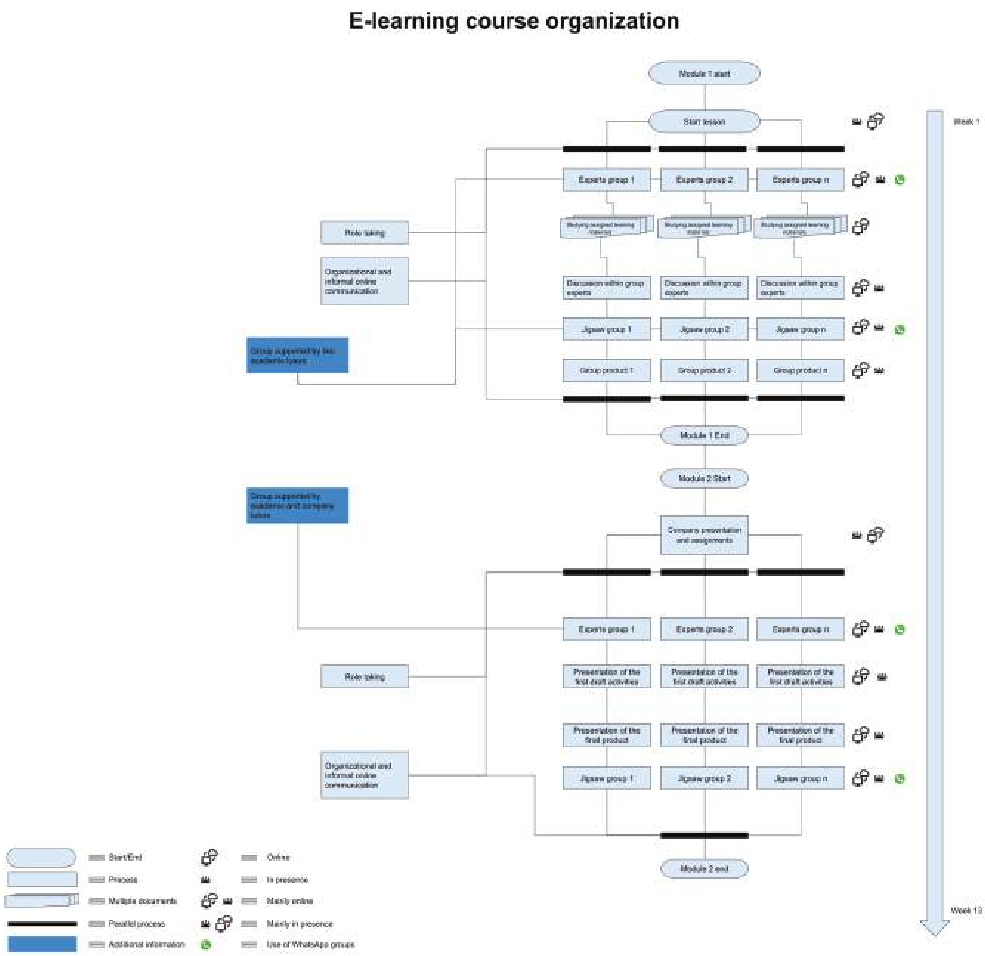

Figure 1. Structure of the course.

The 13-week course is divided into two modules: module 1 (M1) covers the curricular content, while module 2 (M2) focuses on activities designed and performed in collaboration with companies operating in the e-learning market [27]. Students are supervised by two types of tutors: academic tutors and company tutors. The former are volunteer students from previous course iterations who are interested in extending their e-learning expertise. They are purposely trained to guide the students through the course activities and to mediate relationships between students, teachers, and company tutors.

Each company appoints a tutor. This could be the main manager of the company or an employee. In any case, this tutor is only involved in M2. He/she is required to provide a business-oriented perspective and to guide the students in developing the company-based tasks assigned to them.

M1 starts with a face-to-face lecture that ends by negotiating a challenging and motivating research question that guides all subsequent activities. The pedagogical models inspiring this activity are progressive inquiry, collaborative problem solving, and professional knowledge-building [28,29].

Educational materials are assigned to the so-called 'expert' groups. According to the Jigsaw method [30], this type of group allows students to became experts in a particular aspect of the course. In a web-forum, each expert group discusses the educational material assigned. When this phase is concluded, expert groups are dissolved and 'Jigsaw groups' are formed by students who each comes from a different expert group. The Jigsaw groups illustrate their response to the research question (defined at the end of the lecture) by collaboratively designing a conceptual map (e.g., by using Google Drawings).

M2 sees active involvement of the companies. The overall goal is for students to put into practice what they had learned in M1. Companies introduce themselves either in person—when possible—or through videoconferencing, and they invite students to collaborate on a product that will be included into their catalogues (see Table 2 for some examples). M2 has the same structure of M1; however, expert groups now work with a specific company, with the support of both company and academic tutors, while Jigsaw groups compare the different company products and modes of working.

Table 2. Companies and their objects.

E-Learning Company	Objects to Build
Nuvolar	Quick reference guide for the Nuvolar application
Osel	An online course on emotional intelligence
Grifo Multimedia	A Serious Game design
Gruppo Pragma	A course concerning antitrust law
Lattanzio Learning	A MOOC based on existing OERs
Mosaico Learning	A learning object with Articulate

Academic tutors supervise all the groups. They are expected to provide three kinds of monitoring: organizational (e.g., monitoring deadlines), didactic (e.g., supporting reflection on the educational materials and on the connections among concepts in order to finalize the conceptual maps), and technological (e.g., providing suggestions about what technology to use for a specific group's purpose). Company tutors monitor the expert groups in M2.

The interactions between students and tutors are supported by WhatsApp. In M2, each expert group participates in two WhatsApp chats: one monitored by only academic tutors, and the other by both academic and company tutors. We chose WhatsApp because its popularity and widespread adoption did not require students train for its use. Furthermore, some studies have found that WhatsApp greatly contributes to increasing students' learning outcomes [31,32].

3.2. Research Questions

In previous experience, we found that both academic and company tutors acknowledged the advantages of blending university and workplaces practices. Hytönen and colleagues [33] also questioned what kind of instruction academic tutors and tutors from workplaces should give and what type of relationship they should establish with the students. Despite the value of this research, the process through which the company tutors support the blending of the contexts is not yet clear. In particular, in this paper we explore the company tutor perspective, considering how this type of tutor interacts with students and introduces a professional viewpoint, and how these dynamics are received by students. Specifically, the following research questions will be addressed:

(1) What differences are evident in the collaboration process when comparing WhatsApp logs with and without company tutor participation?
(2) How do company tutors describe their contribution to the process of blending academic and professional contexts?

3.3. Corpus of Data and Participants

In selecting our data, we opted for a limited number of chats for two reasons. First, this is an exploratory study and the analytic tools need to be purposely developed. Second, the discursive nature of the data requires a qualitative approach which is time consuming.

The two companies selected—GruppoPragma (G) and Lattanzio (L)—presented the richest chats, compared to the logs produced by the chats involving the other companies. To distinguish the chat-logs with and without the company tutor, the logs with only the academic tutor are marked with 1, and the logs where the company tutor was also present are marked with a 2. There were 13 participants in total: seven students (G = 3; L = 4; F = 5; M = 2; average age 24); four academic tutors (F = 2; M = 2; aged from 25 to 30), and two company tutors (F = 1, M = 1; aged from 30 to 45). Table 3 presents a synopsis of the chats data.

Table 3. Synopsis of the chat data.

