Lorna Uden
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Learning Technology for Education Challenges

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Preface

Welcome to the proceedings of the 10th International Workshop on Learning Technology for Education Challenges (LTEC 2022) held at the FernUniversität in Hagen, Germany, during July 11–14, 2022. The conference was preceded by a day of free tutorials for participants who wished to learn the state of the art of research relating to the topics of LTEC. Tutorials were held on July 11, with the conference itself commencing on July 12, 2022.

Today the education sector is going through an unprecedented period of change with the sudden shift away from the classroom in many parts of the world because of the COVID-19 pandemic. Due to this change, there has been a distinct rise in online learning. The effect of the pandemic on our teaching and research is far from uniform or wholly negative. No doubt there will be many new insights gained from the use of online learning, although the fundamentals regarding the use of technology for learning remain. The question is, how can we use technologies that push the boundaries of the learning experience, engage students more deeply, and produce learning outcomes that live up to the high expectations of society? In this conference, we wanted to focus not just on the impact of COVID-19 on education but on the pedagogical innovations that help us to advance education research. Such innovations include playful learning, learning through wonder, action learning, making thinking visible, and virtual studios, amongst others.

LTEC 2022 sought to examine how technologies and pedagogical advances can be used to change the way teachers teach and students learn while giving special emphasis to the pedagogically effective ways we can harness these new technologies in education. The aim was to provide a platform for research in the very broad area of educational technology that bridges theory, research, practice, and policy.

The proceedings consist of 20 papers covering various aspects of technologies for learning including:

- Serious games and virtual learning environments
- Learning practices and methodologies
- Learning technologies
- Learning technologies performance

The papers were selected following a X-blind review process, with a minimum of X reviews per paper. The authors of the accepted papers come from many different countries including Austria, China, Colombia, France, Germany, Greece, Indonesia, Italy, Malaysia, Mexico, Slovenia, Spain, Russia, and Taiwan.

We would like to thank our authors, reviewers, and Program Committee for their contributions and the FernUniversität in Hagen, Germany, for hosting the conference. Special thanks to the speakers and participants at the conference. Without their efforts,

there would be no conference or proceedings. Special thanks also to Birgit Feldmann for local support and coordination.

July 2022

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Gamified Learning in Online Teaching Through Platforms: The Use of Quizizz

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Abstract. The present research has the goal of exploring the graduate students' perceptions have when using Quizizz. The reference framework for this research is a compulsory subject, within a master's degree at an online Spanish university. For it, this research analyzes students' perceptions about the usage of Quizizz within the classes of Advanced Cultural Management in the Publishing Field, identifies what topics most graduate students who used Quizizz underlined, and, finally, tests whether the quantitative analysis confirms the results obtained from the qualitative phase. This work uses a mixed methodology where qualitative analysis draws the route map for the quantitative one, identifying the key topics revealed by a sample of 11 students, subsequently used to build a survey launched to 106 students. The research comes to the following conclusions: firstly, Quizizz may hold students' curiosity and attention, enhance virtual classroom participation and motivation and generate enjoyable learning experiences; second, the students showed a high perception of Quizizz as an attractive, and amusing platform; third, the competitiveness appeared as a significant variable that gave impulse to the students' intrinsic motivation, fostered by the desire of being among the first positions on the game leaderboard, and fourth, Quizizz is a valuable tool for reviewing and retaining key concepts and ideas, but not necessarily for improving test scores. Finally, Quizizz has a positive influence over motivation, engagement, and dynamization of the virtual classroom. Finally, the quantitative analysis of this research upholds the qualitative one.

1 Introduction

The last decade has assisted crucial changes in the landscape of higher education, among which we can highlight the use of technology to improve learning at all levels of the education system, including university education. Digital technologies have improved traditional face-to-face training by incorporating hybrid systems - face-to-face and distance -, or by betting firmly on online training (Carroza 2018; Daniels and Thistlethwaite 2016; Deborah et al. 2017; Huggett 2019).

Several academic works showed that technology can improve learning (Castro and Tumibay 2021; Orús et al. 2016; Schmid et al. 2014), while other works questioned this view (Englund et al. 2017; Kirkwood 2009; Kirkwood and Price 2014; Popova et al. 2020). Beyond the pros and cons, it is necessary to underline the task of continuing to

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understand the impact of technological transition and transformation on people (Buckingham 2000; Hockey and James 2017; Ihmeideh and Alkhawaldeh 2017; Livingstone and Blum-Ross 2020).

Many teachers have integrated gamification in their classes, and researchers have begun to analyze the impact of classroom gamification on the students' learning process, given the idea that gamification in the classroom is enjoyable and fun (Mekler et al. 2017). Although gamification in the classroom is not something newly discovered, when merging with technology, it begins to be a potent teaching and learning tool for generations accustomed to using the Internet (Bicen and Kocakoyun 2018). Nowadays, mobile technology in the virtual classroom has opened new chances for teachers to accept digital gamification in teaching (Saleem et al. 2021). Gamification favors: a) the teaching-learning process, by raising the level of commitment of students in the study of the subject; b) solving multiple-choice tests with a more optimistic approach and self-confidence; c) greater predisposition of students to teamwork; and d) an entertaining and motivating educational environment (Magadán and Rivas 2022; Vergara et al. 2019).

The Game-based Student Response Systems (GSRSs) provide friendly and competitive learning experiences which foster an enjoyable classroom ambiance. Digital gamification can aggregate a higher level of motivation, engagement, and incentive in many classrooms (Doumanis et al. 2019). The motivational features implicated in the GSRS cover competitiveness, dare classification tables, achievement emblems, points, and immediate feedback systems, among others, enabling students to participate in educational content joyfully and dynamically (Bottentuit 2020; Hanus and Fox 2015). Educational content embedded in digital gamification seems to make learning more fun and engaging (León and Peña 2021).

Quizizz is an educational web platform that implements the concept of gamification (Pahamzah et al. 2020; Zhao 2019). It is an online evaluation instrument that users can download freely (Amalia 2020). In 2015, two Indian teachers designed the system starting from their experience teaching mathematics. Quizizz is used by more than 10 million of students[1] in over one hundred countries (Andayani et al. 2021; Bottentuit 2020). Quizizz allows to add avatars, memes, music, time limits, and images to engage students to participate in the game, compete, and study to achieve better results when playing (Degirmenci 2021; Rahmawati 2021; Yunus et al. 2019; Zuhriyah and Pratolo 2020).

The process to use Quizizz is as follows: first, enter the web (https://quizizz.com) and click on start (get started); second, create an account with an email, being able to choose between three login options, such as teacher (teacher), student (student) or guardian or parent (parent or guardian); third, complete the information requested for the cover such as title, description, and language; fourth, create the questions and answers, being able to add images and include 1 to 5 answer options; fifth, adjust the time; sixthly, press the finish button once the questionnaire has been completed and, finally, give the PIN code or access code to the students to be able to use it (Bottentuit 2020). The use of online interactive games, such as Quizizz, can be seen as a motivating, creative, and powerful way of shifting from the conventional style of imparting knowledge (Anak et al. 2021).

[1] See About Us - Quizizz.

The main goal of this research is to examine the perceptions that graduate university students have when using Quizizz, in the context of the subject of Advanced Cultural Management in the Publishing Field, within the University Master's Degree in Management and Entrepreneurship of Cultural Projects, in a Spanish university of online education. This research poses the following questions to achieve the general objective of this work:

RQ1: What are the students' perceptions about using Quizizz in Advanced Cultural Management classes in the Publishing Field?

RQ2: What variables identified in the interviews do most graduate students who use Quizizz experience in this context?

RQ3: Does the quantitative analysis validate the results of the qualitative one?

The structure of this study is the following: Sect. 2 focuses on the literature review; Sect. 3 explains the methodology applied; Sect. 4 collects the results obtained and, finally, Sect. 5 highlights the conclusions.

2 Literature Review

Gamification is a learning technique or instrument that brings the game dynamics to the educational context to obtain better academic results from students (Robson et al. 2015). Gamification can enhance students' concentration (Licorish et al. 2018), and raise their motivation for collaborative work more efficiently (Müller et al. 2015). In short, gamification can enhance learning experiences and students' grades (Ismail and Mohammad 2017; Johns 2015). A sector in which gamification is being actively studied, mostly because of its potential to motivate, is education (Dichev and Dicheva 2017; Ofosu-Ampong et al. 2021). Gamification is a learning strategy that, by incorporating game elements, increases the student's commitment to achieving better academic results (Dichev and Dicheva 2017; Robson et al. 2015; Sánchez et al. 2020). The main goals of gamification are: a) to improve abilities, b) to introduce objectives that give a purpose to learning, c) to involve students, d) to optimize learning, e) to support behavior change and socialize, f) intensify the concentration of students and g) improve their motivation for group work (Dewi and Astuti 2021; Dichev and Dicheva 2017; Licorish et al. 2018). Gamification also makes ready both teachers and students to fulfill the globalization demands in education (Anak et al. 2021).

Learning is fun when players face the challenge of problem-solving tasks in a stimulating audiovisual environment. Also, challenge, fantasy, and curiosity become factors influencing intrinsic motivation (Malone 1981; Alawadhi and Abu-Ayyash 2021; Ryan and Deci 2000). GSRSs activate curiosity by means of several resources like audio effects, colors, music, instant feedback, and interactive skills offered by GSRSs (Malone 1981). Students perceive virtual classroom gamification as exciting because games foster a sense of control and empowerment (Malone 1981): the more control students have over their learning, the more intense the concentration and fun. Students tend to become more involved in learning as they earn more points with gamification, reach higher levels in the game, and outperform other competitors individually or as a team (Alawadhi and Abu-Ayyash 2021; Domínguez et al. 2013; Malone and Lepper 1987; Poblaciones et al. 2021).

Interplays with classmates and teachers are crucial to promote the student's cognitive growth, improve comprehension, foster critical thinking, and improve higher-order learning (Alawadhi and Abu-Ayyash 2021; Pahamzah et al. 2020; Poblaciones et al. 2021; Awwal et al. 2015). Students must feel challenged, but such a challenge must be located within the proximal development zone (ZPD) to feel competent to face it (Vygotsky 1978). GSRSs encourage challenged students found in their ZPD, besides facilitating enriching social interaction (Chaiklin 2003).

Academic literature has linked the use of GSRSs in the classroom with positive educational outcomes for students. GSRSs generate a positive motivation of students to learn (Iaremenko 2017), promote active participation (Alawadhi and Abu-Ayyash 2021; Bottentuit 2020; Poblaciones et al. 2021; Wang 2015), foster classroom debates (Mason and Yunus 2021), and enhance learning results (Alawadhi and Abu-Ayyash 2021; Dakka 2015; Poblaciones et al. 2021). Besides, GSRSs improve classroom dynamics (Hung 2017; Yunus et al. 2019), increase instructor-student interaction (Alawadhi and Abu-Ayyash 2021; Méndez and Slisko 2013), reduce distractions (Licorish et al. 2018), and facilitate formative evaluation (Balta et al. 2018; Dewi and Astuti 2021). In summary, GSRS is considered beneficial in increasing engagement, motivation, perception of learning, and classroom dynamics (Fakhruddin and Nurhidayat 2020).