	Number of Characters	Number of Posts	Number of Posts by Tutors	Unit of Analysis
G1—only academic tutor	50,606	617	Academic: 257	40
G2—academic tutor + company tutor	32,600	346	Academic: 47 Company: 70	47
L1—only academic tutor	10,073	123	Academic: 35	15
L2—academic tutor + company tutor	82,684	640	Academic: 88 Company: 283	73

To support our interpretation of the chats, we interviewed all company tutors involved in the course. The interviews were conducted using the mirroring technique [34]. In this approach, the interviewer formulates general questions and deepens participant responses by reformulating and recapping the responses. Interviewers were purposely trained in this technique and they were familiarized with the aims of the research. During the interview, the company tutors were asked to talk about: (a) their tutoring experience throughout the course and their tutoring style; (b) which strategies they used to manage the group; (c) how decisions were made within the group they monitored; (d) the reasons their company decided to participate in the course and the benefits they see from this experience; and (e) how they see the interconnection between university and the business world. Table 4 reports the duration and the number of units for each interview. We describe how the units were defined in the paragraph that follows.

Table 4. Synopsis of the interview data.

	Unit of Analysis	Duration
Interview 1—Gr	29	9′25″
Interview 2—L	33	20′26″
Interview 3—G	26	21′07″
Interview 4—M	28	22′29″
Interview 5—O	31	57′07″
Interview 6—N	33	21′34″

In synthesis, our corpus of data comprises:

- Four WhatsApp chats logs produced during M2: two chats with the academic tutor and two where the company tutor was also present;
- Six interviews with company tutors, used to support the interpretation of the group chat dynamics.

3.4. Data Analysis

Log-chats and interviews were analyzed through qualitative content analysis [35]. The first step was to identify the units of analysis, defined as “an idea, argument chain or discussion topic” [35], p. 31 Second, an iterative approach involving several rounds of reading was adopted to code the data. Two different coders worked on a small sample of data (about 25%). Codes developed independently in the first instance were then compared. Divergences were discussed with a third coder until resolved. In each round of analysis, the sample of data analyzed became larger until the whole set of data was coded. Inter-coder reliability for the interviews (Holsti index 89.1%) and the chat-logs (Holsti index 88%) was high enough to provide a good level of reliability. At the end of the analysis cycles, we had a grid of categories—reported in Table 5—which we applied to both the log-chats and the interviews, with just one exception. In analyzing the interviews, we added an extra-category useful to our research aim: the blending of university and professional contexts, which we called blending contexts. This category emerged in the interviews as a result of direct questioning, but it did not appear in the log-chats because the communication was focused on the objects being built.

Table 5. Grid for content analysis.

Macro-Categories	Categories and Description
Decision making	*Goal influence*: References to the goals when a decision has to be made
	Task-structure influence: Reference to task structure when a decision has to be made
Role organization	*Students role*: Reference to students' roles taken as group organization; for instance students may be in charge to find more information or to synthesize the work done
	Relation with academic tutor: Reference to the relation with academic tutor
	Relation with company tutor: Reference to the relation with company tutor
Interdependence	*Conflict:* Conflicts within a group or across groups
	Collaboration: Supportive and collaborative interventions towards other students, might they belong to the same group or not
	Organization: Intervention aims at defining how to organize the work; for instance establishing deadlines
	Strengths/opportunities: Comments about strengths and opportunities of the learning context
	Challenges/weaknesses: Comments about strengths and opportunities of the learning context in general
Blended	*Traditional Blended:* Reference to the relation between online and F2F dimensions
	*Blending contexts *:* Someone refers to the cross-fertilisation between academic and professional knowledge, competences and practices
Psychosocial dynamics	Any other individual or collective process not included into the previous categories

* Used only to analyze the interviews.

We coded each unit of analysis through a no-mutually exclusive approach. This means that a unit is coded with as many categories as are appropriate. The software Atlas.ti was used to retrieve the category's distribution in both chat and interviews: the Occurrence (O)—how often a category appears within the chats. Occurrence results were reported as a percentage. On the interview data, we performed a second level of analysis named co-occurrence (C)—which indicates how often two categories occur together in the same units of analysis. This analysis was used to deepen the understanding of the company tutors' self-reflection and to explore possible relationships among the identified categories. Co-occurrence results are reported through the c-coefficient calculated as follow: $c = n12/(n1 + n2 - n12)$. The c-coefficient indicates the strength of the relation between two categories, similar to a correlation coefficient [36].

4. Results

We first reported the results of the log-chats produced through WhatsApp by collapsing all four chats—with and without the company tutor. Subsequently, we contrasted those chats with both types of tutors, and with those chats managed by only the academic tutor. Finally, we more closely interrogated some interesting aspects that emerged during the interviews.

4.1. Using Instant Messaging Communication

When looking at the whole set of data produced by the chats, we found that the macro-processes with the highest occurrence are: Interdependence (O = 36.3%), Role organization (O = 23%) and Decision making (22.7%), followed by Psychosocial dynamics (O = 11.2%) and Blended (6.9%). Within the Interdependence macro-process, Organization and Collaboration are the two most frequent categories, while Strengths/opportunities and Challenges/weaknesses are slightly less frequent. Concerning Role organization, we found that the category Relation with the academic tutor (O = 14.5%) exceeds both the Relation with the company tutor (O = 5.4%) and the Student role (O = 3.1%), suggesting a centrality of the role of the academic tutor. The Decision making is mainly composed of the Goal influence (O = 13.8%) and, to a lesser extent, of the Task structure influence (O = 8.9%). These results are synthesized in Figure 2.

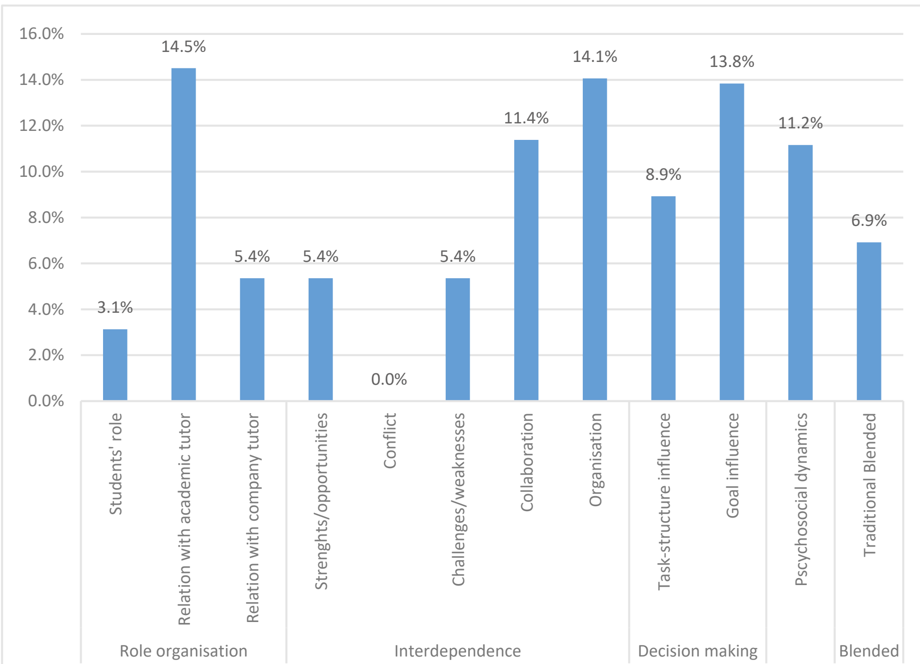

Figure 2. Occurrence analysis all the chats (G1-G2-L1-L2).

In short, academic tutors occupy a relevant role in the chats. This result is probably due to the presence of this type of tutor in all the chats; nevertheless, it is interesting to see the higher frequency of this category (14.5%) compared to the company tutor (5.4%). Further, we notice that the WhatsApp communication is mainly dedicated to organizational issues (14.1%), is structured by the goals (13.8%), and triggers collaborative strategies (11.4%).

To consider the impact on the chats of the company tutor, we now turn to comparing the two types of chats.

4.2. The Company Tutors' Specificity

We now compare the two chats that included only the academic tutors (G1, L1) with the two chats where both academic and company tutors participated (G2, L2). The main difference we found relates to the category Collaboration, included in the macro-category Interdependence. This category is higher in the chats with both tutors (O = 6.7%) and it is lower in the chats with only the academic tutor (O = 4.7%). On the other hand, the category Organization is higher in the chats with only academic tutors (O = 7.6%) and it is lower in the chats with company tutors (O = 6.5%).