The use of GSRSs transmits a series of benefits to the teaching process (Wentao et al. 2017). These interactive technologies rise students' virtual presence, enhance concentration, promote classroom debates, make classes more amusing, improve classroom interaction, encourage anonymous participation, and provide students with opportunities to reflect (Göksün and Gürsoy 2019; Wang 2015).

Students found Quizizz to be a fun and engaging tool (Zuhriyah and Pratolo 2020) and a useful tool for learning (Dewi and Astuti 2021). Additionally, Quizizz seems to boost students' self-confidence to motivate them and increase their learning abilities (Irwansyah and Izzati 2021; Zuhriyah and Pratolo 2020). The research found that from students' perspective, Quizizz is more efficacious than Kahoot (Göksün and Gürsoy 2019). GSRSs, like Quizizz, also help students improve the development of their competencies (Sahak et al. 2021; Wolff 2016) and their learning experience (Chaiyo and Nokham 2017). Some studies indicate that those teachers who applied Quizizz obtained higher scores from their students in teachers' evaluation performance (Zhao 2019).

Despite generally positive perceptions of GSRS, the academic literature has also encountered some problems (Alawadhi and Abu-Ayyash 2021; Aljaloud et al. 2015; Poblaciones et al. 2021). Nameless participation may increase blind guessing to answer the quizzes, which does not always show the students' level of understanding (Nielsen et al. 2013). The repeated and intense use in the classroom of GSRS may lead to some boredom among students derived from an attrition effect of the classroom dynamics that goes from novel to routine (Wang 2015). Students may view the quizzes and exercises done through Quizizz as boring (Mohamad 2020). Appearing among students with lower scores seems to demotivate rather than motivate, negatively impacting participation (Bottentuit 2020). Finally, another drawback is related to classroom interruptions caused by the intense emotion experienced by students while playing (Mason and Yunus 2021).

3 Methodology

This research uses a mixed, qualitative, and quantitative methodology, and the design used was a sequential one, where the central component is qualitative, and the complementary part is quantitative, that is, a QUAL → quan approach. As seen in Fig. 1, this exploratory sequential design has two phases of data collection (see Fig. 1) (Schoonenboom 2019; Schoonenboom and Johnson 2017).

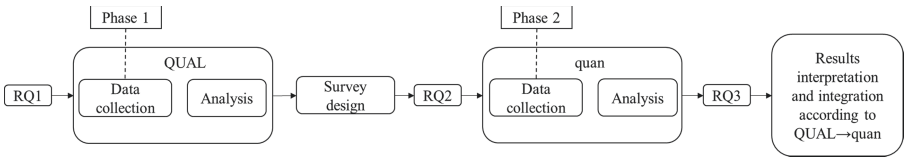

Fig. 1. QUAL → quan exploratory sequential design

The participants were 106 students of Advanced Cultural Management in the Publishing Field in the University Master's Degree in Management and Entrepreneurship of Cultural Projects. The study follows the ethical principles of the Declaration of Helsinki. Before participation, the researchers informed the students about the objectives and ethical guidelines posed in the design and treatment of the data. The selection was carried out through a non-probability sampling for convenience. Table 1 summarizes the participants' sociodemographic data.

The authors of this research designed the Quizizz's multiple-choice questionnaires. The students who attended the virtual classroom received the access code or PIN to begin their game dynamics. These dynamics took place in alternate weeks - a session with Quizizz every two weeks - during an academic semester in two classes, 2019–20 and 2020–21. The activities were designed to be conducted in a time interval between 15 and 20 min. Each questionnaire contained between 20 and 30 closed questions of distinct types: multiple-choice, true/false, or completing part of sentences related to technical concepts, among others (see Image 1). Two weeks before the end of the course, Quizizz was used to reinforce the students' training for the final exam.

A series of semi-structured qualitative interviews were previously conducted with 11 participants, trying to understand their experiences and perceptions about Quizizz. The interview responses were thematically encoded to help analyze the qualitative data findings. Thus, thanks to the feedback from this previous process, the survey could be designed in the quantitative analysis phase. Subsequently, the survey was launched to 106 students.

The qualitative research used personal online interviews and Adobe Connect as the platform for virtual face-to-face encounters with participants. Interviewing implies having a personal dialogue with participants of a qualitative study. Interviewers make questions whose answers afford the required information. Through the process of interviewing several participants, researchers find out emerging themes. Those reoccurring themes formulate the basis for qualitative analysis and draw the route map for the quantitative one. The interview questionnaire was adapted from Alawadhi and Abu-Ayyash

Table 1. Participants' sociodemographic profile

Characteristics	Frequency (n)	Percentage (%)
Age		
21–25	2	1,9
26–30	14	13,2
31–35	28	26,4
36–40	45	42,5
>40	17	16
Gender		
Woman	52	49
Man	54	51
Country of origin		
Spain	51	48,1
Colombia	17	16
Ecuador	38	35,9
Previous training		
Socioeconomic training	62	58,5
Another educational training	44	41,5
Active Professional/Worker		
Yes	91	85,8
No	15	14,2
Previous experience in online training		
Yes	6	5,7
No	100	94,3

Source: own elaboration.

(2021). The researchers piloted the interviews carried out after the completion of the Quizizz during a single day, both in the morning and the afternoon shift.

Qualitative validity means that the researcher checks for the accuracy of the findings by employing certain procedures, while qualitative reliability indicates that the researcher's approach is consistent across different researchers and different projects. This study used the triangulation of researchers and data to guarantee both validity and reliability of the results obtained.

During qualitative data analysis, the researchers reviewed and interpreted the students' comments and significant phrases to, afterward -as said above- encode them. These codes enable to mark and catch anything interesting in the data collected. This procedure provided ten codes that were matched and arranged to give form to potential themes. Then, the leading topics were reviewed and organized into five categories (Table 2), which subsequently shaped the elements for the survey.

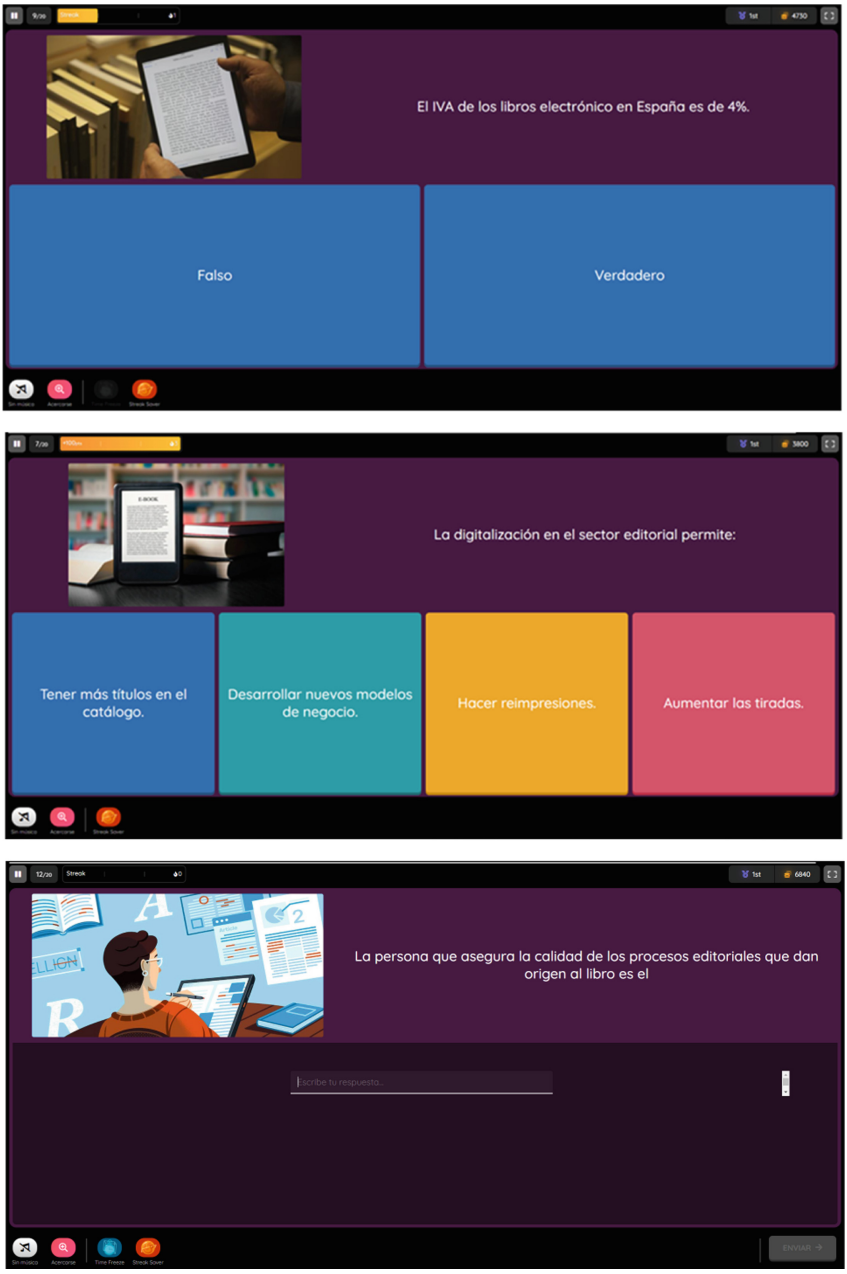

Image 1. Sample of questions made to participants with Quizizz

Table 2. Topics arising from the qualitative analysis of the interviews

Topic	Content area
Fun	Fun and enjoyment
Enjoyment	
Motivation	Motivation and competitiveness
Competitiveness	
Interaction	Interaction and commitment
Commitment	
Attention	Attention and focus
Focus	
Learning	Learning and knowledge assimilation
Knowledge assimilation	

Source: own elaboration.

For addressing the quantitative analysis, this research used the online survey method through the Google Forms tool to detect which variables students experienced to a greater extent. The survey conducted had two parts. The first part was aimed to identify the participant's sociodemographic information (see Table 1). The second part included 16 questions, using a Likert scale whose values had the following meanings: 5, wholly agree; 4, agree; 3, not sure; 2, disagree and 1, totally disagree. The 16 questions, distributed into five categories, are the following: attention and focus (3), interaction and commitment (3), motivation and competence (4), learning and retention of knowledge (3) fun and enjoyment (3). Before launching the survey, a preliminary control with a small group of students outside the sample was carried out. Thanks to this control, spelling errors were detected and corrected, besides reformulating those parts of the survey whose wording was unclear or ambiguous (Gideon 2012). Statistical data analyzes were developed with SPSS 25. The Cronbach's alpha value of the survey was $\alpha = 0.85$, validating the internal consistency of the measurement scale.

Finally, it is crucial to integrate and connect the data obtained by qualitative and quantitative methods to understand the results obtained. Integration is defined as the combination of qualitative and quantitative data within a given stage of the research or within the data analysis itself (Åkerblad et al. 2021). In this study, integration occurred in the design and development phase of the survey (guided by the previous qualitative analysis) and in the results phase.

4 Results

The results obtained in the qualitative and quantitative phases of this research are presented below.

4.1 Qualitative Analysis Results

A series of semi-structured interviews were developed from which various key issues could be identified from the perspective of the students and their perceptions of Quizizz. Such themes were grouped in pairs: attention and focus, interaction and engagement, motivation, and competence, learning and retention of knowledge, and fun and enjoyment.

The results obtained in the interviews conducted with the students are summarized below.

There was a broad consensus among the students in recognizing that the development of weekly sessions using Quizizz had a positive impact on increasing their attention, making it easier for them to remember key concepts and ideas of the subject and helping them to memorize information. Students found Quizizz a useful tool to prepare for final exams (Alawadhi and Abu-Ayyash 2021; Licorish et al. 2018; Vygotsky 1978).

Regarding the sound effects incorporated in Quizizz, most of the students surveyed considered that these sound effects facilitated concentration (Malone 1981; Yunus et al. 2019), while only one student (labeled as student 6) negatively valued the sound effects. sound effects because it distracted him.

The obstacles to an adequate concentration of the students were the schedule and the duration of the session. When adjusting the duration of Quizizz and the time in which the game was played, the evaluation among the students was positive. The students recognized that playing Quizizz was a 'refreshing break'. A student (labeled as student 8) viewed her experience with Quizizz as an opportunity to "recharge" and "refocus" when she felt tired in the last hour of the academic day.

As in previous studies, the qualitative data analysis developed in this research revealed that playing with Quizizz increased the interaction between students and their commitment to the subject (Awedh et al. 2014; Hung 2017; Méndez and Slisko 2013; Wang 2015). All participants stated that Quizizz encouraged participation in the virtual classroom and improved their collaboration skills.

These comments noted above highlight elements of active learning (Alawadhi and Abu-Ayyash 2021; Dakka 2015; Poblaciones et al. 2021): Quizizz encourages discussion and makes the students surveyed perceive that they are an active part and not passive in the teaching process (Alawadhi and Abu-Ayyash 2021; León and Peña 2021).

Another interesting aspect derived from the survey carried out with the students was that related to anonymity. Although a few students negatively perceived anonymity (Nielsen et al. 2013), most thought that allowing nicknames encouraged broader participation in Quizizz, as well as being fun. Anonymity avoided the awkwardness of other classmates recognizing who failed the most on Quizizz (Bottentuit 2020; Licorish et al. 2018).

Students also valued the rivalry and competitiveness they experienced while playing in Quizizz, including leaderboards, time pressure, getting points, suspense music, and ranks, supporting their engagement.

It seems that the students see Quizizz as an excuse to break the ice, encouraging them to interact more with their virtual classroom peers. Participants' comments suggested overall satisfaction in terms of interaction, engagement, and collaboration with peers.

Qualitative data indicated that all students thought that Quizizz fostered friendly competition in the virtual classroom, which enhanced their motivation to acquire subject matter knowledge (Malone 1981; Iaremenko 2017).

Competitiveness in Quizizz seemed to help the surveyed students concentrate and focus better, to the point that most of them prepared days before the game by reviewing ideas and concepts of the subject to obtain better results in Quizizz than the rest of their classmates (Alawadhi and Abu-Ayyash 2021; Grinias 2017; Malone 1981; Poblaciones et al. 2021; Wang and Tahir 2020).

The qualitative analysis developed in this research showed that Quizizz facilitated the improvement in learning. Of the eleven students interviewed, five stated that Quizizz helped them in the learning process of the subject.

The surveyed students indicated that Quizizz was good support to remember key concepts and ideas, identify where their learning difficulties were, and better understand the subject (Alawadhi and Abu-Ayyash 2021; Sahak et al.2021; Wolff 2016). Students found Quizizz to be a useful tool for identifying their mistakes and understanding what the correct answers were.

Quizizz visual elements (images, graphs) and feedback were highly valued by the surveyed students (Dewi and Astuti 2021; Mason and Yunus 2021).

Many students perceived the impact on their performance as a distinguishing benefit of Quizizz. They noted that playing with Quizizz helped them prepare for the exams and, consequently, their study was more focused (Balta et al. 2018; Mason and Yunus 2021). Interestingly, only one student did not perceive that Quizizz helped him improve the results of his final exams, which is consistent with the work of (Vergara et al. 2019).

Finally, some students expressed that the classes were interesting using Quizizz, while others described the virtual classroom sessions as fun and exciting (Bottentuit 2020; Licorish et al. 2018; Yunus et al. 2019).

4.2 Quantitative Analysis Results

Table 3 shows the distribution of responses obtained by the survey, according to the topics and questions raised.

Questions 1 to 3 focus on engagement and interaction (see Table 3). More than half of the respondents perceived that Quizizz brought interaction (60.4%) and engagement (52.8%) among classmates while playing. These results show that Quizizz is a useful means to improve participation and debate in the virtual classroom (Wang 2015).

Questions 4 to 6 focus on attention and concentration (see Table 3). Most of the surveyed students seemed to improve their attention (59.4%) and concentration (55.7%) thanks to Quizizz (Alawadhi and Abu-Ayyash 2021; Yunus et al. 2019).

Questions 7 to 10 focus on motivation, competitiveness, and anonymity (see Table 3). The surveyed students recognize that playing with Quizizz makes them very motivated and that it was fun to compete against other classmates (62.3%). Other students (12.3%) did not perceive that competitiveness motivated them, which shows that the motivating factor of competition is not relevant for all students (Ryan and Deci 2000). Regarding anonymity, only 30.1% of respondents strongly agreed that using nicknames makes it easier to participate in Quizizz, while around 24.5% did not mind being anonymous. Perhaps this result has to do with the interest of the students surveyed in seeing themselves

Table 3. Survey and distribution of the responses obtained according to the Likert scale.

n = 106	Strongly agree (5)	Agree (4)	Not sure (3)	Disagree (2)	Strongly disagree (1)
Interaction and commitment					
1. I don't feel like interacting with the material when using Quizizz	51 (48.1%)	5 (4.7%)	10 (9.4%)	8 (7.6%)	32 (30.2%)
2. I feel that Quizizz makes the virtual session more dynamic and interactive	64 (60.4%)	12 (11.3%)	4 (3.8%)	7 (6.6%)	19 (17.9%)
3. I was engaged and enthusiastic while playing with Quizizz	56 (52.8%)	15 (14.2%)	10 (9.4%)	7 (6.6%)	18 (17.0%)
Attention and focus					
4. I focus more while playing Quizizz to get a good ranking	63 (59.4%)	18 (17.0%)	8 (7.6%)	5 (4.7%)	12 (11.3%)
5. Quizizz helps me focus	59 (55.7%)	17 (16.0%)	10 (9.4%)	7 (6.6%)	13 (12.3%)
6. I get distracted while playing Quizizz	46 (43.3%)	13 (12.3%)	14 (13.2%)	11 (10.4%)	22 (20.8%)
Motivation and competitiveness					
7. Being able to use a nickname motivates me to play Quizizz	32 (30.1%)	13 (12.3%)	26 (24.5%)	11 (10.4%)	24 (22.7%)
8. It is important for me to play well with Quizizz to get good results	58 (54.7%)	16 (15.1%)	19 (18.0%)	4 (3.8%)	9 (8.4%)
9. I try to win by playing Quizizz	52 (49.0%)	12 (11.3%)	13 (12.3%)	11 (10.4%)	18 (17.0%)

(*continued*)

Table 3. (*continued*)

n = 106	Strongly agree (5)	Agree (4)	Not sure (3)	Disagree (2)	Strongly disagree (1)
10. It is very fun to compete with other classmates in the virtual classroom	66 (62.3%)	9 (8.4%)	14 (13.2%)	4 (3.8%)	13 (12.3%)
Learning and assimilation of knowledge					
11. Playing with Quizizz helped me better understand the key concepts and ideas of the subject	71 (67.0%)	11 (10.4%)	10 (9.4%)	6 (5.6%)	8 (7.6%)
12. I often share with my colleagues my arguments to find the correct answers on Quizizz	32 (30.2%)	17 (16.0%)	30 (28.3%)	14 (13.2%)	13 (12.3%)
13. I think that Quizizz does not favor a better learning experience	55 (52.0%)	12 (11.3%)	9 (8.4%)	11 (10.4%)	19 (17.9%)
Fun and enjoyment					
14. Quizizz is fun to play with	69 (65.1%)	12 (11.3%)	11 (10.4%)	4 (3.8%)	10 (9.4%)
15. Quizizz is boring to play with	53 (50.0%)	14 (13.2%)	11 (10.4%)	9 (8.4%)	19 (18.0%)
16. It gives me satisfaction to see my name in the ranking of the best players on Quizizz	70 (66.2%)	9 (8.4%)	11 (10.4%)	6 (5.6%)	10 (9.4%)

Source: own elaboration

at the top of a ranking (Alawadhi and Abu-Ayyash 2021; Domínguez et al. 2013; Malone and Lepper 1987). Winning and reaching the top of the leaderboard emerged strongly in the responses from the respondents (49.0%), indicating that students work hard to win on Quizizz (Grinias 2017; Iaremenko 2017).

Questions 11 to 13 focus on perceived learning and the value of Quizizz to support the understanding of the subject (see Table 3). Students (66.2%) found that playing Quizizz helped them better understand the key concepts and ideas of the topic (Wolff 2016). Students believe that Quizizz can positively influence the assimilation of ideas and concepts (Balta et al. 2018; Dakka 2015; Dervan 2014). However, the answers to questions 12 and 13 seem to indicate that Quizizz can support learning to a certain extent, but not have a significant impact on improving their academic performance (Alawadhi and Abu-Ayyash 2021; Méndez and Slisko 2013; Poblaciones et al. 2021).

Questions 14 to 16 focus on the enjoyment and fun experienced by the students surveyed (see Table 3). Most of the students said that it was fun to participate in the Quizizz sessions. Significantly, question 16 received the second-highest percentage (66.2%): surveyed students reported having fun and enjoying Quizizz, especially when they appeared at the top of the ranking (Ismail et al. 2019; Ryan and Deci 2000; Wang 2015).