Three categories were higher in the chats with both tutors than with only academic tutors: Strengths/opportunities (O = 4.2% vs. O = 1.1%), Challenges/difficulties (O = 3.8%

vs. O = 1.6%) and Student role (O = 2.2% vs. O = 0.9%). Even the Traditional Blended is higher in the chat with both tutors (O = 4.5%) than in chats with only the academic tutor (O = 2.5%). Figure 3 displays these results.

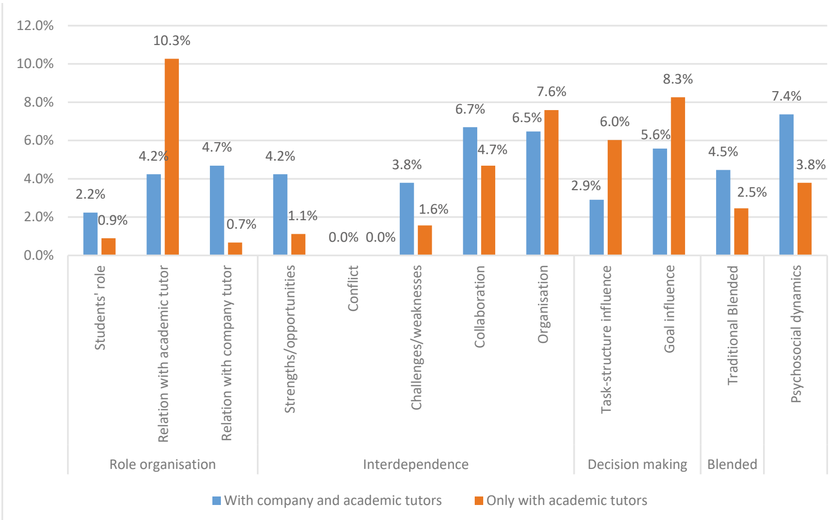

Figure 3. Comparing occurrences in chats with only academic tutors (G1-L1) vs. chats with both academic and company tutors (G2-L2).

The results suggest that the company tutor makes the collaborative dynamics more relevant compared to the organizational dynamics, and emphasizes the student role and the meta-reflection on both strengths and challenges. Moreover, the traditional blending of the offline and online components, to which participants explicitly refer into the chat, is higher in the chat with company tutors. This is well represented in the following excerpt, in which the L2 company tutor is referring to the presentation of the final product of the M2, which usually happens in the physical classroom at the university (see Figure 1).

Excerpt 1. Reference to traditional blended.

Company tutor: *Please let me know how the presentation is going*!
Student 1: *Of course! Tomorrow we will have to start preparing ourselves. It's the 29th. Thanks again.*
Company tutor: *If you share with me a video recording of the presentation on the 29th, I'm even happier ☺ so I can see you at work*!
Student 1: *We'll do it*.

The company tutor asks to video-record the presentation in order to collect more evidence of the students' work. This excerpt shows that even if the participants explicitly refer to "traditional blended" (combination of online/offline; combination of tools and media), they also implicitly move toward a blending of the contexts. In the next paragraph, we will see how this dimension became explicit in the interviews with company tutors.

4.3. Companies Tutor Perspective: The Interviews

For a more nuanced interpretation of the results gathered through the chat analysis, we closely looked at the interviews with the company tutors through the same coding grid, with just the addition of one category, aimed at shedding light on the relevance of blending contexts.

From the analysis of the interviews, the macro-processes have the following occurrences: Role organization (O = 38.8%), Interdependence (O = 26.6%), followed by Blended (O = 17.8%), Decision making (O = 13.7%) and Psychosocial dynamics (O = 3.1%). Within the macro-category Role organization, Relation with the company tutors (O = 17.8%) and Student role (18%) are the most frequent, while the academic tutors are infrequently mentioned by the company tutors (O = 3%). Within the Interdependence macro-category, company tutors focus most on the Strengths and opportunities (O = 14.7%), while Decision making is mainly based on the Task structure (O = 10.9%) (see Figure 4).

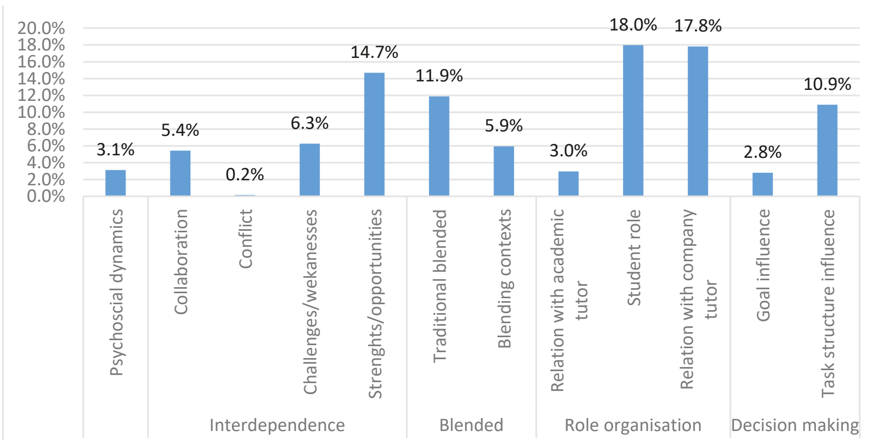

Figure 4. Occurrence analysis of the company tutor interviews.

To explore possible relations among the most mentioned categories, a co-occurrence analysis was run (see Table 6).

Table 6. Co-occurrence emerged from the company tutor interviews.

	BC	COLL	TASK	GOAL	TB	OPP	STUD	COMP_TU	CHAL
BC	0.00								
COLL	0.21	0.00							
TASK	0.07	0.18	0.00						
GOAL	0.06	0.16	0.20	0.00					
TB	0.05	0.11	0.25	0.06	0.00				
OPP	0.36	0.26	0.22	0.10	0.26	0.00			
STUD	0.20	0.19	0.54	0.16	0.37	0.46	0.00		
COMP_TU	0.17	0.17	0.34	0.12	0.29	0.37	0.57	0.00	
CHAL	0.14	0.18	0.27	0.20	0.32	0.20	0.26	0.22	0.00

Legend: BC = Blending contexts; COLL = Collaboration; TASK = Task structure influence; GOAL = goal influence; TB = Traditional Blended; OPP = Strengths and Opportunities; STUD = Student role; COMP_TU = company tutor role; CHAL = Challenges and weaknesses.

The strongest co-occurrence is between Student role and Relation with the company tutor (C = 0.57). Also, Student role and Task-structure influence (C = 0.54) presented a rather strong co-occurrence. Slightly lower is the co-occurrence between Student role and Strength and opportunities (C = 0.46). Interestingly, this latter category also co-occurs with Relation with the company tutor (C = 0.37), and the opportunity for Blending contexts (C = 0.36).

We interpret this group of co-occurrences as demonstrating that the relation between students and company tutors supported effective blending of the learning contexts. The opportunity to blend academic and professional contexts is perceived by company tutors as one of the greatest strengths of the course. The relation between those categories is well represented in the following excerpt:

Excerpt 2. Blending academic and professional contexts.

Company tutor 1: *Involving students in the business process enriches us because, of course, they are aware of all the theoretical and academic innovations and, at the same time, we bring our business experience*.

The traditional blending was reported both as one of the most significant challenges and weaknesses (C = 0.32), but also a strength and opportunity (C = 0.26). Traditional blending also strongly co-occurred with the student role (C = 0.37) and company tutor role (C = 0.29).

Analyzing the interviews, different reasons may explain this co-occurrence. There is a practical reason: the companies' locations were across the whole national territory; therefore, the tutors acted more online than face-to-face. As such, the online components of the tutoring were higher than the presence component. In the academic year 2019-2020, from which these data were collected, the online presence was exacerbated by the pandemic, reducing not only the students' opportunity to meet the company tutors in person, but also to work face-to-face with their peers.