4.3 Mixed Method Results

The combined analysis of the results obtained in the qualitative and quantitative stages shows that university students positively accept the use of Quizizz in the virtual classroom (Bottentuit 2020; Licorish et al. 2018). The qualitative stage underlines Quizizz's ability to capture students' attention and enhance their concentration. These results have been confirmed by the quantitative stage (see Table 3).

The results obtained in the qualitative stage showed that most of the students surveyed considered Quizizz an interesting, exciting, and fun instrument, which makes the virtual classroom more pleasant (Alawadhi and Abu-Ayyash 2021; Poblaciones et al. 2021). The results obtained in the quantitative stage validate those obtained in the qualitative stage. Regarding the students' need for success and their desire to win, the quantitative analysis shows that not all students tried to win (see Table 3).

The results obtained in the qualitative stage also showed that Quizizz seemed to promote interactions between students within the virtual classroom (Alawadhi and Abu-Ayyash 2021; León and Peña 2021), which is in line with the results obtained in the quantitative stage: the students surveyed recognized that Quizizz increased participation in the classroom (see Table 3).

Finally, in both the qualitative and quantitative results, not many surveyed students perceive that Quizizz helped them improve their exam results (Dakka 2015; Méndez and Slisko 2013).

5 Conclusions

The main goal of this research was to analyze the perceptions that graduate university students have when using Quizizz, in the context of Advanced Cultural Management in the Editorial Field within the master's degree in Management and Entrepreneurship of

Cultural Projects of a Spanish online university. In order to achieve the general objective, this work poses the following research questions: a) what are the graduate students' perceptions about the use of Quizizz in the classes of Advanced Cultural Management in the Publishing Field?; b) what variables identified in the interviews do most graduate students who use Quizizz experience in this context?, and c) do the results from the quantitative phase validate the results from qualitative interviews?

A series of semi-structured qualitative interviews were conducted with 11 participants, trying to understand their experiences and perceptions about Quizizz. The interview responses were thematically encoded to help analyze the qualitative data findings. Thus, thanks to the feedback from this previous process, the survey could be designed in the quantitative analysis phase. Subsequently, the survey was launched to 135 students.

The quantitative results obtained in this research validated the qualitative results, providing greater clarity and understanding of all the variables considered in the analysis and valued by the postgraduate students who used Quizizz in the virtual classroom.

First, the results of this study indicate that Quizizz can catch students' attention, enhance participation in the virtual classroom, raise motivation and foster an enjoyable learning experience. Second, the students surveyed showed a high perception of Quizizz as an engaging, entertaining, and enjoyable platform. Thirdly, competitiveness appeared as a significant variable that contributed to the students' intrinsic motivation, promoted by the desire to be among the first places in the game classification. Fourth, it seems that Quizizz was not the best tool to improve students' perceived academic performance. Quizizz is a valuable tool for reviewing and retaining key concepts and ideas from the topic this study was conducted on, but not necessarily for improving test scores. In short, this research concludes that the students' perceptions of the use of Quizizz in the virtual classroom are positive. Quizizz has a positive impact on motivation, engagement, and dynamism in the classroom. Finally, the quantitative analysis confirms the qualitative.

Although this work has significant contributions, the results are subject to the limitations of an exploratory study. In this sense, it would be interesting to expand the number of samples and compare the results obtained, both qualitatively and quantitatively, in various subjects of the selected graduate degree.

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Digital Workbook in Virtual Learning Environment

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Abstract. This research aims at examining the extent students understand and use information in virtual learning environment in STKIP Singkawang. This research used descriptive qualitative approach and 88 students as the subjects of main informants. The data were collected through questionnaire and interview. The research results show that among the students using the learning management system, 71.2% were of agree category and 25.75% were of greatly agree category, while the remaining 3.03% were of disagree category in the Internet search dimension. For the hypertext guide dimension, 76.4% were of agree category and 17.4% were of greatly agree category, while the remaining 5.25% were of disagree category. For the information content evaluation dimension, 73.5% were of agree category and 21.7% were of greatly agree category, while the remaining 4.8% were of disagree category. Lastly, for the knowledge preparation, 76.15% were of agree category, 19.30% were of greatly agree category, while the remaining 4.55% were of disagree category.

Keywords: Digital workbook of STKIP Singkawang · Virtual learning environment · Learning Management System

1 Introduction

The civilization in the educational world keeps developing. Recently, the influence of development of knowledge and technology had been the main trigger, but recently the world is shaken by the covid-19 pandemic, requiring almost all social structures to change. All activities involving many people meeting change to virtual meeting, including education institutions. At elementary school and tertiary levels, the government is urged to have learning process virtually. Online learning certainly requires every student to have the ability and understanding of how to access material or assignment online correct, commonly known as digital literacy.

Paul Gilster defines digital literacy as individual's capability of absorbing and using information from various sources accessed from computer in his book Digital Literacy (1997). Bawden (2001) proposes new knowledge of digital literacy that is also based on computer and information literacy. Computer literacy appeared in 1980s when microcomputer became used far more commonly in the business world and daily life. However,

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information literacy was widely spread only in 1990s, when the network information technology made it easier to make, take and distribute data. Consequently, according to Bawden, digital literacy was more closely related to technical skill in accessing, arranging, understanding and distributing information. Based on the experts' opinions, we may conclude that digital literacy means an individual's capability and skill in accessing and using various kinds of information obtained from digital devices and the Internet. With the development of digital learning that will grow exponentially in the years to come, education institutions rapidly renew their programs to adapt to students' needs that keep increasing in the digital era (Dayag 2018; Eldridge 2018; Vo et al. 2017; Webb 2020). Digital learning process moves towards this standard with faster speed. They create online platforms where students can build constructive relationship with their lecturers and colleagues.

The main impact of the COVID-19 pandemic has led to changes in the techniques and methods in learning and environmental process. Can a method create fun strategy in learning process by performing virtual simulation into learning process? Using this method may motivate students to learn and be involved in better learning process (Ibanez 2014). Moreover, Supriadi (2016) states that as the form of e-learning concept development, the concept of learning with system has also started to be developed; virtual learning using software Learning Management System (LMS). Various learning technologies have been developed during the COVID-19 pandemic; technology acceptance method is used to learn the effect of student involvement in learning and use of Learning Management System (LMS), a very promising instrument to determine student's intention to use computer technology (Venkatesh and Davis 1996). Some researchers (Al-Maatouk et al. 2020; Busuk 2019; Islam 2013) find that understanding student's LMS plan is easy to use, useful, fun and behavioral. Liaw and Huang (2014) and Al-Rahmi et al. (2020) show that student's subjective satisfaction substantially influences their intention of innovation, such as the LMS system.

The specialization of learning through virtual learning environment of digital workbook studied in this research is, fist, to use digital based learning, allowing course materials to be accessed by students any time, and students can re-access the materials on website as necessary. Second, both student and lecturer can participate in course outdoor, in case of phenomena requiring face-to-face study, such as in case of natural disaster, sickness, etc. Third, the digital workbook designed in LMS STKIP Singkawang contains chat column or room that facilitates discussion in virtual class. Lastly, lecturer can monitor student presence and activities online. These considerations are the basis for the researcher to examine student's understanding level related to digital workbook and to express the LMS system into a scientific work. To understand materials during learning process in virtual learning environment, an individual must have competent ability of digital literacy. The theoretical basis supporting this research is based on the conceptualization of virtual learning environment and its function in education by the writers including Dudeney and Hockly (2007), Green et al. (2008), Walker and White (2013), and Ayres (2002). This also includes review from various papers of research on this topic.

2 Method

2.1 Research Approach and Strategy

This research aimed at examining the extent students understand and use information in virtual learning environment in STKIP Singkawang. This research used descriptive qualitative approach, with 88 students as the main informants. The data were collected through questionnaire and interview. According to Sugiyono (2018, 2019), questionnaire is a data collection technique performed by giving a set of written questions or statements to respondents to respond to the interview. The research's questionnaire used Likert scale, that assessed the attitudes or behaviors desired by the researchers by asking some questions to the respondents. The respondents were then asked to give their answers or responses in the measurement scale (Darmadi 2011). Interview means a meeting of two people to exchange information and ideas through questions and answers, thus a meaning can be built on a certain topic (Sugiyono 2018, p. 114). Through- out the analytical procedure, we performed a number of strategies to ensure the quality and avoid bias of confirmation (Flyvbjerg 2006); first, we analyzed each case independently. Besides, the cases were compared with other writer with almost the same research question. The research team members Truijens et al. (2019), and Van Nieuwenhove et al. (2019) systematically cross-check the theme in comparison, allowing them to balance priority and interpretation of theme (Creswell and Miller 2000).

2.2 Research Objective

This research aimed at examining the extent students understand and use information in virtual learning environment in STKIP Singkawang.

3 Result and Discussion

Below is an example of the display of Digital Workbook in LMS STKIP Singkawang (Fig. 1).

Based on the figure above, there are some menus available in lecturer account. Number 1, questionnaire, this menu is used to monitor the extent of a lecturer's basic competence level based on student's scoring, that is evaluated every semester. Number 2, this menu is used to record lecturer's activities in work hours the whole day, or, in other words, this menu is the daily journal of lecturer in STKIP Singkawang. Number 3, presence, this point records automatically lecturer's time of arrival at the campus offline that is directly integrated with finger print. Number 4, course activity, in this menu, lecturer can upload course material, monitor student's presence through recording scoring list at the end of semester. For more detail, note the display of course activity in the figure below (Fig. 2).