The company tutor interviews disclose what it means for them to blend contexts. Many gave interesting explanations. For instance, one company tutor declared: "I think the key is mutual enrichment". This sentence reflects the concept of mixing contexts as it alludes to an enriching exchange of information between university and the workplace. We came across this concept repeatedly in other interviews. As another company tutor mused: "Let's say that for university students who are approaching the world of work for the first time, certainly also the simple fact of having to deal with the corporate reality ... let's say that the university world remains quite muffled in its own world ... Being in touch with the business realities gives them some food for thought."

Based on these statements, we contend that the main advantage for companies is to be in touch with theoretical innovation and have the opportunity to contribute to new generation training. In exchange, they offer a sort of bridge for students in their trajectory towards the workplace. Academia is perceived as "closed into itself" and they want to "help young people to understand the dynamics of the world of work" tasting "the pleasure of passing on what you know. If you learn something and you keep it to yourself it's not nice. Being able to make another person grow is a privilege."

Company tutors claim their capability to train learners by offering their professional insights and experience. This commitment has a reverse side: "Surely getting to know young talents is a useful and beautiful thing. In the group I met, there were valid girls who in the future may also have an interest in continuing the experience with us"; "There is always the possibility to continue the collaboration with students later, because we are a company that is always growing and, for us, it is useful to know that there are new recruits who are well trained by the university and who have already had an experience with us, who already know a little about how the company works." Companies are scouting for young talent and benefit from the opportunity to spot the most suitable future collaborators.

Some company tutors felt they were not sufficiently prepared to provide full online tutoring; similarly, they recognized that working totally online was a limitation, also for students. However, as can be inferred in the following excerpt, some tutors considered this challenge an opportunity to improve their tutoring strategies in the future.

Excerpt 3. Challenges of working online.

Company tutor 2: *Let's say working remotely is more ... more complicated than face-to-face. So in the future I would structure the contents of online meetings in a different way from a face-to-face mode of lesson ... in any case it was a challenge different from the usual ones and then ... and there is always room for improvements... I would create perhaps a little more interactive contents which allow students to exchange their ideas in the groups*.

5. Conclusions

This paper proposes to introduce a new element into the definition of BL. We contend that the traditional vision of blended (i.e., mixing online and face-to-face, several types of technology and educational methods) should be enriched by also including the mix of learning contexts. To unpack this aspect, we analyzed a situation where a formal education context meets the professional world, under the umbrella of a purposely designed course. Specifically, the perspective of the company tutors was analyzed and how the professional viewpoint they introduced is received by the students.

As a meeting place between university and professional contexts, WhatsApp was introduced and this digital space was monitored by two types of tutors: academic tutors and company tutors. Two kinds of WhatsApp chats were used: one with the exclusive presence of academic tutors and the second one with both tutors present. The reason for having these two types of chats was to offer students the opportunity to fully express their learning needs and challenges. In the first chat, they could discuss issues connected to the whole course with the academic tutor; in the second type of chat, students could focus on the construction of an object proposed by the company. The relevance of having an online tutor is already widely proven to be effective [37–39]. In this research, we follow-up on the suggestion coming from Hytonen [33] to investigate how company tutors can support the contextual blending between formal university education and workplaces.

Through qualitative analysis, chat-logs of four chats and six tutor company interviews were analyzed. The results suggest that groups monitored by both types of tutors produce more collaborative communication that reflects on strengths and opportunities as well as challenges and weakness. Students moved from an organizational dynamic when only academic tutors were present, to a collaborative dynamic that supported student reflection when both types of tutors monitored the chat. With the presence of only company tutors, participants more frequently mention the blending of offline and online components. In some interviews, the company tutors explicitly mention that the "traditional forms of learning" should be revised and they acknowledge they should provide additional support for the blending of the contexts, as they recognize its value. Similar research [40] has already highlighted that the tutor can provide an important scaffold for progressive inquiry reasoning, detected by comparing groups tutored online versus groups not tutored online. The former was found to produce more messages that supported high quality inquiry processes.

In this research, we investigated the structure of the communication more closely and found that the tutor presence allowed a convergence mechanism to emerge, demonstrated by the absence of conflict dynamics across the four chats. This could be explained by the pressures students felt to find consensus before approaching the company tutor [41]. The impression is that they wanted to appear cohesive and talk to tutors with one voice, especially with company tutors who students probably perceived as potential future employers. We suspect that students probably used other spaces to explore and compare different ideas in advance, such as face to face or private online groups. This impression is confirmed by a few interviews. For instance, a company tutor stated: "I think once they reached an agreement, they reported the decision in the chat with the tutors ... well ... I think the group I followed met in another space". Another tutor openly specified that: "The students said they had talked to each other frequently . . . they reported that they conferred with each other in advance and they made decisions prior to entering the chat with me. I did not ask where and whether a tutor was present or not... they haven't specified it ... in any case I felt it was a good thing. Surely I will improve the instruction to give them to perform the task but students are able to find their own form of autonomy; I think this is indispensable ... they have to leave the nest, right? "

This company tutor seems to grasp the logic inspiring students' private discussions prior to entering the chats. She considers this positively, as a sign of students' autonomy, acting as adults ("leave the nest"). Further research investigating these private spaces of peer-interaction as a preparatory step before encountering a company tutor can offer new insights into how students perceived the blending of contexts.

From the company tutor interviews, the central role of the academic tutor identified in the whole corpus of the chat did not emerge. These results are in line with previous studies which found that, even in cases where the guidance succeeded well or moderately well with both company and academic tutors, the two contexts were perceived as separate by both tutors and students [33]. In this sense, we believe the way we orchestrated the course improves tutors' awareness of this type of blending.

Based on our results, we propose to add a further element—namely the *Contextual* perspective, to the four perspectives singled out by Castro [17] —*Social*, *Pedagogical*, *Technological* and *Organizational.* This element, featuring BL in HE, refers to the connection to a different but related context, able to enrich the students' learning experience. Adding this dimension would support even greater expansion of the space–time environment, possible under two conditions: (i) having tutors prepared in monitoring the students; and (ii) using digital tools (such as WhatsApp) that are accessible and easily deployed by all participants [42].

Blending contexts can be a reciprocal positive experience, different from boundary-crossing but also with some similarities. In boundary-crossing, the contexts are often situated entirely in professional work [43], whereas in our case we connected formal education with the workplace. Further, boundary-crossing is an unstructured learning process, whereas we consider the role of tutors crucial for blending contexts. Finally, the ultimate scope of boundary-crossing is to generate innovation [44] while blending contexts retains an educational function and, as already stated, it has to be considered an enriching element of the blended approach.

Finally, as stated by Adam and Nel [45], we agree on the relevance of a finer understanding of preparing and planning a blended course, as well as appreciating the consequences in terms of effects on learning and perception of the learning experience. In this sense, our research highlights that a complex architecture needs to be mastered and continuously monitored. However, while adding a new element makes it more complex, it is also more rewarding.

6. Practical Implications and limitations

Our study offers a few practical implications. First of all, it is clear that to blend contexts it is crucial to have roles such as tutors. The teacher/instructor should dedicate some effort in training the academic tutors and make clear what is required from the company tutors. This may appear as extra work but, if well done, it would help a smooth progression of the activities. Furthermore, students should be aware from the outset of the course that the blended approach requires a wider range of learning approaches. In addition to standard learning from textbooks, students must be ready to learn from discussions and group activities (also online) where they will meet also professionals. Therefore, digital skills are required as pre-requisites. To support students to develop the necessary levels of digital skills, it is advisable to allow time for students to become familiar with the technologies adopted within the course. In our case, we think of Module 1 as a safe warm-up environment for Module 2, before encountering the companies.