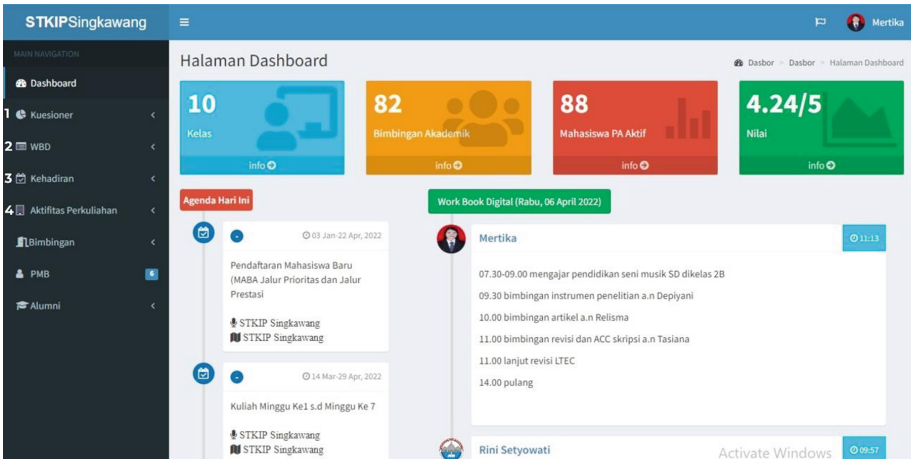

Fig. 1. Web display of lecturer account

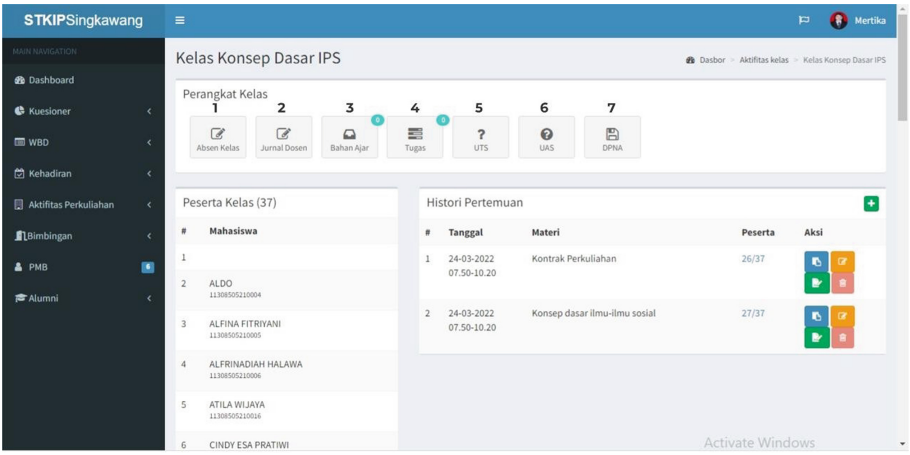

Fig. 2. Display of course activity menu of lecturer account

Course activity menu is the main menu related to course class instrument. This part consists of class attendance list, lecturer journal, teaching material, assignment, mid-term exam, final exam, and final score list. The web also regulates deadline for filling in attendance list online, submission of assignment and filling of Study Plan Card as the effort to train students to keep their discipline and responsibility under control even if it is performed online.

The research was carried out in STKIP Singkawang, with respondents consisting of 88 students of semester 5 taking online learning class in semester 2021/2022.

Table 1. Digital literacy in virtual learning environment (Paul Gilster 1997: 18)

Dimension	Indicator	Greatly agree	Agree	Disagree	Greatly disagree
Internet search	Ability to use internet and wbd	25.37%	70.10%	4.53%	0%
	Ability to use internet and wbd	26.13%	72.37%	1.53%	0%
Hypertext direction	Knowledge of difference between text and Internet	17.05%	72.75%	9%	1.10%
	Knowledge of hypertext in work browser		14.80% 79.50% 4.50%		1.20%
	Knowledge of how Internet and web work	20.45%	77%	2.25%	0%
Evaluation Of Information Satisfaction	Ability to distinguish display and content		22.70% 70.50%	6.80%	0%
	Ability to understand content of information (absence or assignment) from Internet and wbd		24.27% 73.90%	1.90%	0%
	Ability to understand the steps in opening WBD		18.20% 76.10% 5.7 0%		0%
Compilation Knowledge	Ability to collect knowledge from information from Internet and wbd		19.30% 77.30%	3.40%	0%
	Ability to read and understand information from Internet and wbd	19.30%	75%	5.70%	0%

The digital literacy dimension used is searched for in the Internet. Based on the result of questionnaire on the indicators of the ability to use Internet and WBD, it is found that the students used learning management system for 70.10% of agree category and 25. 37% of greatly agree category, while the remaining 4.53% of disagree category. The results of questionnaire on the indicators of ability to use the Internet and Digital Work- book were that 72.37% students responded by agreeing with the habit of searching for course material by applying LMS called Digital Workbook, and 26.13% of greatly agree category, while the remaining 1.53% of disagree by using the Digital Workbook developed.

The second dimension for Digital Literacy is knowledge of difference between textbook and the Internet. The indicator shows whether students prefer searching for information from wbd to searching for information from textbook since it is easier and faster for the result, 72.75% responded with agree and 17.05% responded with greatly agree. For knowledge of hypertext in Work browser, 79.50% responded with greatly agree 14.80% and disagree 4.5, greatly disagree 1.2%. For the indicator of knowledge of internetwork and Digital Workbook, 20.45% responded with greatly agree, 79.5% responded with agree.

The third dimension for digital literacy was evaluation of information content. For the sub-indicator of ability to distinguish display from content, 70.5% agree, 22.7% greatly agree, and 6.8 disagree. The ability to understand content of information from Internet or WBD 73.9% agree 24.27% greatly agree, and 1.9 disagree. For understand the steps in accessing Digital Workbook, the results are 76.1% agree, 18.2% greatly agree, and 5.7% disagree.

The dimension for digital literacy is the dimension of compilation of knowledge, sub-indicator. For the ability to set knowledge from information obtained from the Internet and WBD, the results are 77.3% agree, 19.3% disagree, and 3.4 disagree. For the ability to read and understand information from the Internet and Digital Workbook, the results are 75% agree, 19.3 greatly agree, and 5.7% disagree.

From the interview with some lecturers, the information reveals that the lecturers have applied digital literacy. The learning process has changed. The Digital Literacy developed uses Learning Management System, using Digital Workbook developed by STKIP Singkawang as the media to deliver message to students. From interview with some students, it is found that Learning Management System based learning may enrich learning source between lecturer and student. It is concluded that learning based on Learning Management System may help them understand the materials compared to only using textbook. The indicator of whether the students prefer searching for information from LMS also finds that the students understand information and materials based on Learning management system more easily than those based on textbook since they are easier and faster result, with 72.75% agree and 17.05% greatly agree. In line with previous research by Li Shuping et al. (2019), Learning Management System based learning will enrich student's knowledge. With the development of digital learning that will grow exponentially in the years to come, education institutions quickly renew their programs to adapt to student's needs that keep increasing in the digital era (Dayag 2018; Eldridge 2018; Vo et al. 2017; Webb 2020). The teaching process in STKIP Singkawang moves

towards this standard with a faster speed. They create online platforms where students can build a constructive relationship with lecturers and col- leagues.

The development of virtual learning environment allows students to access information from everywhere. The indicator of digital literacy used is search in the Internet. In line with the research by Martin (2008), digital literacy uses Internet and can cooperate in virtual learning environment with discussion and use of chat room. Based on the outcome of questionnaire on the indicators of ability to use the Internet and WBD, it is found that the students use learning management system with 70.10% of agree category and 25.37% of greatly agree category, while the remaining 4.53% of disagree category. This result is in line with the research conducted by Buckingham (2006), that digital literacy skill I sat level 2, that students are able to use the Internet and able to store database, thus their knowledge improves.

The other benefit of Learning Management System based learning is shortening time since the materials can be packaged concisely. This result is in line with the research conducted by Ying (2016) that Learning Management System can shorten the time since students can have access faster and are aware of the keywords of the materials. Learning Management System based digital literacy is one of the alternative learning methods that can combine e-learning, mobile learning, and blended learning.

The result of questionnaire on Indicators of digital literacy in the form of Evaluation of Information Content on Sub-Indicator ability to distinguish display from content is 70.5% agree, 22.7% greatly agree, and 6.8 disagree. For the ability to understand the content of information in the internet or Digital Workbook, 73.9% were agree, 24.27% were greatly agree, and 1.9 were disagree. For the statement I understand the steps in accessing WBD, the results are 76.1% agree, 18.2% greatly agree, and 5.7% disagree. In line with the research that learning environment using virtual environment must be equipped with student's ability to absorb information, evaluate, and validate information (Alkali et al. 2004).

4 Conclusion

The students think that using information technology and information is useful and that the program used during the process is simple and easy to use. Majority of students prefer using information technology resource to traditional textbook, as expected; however, regardless of advancement of modern technology, there is a segment of student population who are unsure of this option. Education technology is not equal to community technology in daily life. Likewise, because of assistance of infrastructure made at their campus and the use of Digital Workbook as the media of communication between professor and student, lecturers' competence in technology is very good. Students are proficient in using various gadgets and applications for communication and fun, but they believe that the professors should include technology into class.

When constraints come, it is found that widely available limitless information is a challenge in building a virtual learning environment. The constraints from social media and other entertainment websites can be the main constraint in the process. This is the role of infrastructure to solve such threat, with a way understandable and meaningful. In terms of student's attitude, most of the students are motivated and enthusiastic to

use virtual learning environment to access various sources of knowledge and digital workbook. Students are also driven to do work better with ecology of virtual learning environment, that gives them self- confidence to improve their digital literacy skill. The students have in- creased their involvement and class behavior; they especially work on projects during process and tend to associate their previous knowledge with new information.

Different instruction, or lecturer's ability to proactively adjust teaching material, teaching technique, resource, learning activity, and student product to accommodate unique student and individual requirements, is found as the benefit of using Digital Workbook. Likewise, beyond the limit of class time, deadline of assignment can be set more freely, which may benefit certain type of student. Media of information and communication are used to create digital learning environment. Digital Workbook is a new way of learning that perfectly completes the traditional class practice.

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The Assessment Pattern Catalog for a Distant Education: The Study of the Classroom Applicability

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Abstract. A crucial part of education is knowledge assessment. In the distant setting it seems even more important. A knowledge assessment provides a lot of important feedbacks, among others, students' acquired knowledge. The COVID-19 pandemic forced teachers and students online for a few semesters. Quite a few knowledge assessments were implemented online during that period. They provided an extensive collection of recurring practices. Within the research we collected and categorized them into an assessment pattern catalog for distant education. We also validated and rated the catalog using empirical research with a help of practitioners. In this paper, we present the catalog and its definition process, emphasizing the top-rated patterns in each category. However, practice and experience show that some patterns could also be used in a classroom setting. This is why we also investigated the classroom pattern appropriateness. In this paper we present the top-rated patterns in each category that are, according to our survey participants, suitable for classroom use. Since our lives are getting back to normal and the learning process is moving back to the classroom, this paper demonstrates that most patterns within the catalog, although formed for distant education, could also be applied in a classroom knowledge assessment.

Keywords: Distant learning · Assessment patterns · Evaluation practices

1 Introduction

The COVID-19 pandemic interfered significantly with our everyday lives, wherein higher education was no exception. The widely known and well-established teaching approaches were, practically overnight, replaced by distant learning. New obstacles were introduced for both teachers and students, which resulted in many, sometimes negative, consequences. According to the literature review (Pokhrel and Chhetri 2021), there were serious challenges related to connectivity, internet and network, physical space and environment, lack of teaching and learning resources, and issues associated with mental health.