A second recommendation concerns choosing which digital technologies will best support the blending of contexts. In line with other research [46], our work has shown that having a tool familiar to the participants helps the blending of different contexts. Options include informal instant messaging tools (e.g., WhatsApp) or more professional based chat tools (e.g., Slack, Microsoft Teams chat, Discord). Moreover, digital technologies can be exploited to collect evidence of the students' learning. This evidence can be used both by the teachers for assessment, as well as by company tutors, who are interested in the opportunity to recruit students.

We also gathered a few recommendations for the academic tutors. Academic tutors should promote a professional mindset by clearly presenting the processes involved in the collaborative activities. They should make clear their appreciation for students' autonomy and initiative. Students may feel in awe of interacting with company representatives, and this could refrain them from taking risks by voicing their views. As such, academic tutors need to encourage students to engage with company representatives by fostering the right confidence and communication skills.

The research we present has many limitations, mostly due to the ecological nature of the research design. In collecting the data, our scope remained largely educational, so our efforts were directed at guaranteeing an optimum learning experience for the students. Therefore, the conclusions of our results remain confined to the specific situation of the course. Nevertheless, we believe our results can offer some insights and contribute to the ongoing discussion about what blended is—or should be—and the role of company tutors in blending contexts.

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education sciences

Communication

Redesigning Mathematical Curriculum for Blended Learning

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Abstract: The Coronavirus pandemic has thrown public schooling into crisis, trying to juggle shifting instructional modes: classrooms, online, home-schooling, student pods, hybrid and blends of these. This poses an urgent need to redesign curriculum using available technology to implement approaches that incorporate the findings of the learning sciences, including the emphasis on collaborative learning, computer mediation, student discourse and embodied feedback. This paper proposes a model of such learning, illustrated using existing dynamic-geometry technology to translate Euclidean geometry study into collaborative learning by student pods. The technology allows teachers and students to interact with the same material in multiple modes, so that blended approaches can be flexibly adapted to students with diverse preferred learning approaches or needs and structured into parallel or successive phases of blended learning. The technology can be used by online students, co-located small groups and school classrooms, with teachers and students having shared access to materials and to student work across interaction modes.

Keywords: dynamic geometry; group practices; CSCL; group cognition; learning pods

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1. Introduction: Student Pods during the Pandemic

Alternatives to the traditional teacher-centric physical classroom suddenly became necessary during the coronavirus pandemic to cover a variety of shifting learning options at all age levels. Although the creation of student "pods" (small groups of students who study together) was popularized as a way of restricting the spread of virus, it was rarely transferred to the organization of online learning as collaborative learning.

Research in the learning sciences has long explored pedagogies and technologies for student-centered and collaborative learning [1]. However, the prevailing practice of schooling has changed little [2]; students, parents, teachers, school districts and countries were poorly prepared for the challenges of the pandemic. Case studies from countries around the world documented the common perceptions by students, teachers and administrators of inadequate infrastructure and pedagogical preparation for online learning [3,4].

An abrupt rush to online modes found that the digital divide that leaders had promised to address for decades still left disadvantaged populations out [5,6]. Income inequality by class and nation correlates strongly with lack of computer and Internet access. In addition to confronting these hardware issues and low levels of computer training, teachers everywhere had access to few applications designed to support student learning in specific disciplines. They had to rely on commercial business software like Zoom and management systems like Blackboard, which incorporated none of the lessons of learning-sciences research.

While school districts planned for "reopening," administrators prepared scenarios for combining in-class, online, home schooling and small student pods. The plans kept shifting and little was done to prepare and support teachers to teach in these various combinations of modalities. Moreover, teachers were rarely guided in redesigning their curriculum for online situations, in which they were often neither trained nor experienced.

Pundits and early surveys were quick to call the attempt to teach online a failure and declare that it simply highlighted how important social interaction was to students. They argued that online media severely reduced student motivation by removing inter-personal interaction [7,8].

However, the field of computer-supported collaborative learning (CSCL) has always emphasized the centrality of social interaction to learning, demonstrating that sociality could be supported online as well as face-to-face [9,10]. Micro-analyses of knowledge building in CSCL contexts detail the centrality of social interaction to effective online collaborative learning and even the students' enjoyment of the online social contact [11]. The source of asocial feelings is the restriction of online education to simply reproducing teacher lectures and repetitive individual drill. It is necessary to explicitly support social contact and interaction among students to replace the subtle student-to-student contact of co-presence. This can be done through collaborative learning, which simultaneously maintains a focus of the interaction on the subject matter.

The pandemic forced teachers to suddenly change their teaching methods and classroom practices, as reported by [12]. The sudden onset of pandemic conditions and school lockdown made it infeasible to introduce new technologies, let alone scale up research prototypes for widespread usage. Nevertheless, the lessons of the pandemic should lead over the longer run to more effective online options, as well as preparation in terms of infrastructure, support, attitude and skills for innovative online educational approaches and applications [13].

In the face of the pandemic, teachers and school districts were largely on their own to adapt commercially established technologies like Zoom and Blackboard to changing local circumstances. One innovative example was an attempt to make teacher presentations in Blackboard more interactive by instituting a hybrid audience of some students in class (to provide feedback to the teacher) and others online [14]. Other researchers stressed the need to go further and introduce an intermediate scale between the individual students and the teacher-led classroom—namely a student-centered small-group or pod learning unit [15]. The following provides an example of how a careful integration of existing technologies (Zoom or Blackboard with GeoGebra) can support pod learning and blend the online with in-class as well as the small group with whole classroom.

This article describes how the Virtual Math Teams (VMT) research project translated the ancient pedagogy of Euclidean geometry into a model of CSCL, and how that was then further redesigned to support blended-learning pedagogy for pandemic conditions (with GeoGebra Classes). This can serve as a prototype for the blended teaching of other subjects in mathematics and other fields. If such a model can succeed during the pandemic, it can herald on-going practical new forms of education for the future. The pandemic experience will change schooling to take increased advantage of online communication and offers an opportunity for CSCL to guide that process in a progressive direction. The approach described here using GeoGebra Classes with VMT curriculum can be implemented immediately, during the pandemic, and then further developed later for post-pandemic blended collaborative learning.

2. Designing for Virtual Math Teams

The VMT research project was conducted at the Math Forum at Drexel University in Philadelphia, USA, from 2004 through 2014. The VMT research has been documented in five volumes analyzing excerpts of actual student interaction from a variety of viewpoints and methodologies [11,16–19].

The project was an extended effort to implement and explore a specific vision of computer-supported collaborative learning (CSCL), applied to the learning of mathematics:

- First, it generated and collected data on small online groups of public-school students collaborating on problem solving.
- Second, it provided computer support, including a shared whiteboard and a dynamic-geometry app.
- Third, it analyzed the group interaction that unfolded in the team discourse.

- Fourth, it elaborated aspects of a theory of "group cognition" [19]. Several papers published during this period and contributing to the broad vision of CSCL have now been reprinted and reflected upon in *Theoretical Investigations: Philosophic Foundations of Group Cognition* [11]. Several chapters in this volume analyze aspects of group cognition based on excerpts of student discourses during VMT sessions.

The VMT project cycled through many iterations of design-based research (design, trial, analysis, redesign), developing an online collaboration environment for small groups of students to learn mathematics together. The eleven chapters of [17] describe the project from different perspectives: the CSCL vision; the history, philosophy, nature and mathematics of geometry; the theory of collaboration; the approach to pedagogy, technology and analysis; the curriculum developed; and the design-based character of the research project. The theory of group cognition provides a framework for pod-based education by describing how knowledge building can take place through small-group interaction, with implications for conceptualizing collaborative learning, designing for it, analyzing group-learning processes/practices and assessing its success. The theory explores the inter-weaving of individual, group and classroom learning.

The VMT software eventually incorporated GeoGebra (https://www.geogebra.org (accessed on 31 March 2021)), an app for dynamic geometry, which is freely available and globally popular (available in over 65 languages). Dynamic geometry is a computer-based version of Euclidean geometry that allows one to construct figures with relationships among the parts and then allows the constructed points to be dragged around to test the dependencies-providing immediate visual feedback [20–22].