Since the virtual classrooms replaced the face-to-face communication, the students' assessments were also practiced online. Faced with the new circumstances, teachers had

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to perform knowledge assessments in an online-adopted format. In addition to objective knowledge assessment, while keeping teachers' and students' satisfaction at acceptable levels, the completely new state demanded certain adjustments. At the Institute of informatics, we have a history of practicing several online tools while teaching, even before the pandemic. This is why the transition to online teaching was easier for us. With an awareness of the possible shortcomings which a remote format brings, we believed that knowledge assessments could and should be organized appropriately with properly designed, validated, implemented and communicated sessions. Since the COVID-19 pandemic affected much more than just one study semester, we started to collect and share experience and lessons learned, that seemed to be working well during an online knowledge assessment at the Institute of informatics. Following a few sequential steps, the result was the refined novel catalog of assessment patterns. The catalog consists of recurring practices that can motivate and assess students successfully, and, at the same time, avoid restrictive measures and technology-related incidents.

In this paper we will present the results of the research, implemented while constructing and validating our novel assessment pattern catalog. Our lives are getting back to normal, and the distant learning experience must be a unique learning experience for us (Neuwirth et al. 2021). This also includes the assessment patterns for distant learning. Though some parts of distant learning will be retained, parts of the pattern catalog will remain appropriate for a classroom setting also. Therefore, our research focused on three research questions:

- *RQ1 – What recurring practices were used during distant student knowledge assessment within the COVID-19 pandemic?*
- *RQ2 – Which practices are the most popular / used regularly by teachers and teaching assistants?*
- *RQ3 – Which patterns in the assessment pattern catalog are also appropriate for a face-to-face knowledge assessment?*

The rest of the paper is organized as follows. In the next section we will present the related work in terms of existing published pedagogical practices catalogs for knowledge assessment. In the Sect. 3, we present our novel assessment pattern catalog and the process that was used to construct it. The research method used to identify and validate classroom-appropriate patterns in the catalog is presented in Sect. 4. The results are also in this section. The paper is finished with the last section – Conclusions.

2 Related Work

According to (Koppe et al. 2017) educational patterns are "hypothesized solutions to recurring problems in an educational context". Moreover, some other terms are also used in the literature, like pedagogical patterns, educational patterns and advice for educators (Bergin et al. 2012). Since the assessment is a crucial part of education (Koppe et al. 2020a), different educational patterns could also be found in the knowledge assessment domain (Koppe et al. 2017). During our systematic literature review, done within

our previous work, we found several different pedagogical patterns. However, their categorization or cataloging was usually not available, or was not consistent within different authors (Pavlič et al. 2022).

In addition, very little is available regarding assessment-related pedagogical patterns. The systematic literature review (Pavlič et al. 2022) detected pedagogical patterns catalogs. The SLR (systematic literature review) was performed in 2021 with a combination of 7 keywords in 9 different databases (IEEE, Scopus, ACM, Web of Science, ScienceDirect, SpringerLink, ResearchGate, arXiv, Wiley). Out of the 38 identified primary studies, just some of them included assessment patterns, among them:

- Pedagogical Patterns by Teaching Activities and Pedagogical Values (Bennedsen and Eriksen 2006),
- Pattern Language for Hybrid Education (Koppe et al. 2017),
- Patterns (Online document storage) (EduPLoP) and
- Open Repository for Online Learning System Patterns (Open Pattern Repository for Online Learning Systems).

Also, assessment patterns were presented by some authors (Koppe et al. 2020a, b, Bergin et al. 2016, Warburton et al. 2016, Seoane Pardo and García-Penalvo 2014), however not in the form of the catalogs.

The literature review clearly showed the lack of systematically categorized and cataloged pedagogical patterns for distance assessment. Therefore, our research and defined assessment pattern catalog for distant learning filled the research gap in the field.

3 The Remote Assessment Patterns Catalog

The assessment pattern catalog started to grow organically at the Institute of Informatics. We started with the initial set of patterns, identified by analyzing the recurring practices applied by teaching staff for remote assessments. The patterns were aggregated and refined gradually using a systematic approach.

The final catalog and a few sequential steps for its core validation are presented in the paper by Pavlič et al. (2022). In this section we are highlighting the main steps while creating the assessment pattern catalog and its final structure.

3.1 The Assessment Pattern Catalog Definition Process

The process of creating, refining, and validating the assessment pattern catalog took place in 2020 and 2021 as shown in Fig. 1. It consisted of several sequential steps, which led from in-house, informal organically recurring practice gathering, to the systematically structured and validated catalog.

1. Collecting the preliminary recurring practices was a step which was triggered by the investigation of patterns used in our institution after 10 months of online teaching and assessing knowledge. A small focus group of teachers and teaching assistants met several times to identify practices used frequently for distant students' knowledge assessment. The first set of patterns was designed as a result.

2. Preliminary Cataloging, the second step, was a first attempt to create a structured representation of a design pattern catalog. The activities included workshops for practitioners at the institutional and departmental levels. The resulting first version of the catalog was presented, seeking feedback. In the end, additional workshops were organized with focus groups, where some additional patterns were identified and some patterns classifications fine-tuned. Patterns were classified; however, they were not yet described fully.

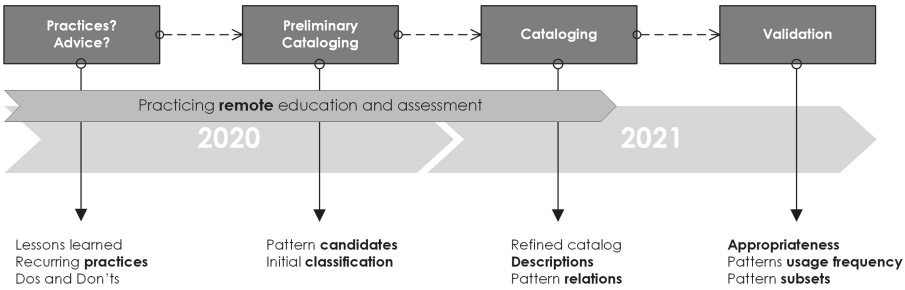

Fig. 1. The assessment pattern catalog development process

3. Cataloging was a well-planned and implemented research activity that put the catalog into a global framework. The third (cataloging) was finalized iteratively by a focus group, based on previous two activities. The patterns were classified and described, and documented carefully. A novelty evaluation was executed alongside the organized workshops. Feedback and a preliminary literature review indicated that there was a need for an assessment pattern catalog. This also leads to the need to document patterns in an established, proven way. The primary studies, extracted from a systematic literature review, were examined carefully to capture existing pedagogical pattern catalogs, especially assessment patterns and their description structure. The final catalog was finalized iteratively by a focus group. In addition to the final pattern descriptions and classification, the catalog was documented carefully.

4. Validation was the final activity. In its core, empirical research took place to validate the designed catalog. Several questionnaires were answered by 33 teachers and teaching assistants. On average, the respondents had 11 years of teaching experience and have taught more than five different courses. Their average attitude towards remote teaching was assessed with a 4 on a scale from 1 to 5, and their attitude towards remote knowledge assessment was evaluated with an average of 3 on the same scale. Several aspects were examined to validate the correctness, usage frequency and adequacy of the patterns in the constructed assessment pattern catalog.

An important part of the questionnaire was aimed at gathering information about the need for good practices and advice while assessing knowledge remotely. We questioned the participants if they ever performed a search for any advice regarding remote assessment before assessment implementation within their study courses. The majority, 54% of the participants, answered that they had done a quick search on the web, while 4% investigated the domain in depth. While doing so, 25% of the participants found

a few good practices and advice, and only 4% found some good practices. Coincident with an implemented literature review, none of the participants was able to find a lot or systematically categorized good practices or patterns for distant knowledge assessment. Please see Table 1 for details.

Table 1. Capturing the need of an assessment pattern catalog

	Have you searched for any advice for remote assessment before doing it on your own?
Yes – I invested **a lot** of time in research.	4 %
Yes – I did a **quick search** on the web.	**54 %**
No – I did not search.	42 %
	While doing so - did you find any recurring practices that you could employ?
Yes, a lot.	0 %
Yes, some.	4 %
Yes, a few.	25 %
Almost **nothing.**	**29 %**
No, I did not search.	42 %

As the results in Table 1 suggest, in addition to the SLR results, the practice also showed a clear need for an organized catalog of knowledge assessment patterns during remote education. The resulting catalog is presented briefly in the next section.

3.2 The Result

The assessment pattern catalog (see Table 2) was created and adjusted as a result of the process that is highlighted in Fig. 1. The catalog consists of 47 unique assessment patterns, classified into 6 different categories. In addition to 2 categories, which combine 2 unclassified assessment patterns and 3 anti-patterns (not advised practices), the assessment patterns are classified into 4 categories that support the whole higher education assessment process (Pavlič et al. 2022):

- Patterns for the **assessment conceptual design** group patterns on deciding how to design or organize a student assessment. Within this, we decided which assets are allowed, how the assessment was to be structured, and others.
- Patterns for **defining questions, answers and schedules** are intended for selecting the questions or tasks that students are given during assessment carefully. The validation patterns for questions and possible answers are done, not only on a content level, but also from a schedule perspective. This is how teachers can use these patterns to figure out the time needed to answer questions or fulfil tasks.
- **Execution and grading patterns** are used when the exam is decided conceptually, and the questions/tasks are fixed. They enable teachers to evaluate and grade outcomes fluently with a guarantee of grades‘ quality.
- **Communication patterns** enable teachers and students to improve the assessment process and results‘ presentation by permanent, honest, and well-meaning communication.

Each of the patterns (see Table 2) is described in a uniform way, addressing the category, plot (one-line description), challenge solved by the pattern/pattern purpose, the main idea of the solution, applicability/context, participants, participation and environment, implementation steps, possible variations, advantages, disadvantages and threats, known uses, related patterns, do not use with and specific resources/tools required for implementation. The example descriptions of patterns *Pentathlon* and *Game Rules* can be found in the paper by Pavlič et al. (2022).

Table 2. The assessment pattern catalog

(1) ASSESSMENT CONCEPTUAL DESIGN	(2) DEFINING QUESTIONS, ANSWERS, AND SCHEDULE	(3) EXECUTION AND GRADING	(4) COMMUNICATION
Open Book	**Content Validators**	Timebox	Appetizer
Stagewise Approach	Expert Validator	Randomized Order	Game Rules
Pentathlon	Statistical validator	Results With Delay	Time Reminder
Continuous Testing	Hidden Validator	Identity Guarantee	To-Do List
Expert-Level	Colleague Veto	Accessibility Adjustments	**Separate Channel**
Innovator alias Open Spectrum	**Time Validators**	Objective Assessor alias Score Calibrator	Emergency Call alias 911
Student Achievement Portfolio	Mathematical Validator	Criteria List	Member Channel
Colleague Bloom	Professional Multiplier	Eurosong	Academic Integrity Appeal
	Val. with a Try	Bonus Points	Proactive Teacher
	Dress Rehearsal	Third Shift	Firewall
	Example Questions	Number Draw	Student Proxy
	Questions Donor	Impro League	
	Theme Variants alias Alternate BOM	Self-Assessment	
		Personal Defense	

ANTI-PATTERNS	OTHER
24/7 alias Permanent Availability	Safe Exam Browser
Full-Time Job	Big Brother
Certification Center	

4 Patterns' Popularity Rating and Classroom Appropriateness

4.1 The Most Popular Subsets of the Assessment Pattern Catalog

Within the research, the participants had to choose their top-picks in the catalog (i.e., patterns that they practice the most on distant knowledge assessment). When combining their preferences, the patterns were assigned points according to the answers:

- 5 points ranked highest;
- 4 points second;
- 3 points third;
- 2 points fourth;
- 1 point listed last;
- 0 points all other patterns.

Table 3 presents the top three rated patterns by categories, teachers, and teaching assistants. As shown in Table 3, some minor differences can be detected between teachers and teaching assistants. For example, within the patterns for assessment of the conceptual design, the top-rated pattern in both groups was *Pentathlon.* At the same time, the second and third places varied between teachers and teaching assistants. While teachers saw that the patterns *Open Book* and *Continuous Testing* follow *Pentathlon* in the appropriateness for distance assessment, the teaching assistants placed *Innovator* and *Multi-Stage Implementation* patterns in the following places. The first place within the Communication patterns was chosen for pattern *Game Rules* for both teachers and teaching assistants. This was followed by the patterns *Proactive Teacher*, *Appetizer*, *Emergency Call* and *Firewall* among teachers, and *Academic Integrity Appeal*, *Emergency Call* and *Criteria List* among teaching assistants.

Table 3. The most popular subsets of the assessment pattern catalog

	Teachers	Teaching assistants	Combined
ASSESSMENT CONCEPTUAL DESIGN	Pentathlon Open Book Continuous Testing	Pentathlon Innovator Stagewise Approach	Pentathlon Open Book Continuous Testing
DEFINING QUEST., ANS., AND SCHEDULE	Theme Variants Professional Multiplier Hidden Validator	Colleague Veto Professional Multiplier Expert Validator	Theme Variants Professional Multiplier Colleague Veto
EXECUTION AND GRADING	Timebox Randomized Order Personal Defence	Personal Defence Randomized Order Timebox	Personal Defence Randomized Order Timebox
COMMUNICATION	Game Rules Proactive Teacher Emergency Call	Game Rules Academic Inte g. Appeal Emergency Call	Game Rules Emergency Call Proactive Teacher

Based on the questionnaire results, the most popular subset of the assessment pattern catalog consists of 12 patterns:

- **Pentathlon** - The final grade is composed of multiple assignments, e.g., hands-on, quizzes…
- **Open Book** - All assets are allowed during an online assessment.
- **Continuous Testing** - Integrate remote assessment into lectures as a tool for teaching.
- **Theme Variants** alias **Alternate BOM** - Prepare different online assignment variants for the same assessment type.
- **Professional Multiplier** - Multiply the time required for completion by an expert by three (or two).
- **Colleague Veto** - Eliminate or correct questions in the case of doubts or concerns of a colleague.
- **Personal Defence** - Introduce remote oral defence of students' e-solutions.
- **Randomized Order** - Introduce random ordering of online questions and their answers.
- **Timebox** - Introduce a time-limit for online assignments.
- **Game Rules** - Explain the remote assessment rules at the first lecture and before the assessment.
- **Emergency Call** alias **911** - Be available in the separated channel to address urgent student calls.
- **Proactive Teacher** - A teacher contacts the students periodically to see if there are any problems.

4.2 The Classroom-Appropriate Subsets of the Assessment Pattern Catalog

The presented assessment pattern catalog was, as explained, created for distance assessment. However, the practice and experience show that the majority of the patterns might also be helpful in the physical classroom setting. To verify this, we asked the survey participants to rate every pattern using a 5-point Likert scale with this statement: "*The use of the pattern is appropriate in the classroom.*" Based on the answers, we were able to rank the patterns from the most suitable in the classroom (the majority answered between "agree" and "strongly agree") to the least suitable ones. We segmented the ratings afterwards based on the pattern category and participant role (teacher/teaching assistant). The most appropriate three patterns by each category are shown in Table 4.

As the participants rated the *Pentathlon* pattern as the most suitable for distance learning, this is also the case when evaluating patterns for their applicability and suitability for classroom assessment. In the category Conceptual design the mentioned pattern was also the top-rated pattern by teachers and teaching assistants. This was followed by the pattern *Continuous Testing* and the pattern *Colleague Bloom* by teachers, and *Student Achievement Portfolio* by the teaching assistants. Within the execution and grading patterns the teachers chose *Bonus points*, *Accessibility Adjustments*, *Criteria List* and *Number Draw* as the three most appropriate patterns for a face-to-face assessment. On the other hand, teaching assistants choose *Accessibility Adjustments*, *Personal Defence* and *Bonus Points.*

Within the Communication patterns, the pattern *Game Rules* remained very important, which was also the case within distance knowledge assessment. The overlap of distance and classroom assessment patterns can, additionally, be seen in Fig. 2. As depicted, especially within the Communication and Execution and grading patterns, the overlap is considerable, while the overlap within Conceptual design patterns is not so extensive.

Table 4. Rating of the catalog's patterns by its appropriateness for classroom knowledge assessment by teachers, teaching assistants, and combined

	Teachers	Teaching assistants	Combined
ASSESSMENT CONCEPTUAL DESIGN	Pentathlon Continuous Testing Colleague Bloom	Pentathlon Continuous Testing Student Ach. Portfolio	Pentathlon Continuous Testing Student Ach. Portfolio
DEFINING QUEST., ANS., AND SCHEDULE	Expert Validator Colleague Veto Professional Multiplier	Expert Validator Colleague Veto Theme Variants	Expert Validator Colleague Veto Theme Variants
EXECUTION AND GRADING	Bonus Points Access. Adjustments Criteria List	Access. Adjustments Personal Defence Bonus Points	Access. Adjustments Bonus Points Personal Defence
COMMUNICATION	Game Rules Academic Integ. Appeal Appetizer	Time Reminder Game Rules Academic Integ. Appeal	Game Rules Time Reminder Academic Integ. Appeal

Based on the questionnaire results, the most classroom suitable subset of assessment pattern catalog consists of 12 patterns:

- **Pentathlon** - The final grade is composed of multiple assignments, e.g., hands-on, quizzes…
- **Continuous Testing** - Integrate remote assessment into lectures as a tool for teaching.
- **Student Achievement Portfolio** - Use assignments evolution/progress as an auditing trail for a later retrospective.
- **Expert Validator** - Use a colleague teacher or domain expert to validate the questions and answers.
- **Colleague Veto** - Eliminate or correct questions in case of doubts or concerns of a colleague.
- **Theme Variants** alias **Alternate BOM** - Prepare different online assignment variants for the same assessment type.
- **Accessibility Adjustments** - Allow online accessibility adjustments for students with special needs.
- **Bonus Points** - Introduce bonus points to engage students better in an online setting.
- **Personal Defence** - Introduce remote oral defence of students' e-solutions.
- **Game Rules** - Explain the remote assessment rules at the first lecture and before the assessment.

- **Time Reminder** - During an online assessment, remind students about the remaining time.
- **Academic Integrity Appeal** - Emphasize the importance of academic integrity while carrying out online assessments.

The subset of classroom appropriate patterns is important, when one would like to design, implement, and communicate in-classroom knowledge assessments. However, additionally, having a list of patterns that are not appropriate for a classroom might be even more important. The subset of classroom inappropriate patterns is as follows:

- Assessment conceptual design: **Stagewise Approach**,
- Defining questions, answers, and schedule: **Dress Rehearsal**,
- Execution and grading: **Third Shift**, **Randomized Order**,
- Communication: **Member Channel**,
- Anti-patterns: **24/7** alias **Permanent Availability**, **Full-Time Job**, **Certification Center**,
- Other: **Safe Exam Browser**, **Big Brother**.

5 Conclusions

The presented assessment pattern catalog for distant education combines recurring validated practices for knowledge assessment. Based on "*RQ1 - What recurring practices were used during distant student knowledge assessment within the COVID-19 pandemic?*", we formed the catalog following four definition steps. The catalog combined 47 assessment patterns, categorized into 6 categories. Each pattern was also described following a uniform format. In the research, practitioners also rated the patterns, providing the answer to "*RQ2 – Which practices are the most popular/used regularly by teachers and teaching assistants.*"

Within the *RQ3* we investigated the *pattern appropriateness for classroom usage.* Based on the presented results, we were pleasantly surprised that the presented assessment pattern catalog showed itself to be useful, not only for remote assessment, but also for knowledge assessment in the classroom. Even more, when rated by the practitioners, a significant overlap was detected between the top-rated patterns for distance and face-to-face. The overlap is also shown in Fig. 2. It depicts this overlap, showing the top-rated patterns suitable for the classroom setting, patterns crucial for distant knowledge assessment, and patterns top-rated in both categories. Please note that Fig. 2 captures all patterns, that were top-rated for classroom usage from both teachers and teaching assistants. The patterns that are crucial and practised at a distance, were identified systematically during related research (Pavlič et al. 2022).

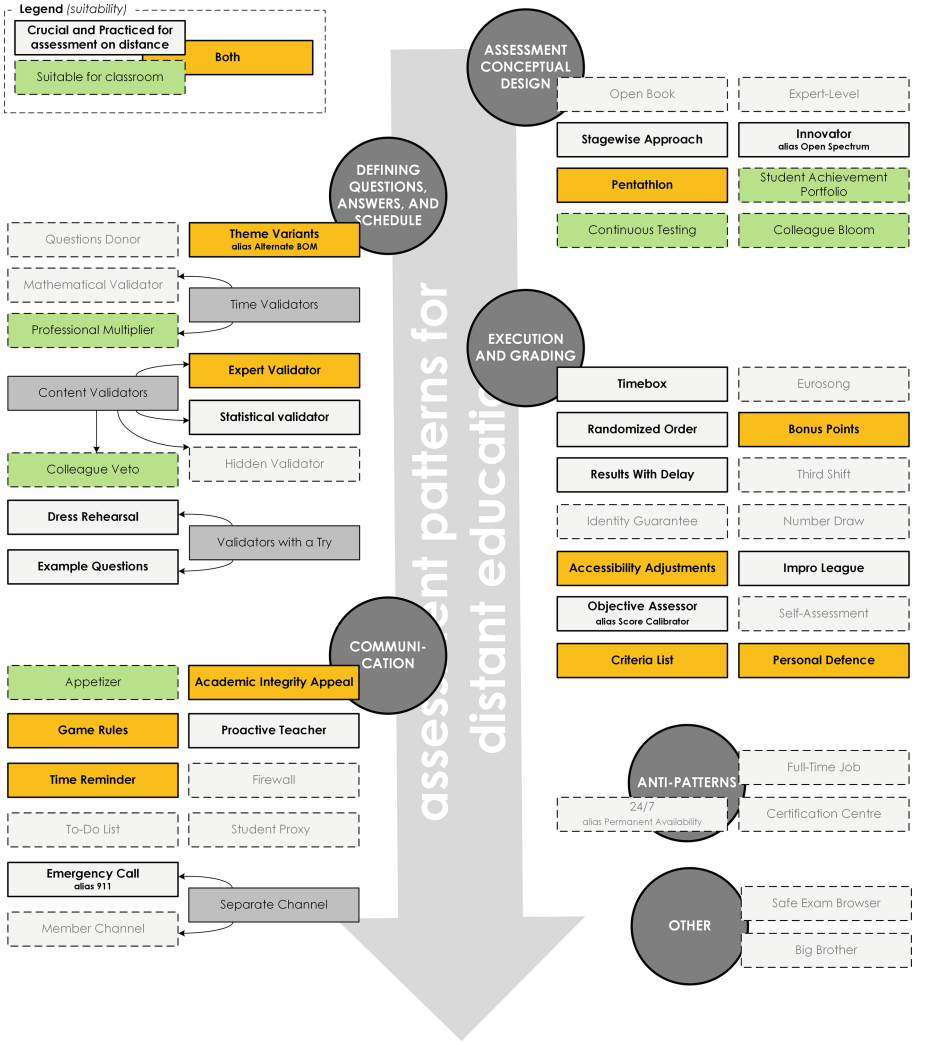

Fig. 2. The assessment pattern catalog with a subset of the most important patterns for distant knowledge assessment and a subset for classroom knowledge assessment