As part of the VMT Project, curricular units were designed and tried out in online after-school settings (primarily in the Eastern USA), with teacher training on how to guide the student groups and how to integrate and support the online collaborative learning with teacher presentations, readings, homework and class discussion [23]. The geometry activities provided hands-on experience exploring the basics of dynamic geometry in small-group collaboration. Student peer discussion was encouraged that would promote mathematical discourse and reflection [24]. In this way, the research project translated Euclid's curriculum into the computer age. Euclid's *Elements* [25], which had inspired thinkers for centuries, was reworked in terms of dynamic geometry and a learning-sciences perspective [2].

3. Redesigning for Pandemic Pods with GeoGebra Classes

The VMT platform was no longer available when the pandemic appeared and made the need for supporting online learning particularly urgent. While teachers and students can download GeoGebra without VMT, that would not support full collaboration, where several students can work together on a shared geometric figure. Fortunately, GeoGebra recently released a "Class" function, in which a teacher can invite several students (a pod) to work on their own versions of the same construction, and the teacher can view each student's construction work and discussion in a Class dashboard (Figures 1 and 2). The dashboard provides a form of "learning analytics" [10] support for the teacher, which can also be adapted to facilitate student collaboration.

To take advantage of GeoGebra Classes, VMT's dynamic-geometry curriculum has now been adapted to small pods or even home-schooled individual students using the Classes functionality. The new curriculum is called *Dynamic Geometry Game for Pods* [26]. Using a set of 50 GeoGebra activities that cover much of basic high-school or college geometry, the instructions and the reflection questions were reworked for the new scenario (Figures 3 and 4). The sequencing of tasks was maintained from VMT, which roughly followed Euclid's [25] classic presentation as well as contemporary U.S. Common Core guidelines for geometry courses [27].

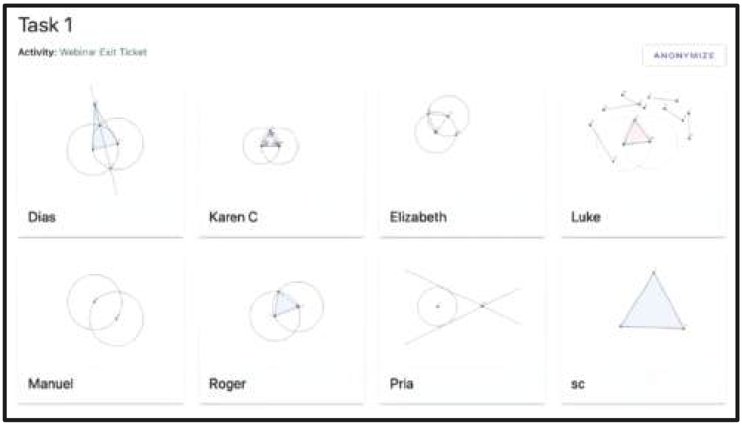

Figure 1. The GeoGebra Class dashboard displays the current state of each student's work on a selected task. In this example, the students are learning Euclid's construction of an equilateral triangle.

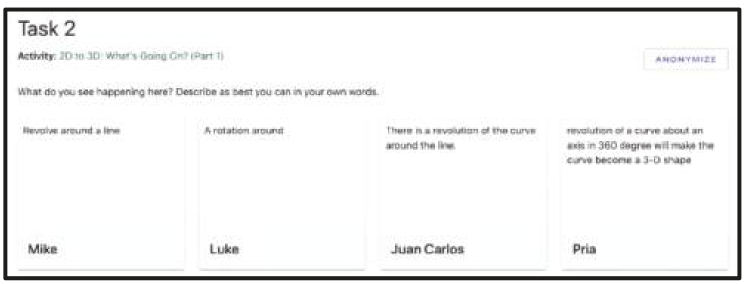

Figure 2. The GeoGebra Class dashboard also displays each student's response to selected questions. In this example the students are discussing rotating a 2-D curve into the 3rd dimension.

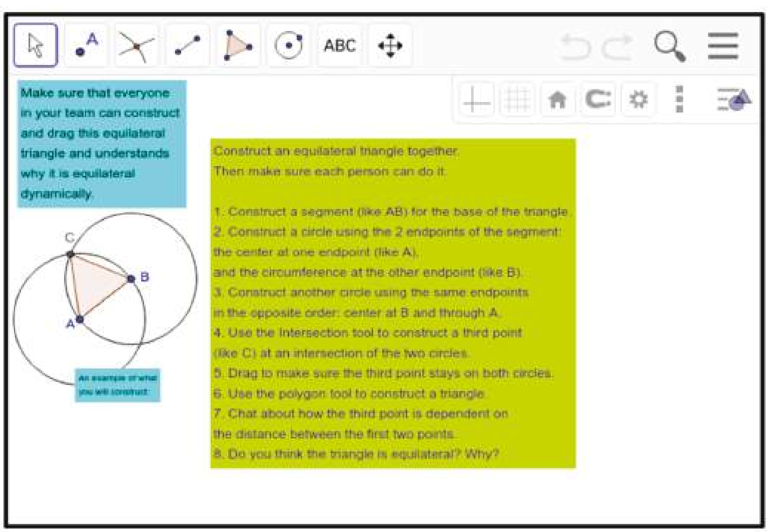

Figure 3. One of 50 tasks for student pods: Euclid's construction of an equilateral triangle.

Questions.

Did you construct your own equilateral triangle?

Did you use the DRAG TEST to make sure it works properly?

The equilateral construction opens up the world of geometry; if you understand how it works deeply, you will understand much about geometry.

In geometry, a circle is defined as the set of points that are all the same distance from the center point. So every radius of a certain circle is the same length.

Drag each point in your triangle and discuss how the position of the third point is dependent on the distance between the first two points.

Is your triangle equilateral (all sides equal and all angles equal)?

Figure 4. A set of reflection questions for members of pods to discuss related to the task in Figure 3.

The revised curriculum is available on the GeoGebra repository site as an interactive GeoGebra book (https://www.geogebra.org/m/vhuepxvq#material/swj6vqbp (accessed on 31 March 2021)). Additionally, a free e-book is available so people can conveniently review the curriculum offline [26]. The book's introductions guide classroom teachers, home-schooling parents, pod tutors or self-guided students to use the curriculum. The format is that of a game with successively challenging levels, which must be conquered consecutively. It is structured as a sequence of five parts, each including about 10 of the hour-long curricular activities, grouped by geometry level and degree of expertise required. The game levels are: (1) beginner, (2) construction, (3) triangles, (4) circles, (5) dependency, (6) compass, (7) congruence, (8) inscribed polygons, (9) transformation, (10) quadrilaterals, (11) advanced geometer, (12) problem solver and (13) expert.

The ideal usage would be by pods of students working online and communicating through the dashboard. A pod coordinator or teacher can provide all participants with access to the real-time dashboard, so that everyone can observe and discuss what everyone else is doing in GeoGebra and typing in the Class interface. Furthermore, GeoGebra can be shared in Zoom, to provide spoken interaction and recording of sessions for student reflection, teacher supervision or researcher analysis.

Note that the Class functionality is not fully collaborative, even when all students have access to the dashboard. Individual students work in their own construction areas (Figure 1), unlike the shared workspace of the VMT software (Figure 3). Additionally, each student answers the reflection questions in their own window (Figure 2), rather than in an interactive chat window as in VMT. However, at least the students can see each other's work and learn from it. Moreover, if GeoGebra is embedded in Zoom, then the students can verbally discuss their approaches together. The limited support for collaboration is a trade-off of using established software for innovative pedagogy.

The goal is that math teachers and others can adapt the use of this curriculum and technology to diverse and rapidly changing teaching conditions and learning modalities. If used with full online access—including the Class dashboard shared by everyone, possibly embedded in Zoom—the collaborative learning experience can approach that envisioned in the VMT research. However, it can also be used in other ways and across various presentation modalities of blended approaches. Student work carried out individually can be shared within a Class pod and then presented in a whole classroom setting, whether virtual or face-to-face.

The usage of GeoGebra in a collaborative online session can provide all students with hands-on experience in geometry construction and investigation (manipulation and reflection). A major advantage of collaborative learning is that students can help each other, pooling their partially developed skills and understanding. However, it is also important for teachers to provide introductions to new ideas and to review in the classroom context the work that students are doing in pods or individually. Furthermore, individual students must make sense of the material for themselves; reading and working individually on problems is important to support collaborative learning. That is why teachers should orchestrate blended learning, incorporating individual, small group and classroom learning in a coordinated, mutually supportive way. Of course, students learn best in diverse ways, so it is productive to offer them alternative educational modalities. Teachers can adapt and mix the modalities in response to local circumstances and learning differences among their students.

4. Findings from VMT Trials

The VMT Project was conceived and executed as extended design-based research (DBR), as detailed in [17]. This involved innovations in technology, pedagogy, assessment and theory. Each aspect of the VMT Project has been reviewed in multiple formats and contexts by international researchers from relevant disciplines.

Findings from the project have been discussed in about 250 publications, including peer-reviewed workshops, conference papers, journal articles, dissertations and books. The project evolved over a decade, prototyping and testing technologies and curricula that underwent multiple iterative revisions each year. The current curriculum for blended learning, *Dynamic Geometry Game for Pods,* is the latest iteration, moving from the VMT software platform to the GeoGebra Class function to support blended learning including collaborative learning in online student pods.

Although a variety of analysis approaches were applied to identify successes and problems during VMT trials, most of the published analyses used a form of conversation analysis adopted from informal conversation to the interaction of online school mathematics. While most of the analyses focused on brief interactions among small groups of students, some included longer sequences, sometimes spanning multiple sessions. For instance, the entire interaction of a group of three middle-school girls—the "Cereal Team"—was followed longitudinally across eight hour-long online sessions and was subjected to detailed micro-analysis of all the discourse and geometry construction [16,17].

As suggested by the title of [17], *Translating Euclid: Designing a Human-Centered Mathematics*, the pedagogy was converted away from expecting students to accept and memorize concepts, theorems and techniques based on authority. Instead, the project promoted a student-centered and inquiry-based approach of exploration, feedback and discourse based on situated and embodied interaction with computer-based artifacts and guided discussion practicing the use of mathematical terminology.

Although the VMT Project was originally intended to investigate and document phenomena of *group cognition* [19], in the end it proposed a methodological focus on *group practices* [16]. The sequencing of challenges in the *Dynamic Geometry Game for Pods* is carefully designed to guide student groups and individuals to adopt group practices and individual skills needed to progress through the process of collaboratively learning dynamic geometry. For instance, procedures for placing lines, dragging points, constructing circles and checking connections among objects are practiced before more complex constructions are proposed, which rely on these skills. The VMT research indicates that such an approach can be effective without being overly directive if a group of students can explore and discuss each technique collaboratively. The *Dynamic Geometry Game for Pods* is based on this body of findings, as well as on the extensive learning-science literature that underlies the VMT project's theory of group cognition, reviewed in [11].

5. Supporting Group Practices in Blended Learning

Teachers, parents and pod organizers can now use the GeoGebra book with its 50 challenges for courses in high-school geometry. Educators in other fields could follow this example and develop analogous curriculum and technology usage. Then, the results of such educational interventions could be collected, shared and analyzed. Analysis techniques honed during the VMT Project [28] could be used along with other methods to investigate collaboration patterns in interaction discourse, the adoption of targeted group practices and advancement of learning goals.

This approach contrasts with the view of learning as primarily a psychological process of changing an individual's mental contents or cerebral representations [29,30]. Rather, individual learning is seen as largely a result of group and social processes or practices in which multiple people, artifacts, technologies and discourses interact to evolve cognitive products at the group level, such as geometric constructions, informal proofs, group reports and textual responses to questions [31]. Such group products require the establishment and maintenance of mutual understandings, intersubjectivity, distributed cognition, communal conceptualizations, common interpretations of problems, collaborative problem solving and shared knowledge. While individuals contribute to these group phenomena, the collective products have a life of their own [32–37].

One way that group cognition can result in individual learning is through the adoption of *group practices*, which then provide models for individual behavior [11] (chp. 16). For instance, a pod of students working on a geometry problem can encounter a concept, theorem or technique that may originate with a pod member, from the problem description or from the history of geometry. The pod discussion may then explicitly discuss what was encountered, come to a shared understanding of how it applies to the pod's current situation and even overtly agree to use it. In subsequent interactions, the pod simply applies the new practice without discussing it again. It becomes a tacit group practice, recognized by everyone in the pod. Pod members may also retain this practice as their own individual mathematical skill when they work outside the pod.

While the theory of group cognition and group practice has been discussed at length in the reports of the VMT Project, it will be interesting to see how these theories are manifested in new situations in which the *Dynamic Geometry Game for Pods* or analogous curricula are enacted. In addition to these quite broad theories, the VMT Project developed characteristics that may be more specific to digital geometry. It will be important to investigate the applicability of these features in new contexts and disciplines.

A central focus of the *Dynamic Geometry Game for Pods* is on the practices involving *dependency* as central to dynamic-geometric constructions. For instance, in constructing an equilateral triangle with radii of equal circles, it is essential that the length of the three sides are dependent upon the equal radii, even when a triangle vertex or a circle center is dragged to a new location. Indeed, the proof that the triangle is equilateral hinges on this dependency—and has for thousands of years since Euclid [25]. Viewing constructions in terms of practices that establish and preserve dependencies (rather than in terms of visual appearance or numeric measurements) is quite difficult for students to learn. One can observe such an insight as it emerges in the discourse of a pod, assuming that the curriculum has been effectively designed to promote such a group practice.

One aspect of curriculum design to support the adoption of specific group practices in dynamic geometry is to sequence tasks and associated practices carefully. This is clear in Euclid's carefully ordered presentation and in the hierarchies of theorems in every area of mathematics.

However, in collaborative learning of geometry, groups must adopt more practices than just the purely mathematical ones. Specifically, the micro-analysis of the eight sessions of the Cereal Team identified about sixty group practices that the group explicitly, observably enacted. These practices successively contributed to various core aspects of the group's abilities: to collaborate online; to drag, construct, and transform dynamic-geometry figures; to use GeoGebra tools; to identify and construct geometric dependencies; and to engage in mathematical discourse about their accomplishments.

Table 1 lists practices explicitly discussed by the Cereal Group and identified in the analysis of their discourse [16]. Each of these practices is illustrated in the commentary on the detailed transcript of the student group's interaction. One can see the group negotiating, adopting and reusing each group practice in the context of their mathematical problem solving and online collaborative learning.

Table 1. Identified practices adopted by the Cereal Group.

Group Collaboration Practices:
1. Discursive turn taking (responding to each other and eliciting responses). 2. Coordinating activity (deciding who should take each step). 3. Constituting a collectivity (e.g., using "we" rather than "I" as agent). 4. Sequentiality (establishing meaning by temporal context). 5. Co-presence (being situated together in a shared world of concerns). 6. Joint attention (focus on the same, shared images, words and actions). 7. Opening and closing topics (changing discourse topics together). 8. Interpersonal temporality (recognizing the same sequence of topics, etc.). 9. Shared understanding (common ground). 10. Repair of understanding problems (explicitly fixing misunderstandings). 11. Indexicality (referencing the same things with their discourse). 12. Use of new terminology (adopting new shared words). 13. Group agency (deciding what to do as a group). 14. Sociality (maintaining friendly relations). 15. Intersubjectivity (sharing perspectives).
Group Dragging Practices:
1. Do not drag lines to visually coincide with existing points, but use the points to construct lines between or through them. 2. Observe visible feedback from the software to guide dragging and construction. 3. Drag points to test if geometric relationships are maintained. 4. Drag geometric objects to observe invariances. 5. Drag geometric objects to vary the figures and see if relationships are always maintained. 6. Some points cannot be dragged or only dragged to a limited extent; they are constrained.
Group Construction Practices:
1. Reproduce a figure by following instruction steps. 2. Draw a figure by dragging objects to appear right. 3. Draw a figure by dragging objects and then measure to check. 4. Draw a figure by dragging objects to align with a standard. 5. Construct equal lengths using radii of circles. 6. Use previous construction practices to solve new problems. 7. Construct an object using existing points to define the object by those points. 8. Discuss geometric relationships as results of the construction process. 9. Check a construction by dragging its points to test if relationships remain invariant.
Group Tool-Usage Practices:
1. Use two points to define a line or segment. 2. Use special GeoGebra tools to construct perpendicular lines. 3. Use custom tools to reproduce constructed figures. 4. Use the drag test to check constructions for invariants resulting from custom tools.
Group Dependency-Related Practices:
1. Drag the vertices of a figure to explore its invariants and their dependencies. 2. Construct an equilateral triangle with two sides having lengths dependent on the length of the base, by using circles to define the dependency. 3. Circles that define dependencies can be hidden from view, but not deleted, and still maintain the dependencies. 4. Construct a point confined to a segment by creating a point on the segment. 5. Construct dependencies by identifying relationships among objects, such as segments that must be the same length. 6. Construct an inscribed triangle using the compass tool to make distances to the three vertices dependent on each other. 7. Use the drag test to check constructions for invariants. 8. Discuss relationships among a figure's objects to identify the need for construction of dependencies. 9. Points in GeoGebra are colored differently if they are free, restricted or dependent. 10. Indications of dependency imply the existence of constructions (such as regular circles or compass circles) that maintain the dependencies, even if the construction objects are hidden.

Table 1. *Cont.*

Group Dependency-Related Practices:
11. Construct a square with two perpendiculars to the base with lengths dependent on the length of the base. 12. Construct an inscribed square using the compass tool to make distances on the four sides dependent on each other. 13. Use the drag test routinely to check constructions for invariants.
Group Practices Using Chat and GeoGebra Actions:
1. Identify a specific figure for analysis. 2. Reference a geometric object by the letters labeling its vertices or defining points. 3. Vary a figure to expand the generality of observations to a range of variations 4. Drag vertices to explore what relationships are invariant when objects are moved, rotated, extended. 5. Drag vertices to explore what objects are dependent upon the positions of other objects. 6. Notice interesting behaviors of mathematical objects 7. Use precise mathematical terminology to describe objects and their behaviors. 8. Discuss observations, conjectures and proposals to clarify and examine them 9. Discuss the design of dependencies needed to construct figures with specific invariants. 10. Use discourse to focus joint attention and to point to visual details.
11. Bridge to past related experiences and situate them in the present context. 12. Wonder, conjecture, propose. Use these to guide exploration. 13. Display geometric relationships by dragging to reveal and communicate complex behaviors. 14. Design a sequence of construction steps that would result in desired dependencies. 15. Drag to test conjectures. 16. Construct a designed figure to test the design of dependencies.

The design of curriculum for collaborative or blended learning can be motivated by the goal of promoting the adoption of specific group practices. The curriculum can, for instance, scaffold collaboration practices like turn taking to get all students in a group involved. Then, it can support discourse practices to help groups make their meanings explicit and shared.

Some of the listed group practices are specific to the collaborative learning of dynamic geometry with GeoGebra. Many are generally supportive of productive collaborative interaction and discourse. Each subject area will have its own central practices to be supported and mastered, as well as the more universal ones. It is instructive to see the special demands of dynamic geometry. In addition to the focus on construction of dependencies and the associated discourse of how different elements of a figure are dependent upon each other, the use of GeoGebra introduces further specific challenges. For instance, it was necessary to design the VMT technology to allow all group members to observe each other's construction sequences in detail as they unfolded in real time in the app, because the animation of those processes could be quite informative [38]. In addition, the immediate feedback afforded by GeoGebra—for instance when someone dragged a point and the whole construction changed, revealing what was and what was not dependent on that point—was crucial for group behavior, discourse and learning.

6. Broadening the Model for Blended Learning

The proposed use of GeoGebra Classes illustrates the adaption of existing technology to an educational innovation explored in research using a prototype that is not available for widespread use during the pandemic. While the GeoGebra Classes functionality does not fully support small groups to share a workspace for exploring geometric construction, it does provide an available platform for student pods working within a teacher-led classroom. Students in a pod can see each other's work in real time and can reflect upon it by answering questions that are integrated into the curriculum. The teacher can also follow all the student work and discourse and display this within a classroom context. Thus, blended learning is supported with online GeoGebra, individual construction and reflection, small-group interaction and classroom presentation and discussion. The latest version of the online VMT curriculum is fully incorporated in a motivational game-challenge format. Optionally, the GeoGebra Class can be embedded in Zoom or Blackboard to support additional online and blended functionality.

The research that lies behind the VMT curriculum resulted in enumeration of group practices that are important to support for collaborative learning in its subject domain of dynamic geometry. Research reports developed the theory of group cognition, which describes how small groups can build knowledge collaboratively, in orchestration with individual learning and classroom instruction. They analyzed in considerable detail the nature of online mathematical discourse and problem solving, including how to support and analyze it.

These features of the VMT experience will need to be reconsidered in the design and analysis of support for blended learning in other subject areas, particularly to the extent that curriculum and technology diverge from dynamic geometry and GeoGebra. Just as the VMT project focused its curriculum on geometric dependencies as central to mastering dynamic geometry, efforts in other disciplines may target concepts that underlie their subjects, much as Roschelle's [39] early CSCL physics support app targeted the understanding of acceleration as core to learning Newtonian mechanics or an algebra curriculum might revolve around the preservation of equalities.

Dynamic geometry is just one area of mathematics covered by GeoGebra. The software supports all of school mathematics from kindergarten through junior college. It is available in most major world languages. Thus, a teacher, parent or student who masters dynamic geometry through the curriculum discussed here can go on to explore other areas of mathematics with this kind of computer support. Learning scientists can develop curriculum units for all ages in all countries following the model illustrated here by the *Dynamic Geometry Game for Pods*.

This is not to say that all instruction should be provided in a CSCL format. Collaboration can be particularly productive for exploring problems that are somewhat beyond the reach of individual students. Additionally, small-group collaborative learning is most effective in sessions that are orchestrated into sequences of individual, group and classroom activities that support each other [40,41]. Blended learning approaches can supplement collaborative learning with complementary instructional modes. For example, a teacher presentation and student readings can precede online peer interaction, which is followed up by classroom discussion and reporting. While teachers struggle to find effective approaches in flipped, hybrid and online classes, there is now a clear opportunity for moving CSCL ideas into widespread practice. Exploration of pod-based learning during the pandemic could lead to important innovations in post-pandemic blended, collaborative and online learning.

It is difficult to convert courses from in-class to online. Typically, much of the effort goes into designing the curriculum and student tasks in advance and instituting new procedures and expectations for the students. A culture of collaboration must be established in the classroom over time. For instance, grading should be redefined in terms of group participation and team accomplishments. It takes several iterations to work things out; in each course, it requires teacher patience while students adjust. Students must be guided to communicate with their collaborators and to let go of competitive instincts.

The model proposed here is not a panacea for the current crisis of schooling, but rather an indication of a potential direction forward, for the remainder of the pandemic and beyond. We need to overcome the digital divide, promote collaborative learning, develop educational technology for exploring many domains, train teachers in online teaching, redesign curriculum to make it flexible for shifting modes of schooling. If we do not do this, then the learning sciences will have missed an opportunity to promote new forms of collaborative, inquiry-based and computer-supported learning. Only by meeting this challenge can we avoid the looming destruction of public education and the resultant serious worsening of social inequity.

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