The side-effect of conducting the research, combining the patterns to a catalog and implementing a survey among teaching staff at the institute was, that the interest in employing patterns while teaching and assessing knowledge has increased among our colleagues, which accelerated their knowledge exchange on the topic.

We plan to expand our research on knowledge assessment patterns. In addition, we will offer the presented catalog in the form of an online platform. It will be available in different languages, allowing all the practitioners to contribute to its validated and well-established practices.

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Learning Practices and Methologies

Testing the Instructional Design for Knowledge Nuggets Implementation

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Abstract. Currently not only based on the pandemic but forced by technological development, the education sector is undergoing profound changes, challenging many traditional models of pedagogy and making the use of digital teaching formats essential. This work examines Knowledge Nuggets as a new form of knowledge delivery, built on the foundation of the instructional design developed and related to cognitive load. The empirical results in this work are based on a pre-study that tests the general applicability of Knowledge Nuggets design and tries to find out more about the perceived stress level of learners during learning with Knowledge Nuggets. The findings will form the basis for further research. To empirically investigate this issue, an experiment is conducted comparing three different levels of Knowledge Nuggets built around the topic of Business Intelligence. While level 1 contains only text within a document, level 2 and level 3 address additional senses. Level 2 provides knowledge in the form of a slideshow with an added audio track, whereby the combination of image and sound, thus addresses two senses in parallel. On the other hand, the linking of text, language, images and animations through a video tutorial forms the basis for Level 3. The results from the experiment confirm the applicability of the developed Knowledge Nuggets and the feasibility of the study.

Keywords: Online teaching · New ways of learning · Knowledge Nuggets

1 Introduction

In the last decades, teaching and learning have changed significantly. Traditional knowledge changed has fundamentally transformed from an all-familiar book with text and pictures to a comprehensive and diverse repertoire of teaching materials. That development has its origins in technological change. Digitization is changing the way we think and act, and thus also our business methods and models. That is accompanied by a transformation of the entire education sector to meet the needs of today's generation and their new ways of learning. Many traditional models of pedagogy are being challenged [5]. To continue to

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sustain education, the short-term development and use of digital teaching formats are essential. One approach to deliver knowledge is through Knowledge Nuggets [18,19], which are developed for self-directed and self-paced learning. These Knowledge Nuggets aim to maximize student learning by utilizing individuals' cognitive abilities in a goal-directed manner. This paper seeks to find out more about learners' perceived stress levels while learning with Knowledge Nuggets and test the general applicability. In doing so, there is one theory that stands out to provide more insight into perceived stress levels: the Cognitive Load Theory [8].

Since there is little literature and research about Knowledge Nuggets, this paper aims to provide a way to answer open questions and test the use of Knowledge Nuggets for the first time. Students' difficulties in learning new content through different methods can vary greatly, and Knowledge Nuggets are no exception. Within the learning process, the cognitive load is felt. If this cognitive load exceeds the human working memory capacity, we speak of a mental overload, which negatively affects learning success. This observation is described in the Cognitive Load Theory (CLT) [21]. So the authors of this paper came up with the following research question: How does the cognitive load behave during learning depending on the Knowledge Nugget used in the subject area of business intelligence?

After the introduction in Sect. 1 the theoretical basics are explained in detail. Section 3 shown the research design and the results from the study are shown in Sect. 4 followed by the discussion in Sect. 5. The paper will be closed up with showing the limitations and providing a future outlook of the research in this field in Sect. 6.

2 Theoretical Background

The chapter presents the theoretical background and is divided into four subsections. After an introduction through the area of Knowledge Sharing in Subsect. 2.1, which takes place from teacher to learner, the scope of multimedia learning (Subsect. 2.2) is discussed. The following Subsect. 2.3 explains the main idea of the cognitive load theory and its multimedia application. Furthermore, the area of Knowledge Nuggets is presented in Subsect. 2.4, which is a possibility of knowledge exchange.

2.1 Knowledge Sharing

Knowledge Sharing is a fundamental part of knowledge management [17] and according to King [10] the term can be understood as a fundamental process that is central to learning. This process involves capturing, collecting, and sharing explicit or tacit knowledge, including skills and competencies, and meanwhile, objects can be used to visualize, store, and transport the knowledge [17]. Knowledge Sharing can generally be understood as "the exchange of knowledge between individuals, within teams, and between organizations, organizational

units, and organizations" [10, p.493]. This sharing combines two actions. One is the transmission of knowledge, i.e., the sending or passing on of knowledge, and the other is the reception of the knowledge by a recipient [6]. The definition of Davenport and Prusak [6] is the reason for the authors to stick with the Knowledge Sharing term instead of using Knowledge Transfer. In the literature, the term Knowledge Sharing is sometimes used synonymously with Knowledge Transfer [9]. While Knowledge Sharing is more often used to focus on the individual level, Knowledge Transfer is more often used when groups, departments, organizations, or even companies are the focus [1]. In addition, Knowledge Transfer is focused and unidirectional, while Knowledge Sharing can be both focused and unfocused and multidirectional [17].

2.2 Multimedia Learning

The use of multimedia in learning offers the possibility of supporting the learning process and simplifying it in a certain way. However, the danger of overload and transient information transfer must not be ignored. The term multimedia has become an integral part of everyday language. The simplest definition understands multimedia as a combination of different media types, for example, text, graphics, images, audio, and video [20]. In addition to this straightforward and general definition, Weidenmann [26] provides a more precise version by differentiating between the following dimensions: (1) Medium: serves to store or communicate information and is understood in the sense of a technical device, (2) Encoding form: text, numbers or also pictures, by which the message is conveyed and (3) Sensory modality: Auditory or visual, through which a media offer is perceived. For all three aspects, Weidemann additionally distinguishes between single or multiple. Thus, while a purely computer-based learning environment is considered mono-medial, a continuous text displayed on a monitor is described as mono-codal and mono-modal. In this paper, therefore, following Weidenmann's description, multimedia is understood as an umbrella term for a system that contains multicodal and multimodal elements.

2.3 Cognitive Load of Multimedia Learning

Cognitive Load Theory (CLT) [24] addresses the cognitive load on memory by explaining how it acquires and stores knowledge. The theory draws on findings from memory research and, in particular, on the cognitive processes that occur during interactions between working memory and long-term memory [15]. In this regard, CLT is based on the assumption of limited working memory in conjunction with unlimited long-term memory [2]. It assumes that learning is linked to cognitive load and attributes an essential function to working memory, particularly for this purpose. For example, working memory is used to read and subsequently process just this text. It is crucial to take into account that the capacity of the working memory, in contrast to the comprehensive long-term memory, is very limited [22]. That means that only a certain number of items can be stored and processed simultaneously. This fact plays a crucial role,

especially concerning multimedia learning since not all information presented to the learner can be processed simultaneously and at the same level. Miller [12] already assumed the existence of limited working memory in 1956. According to Miller, working memory can only hold 7 ± 2 things at a time, and it must be transferred to the unlimited long-term memory to retain information permanently. Consequently, learning occurs precisely through this transfer of information from working memory to long-term memory. At its core, Cognitive Load Theory describes the importance of schema construction as the central process of knowledge acquisition [23]. According to this theory, people store knowledge in long-term memory in individual schemas [25]. Schemas categorize different elements of information and relate them to each other [3]. A relevant process of schema construction in this context is automation. Automation describes the process by which information can be processed automatically with minimal conscious effort and which only sets in after intensive practice, for example, the unconscious information processing of individual letters in skilled readers [25].

The Cognitive Load approach distinguishes three types of mental load [16] that compete for limited capacity in working memory: Intrinsic Cognitive Load (1), Extraneous Cognitive Load (2), and Germane Cognitive Load (3). Together, they constitute the overall cognitive load [14], illustrated in Fig. 1.

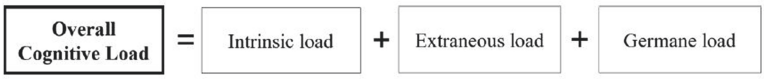

Fig. 1. Overall cognitive load

Cognitive theory of multimedia learning (CTML; Cognitive Theory Of Multimedia Learning) extends Cognitive Load Theory by attempting to look at the entire process of understanding rather than focusing principally only on working memory [13]. It builds on existing approaches and incorporates several concepts from both the science of learning (how people learn) and the science of instruction (how to design instruction) [11].

2.4 Knowledge Nuggets

One way of sharing knowledge is through the use of Knowledge Nuggets [18]. They are developed specifically for self-directed learning. "Knowledge Nuggets are digitally prepared learning materials organized within small, defined topics" [19, p. 245]. This definition forms the basis for the construction of Knowledge Nuggets. The granularity described makes consuming the knowledge content prepared in them at an individual pace. This type of Knowledge Sharing is thus closely linked to the areas of microlearning, e-learning, and also multimedia learning. The instructional design, developed by Ploder et al. [19], delineates the three levels from each other to create an effective learning environment through

the resulting framework [13]. The purpose of this subsection is to identify the factors that define these levels, distinguish them from one another, and thus must be considered when planning differentiated Knowledge Nuggets. Design recommendations are also included, which should help to achieve a reduction of redundant extrinsic cognitive load. In addition, facilitative elements help understand and process the material (more details will be presented at: END2022 conference).

3 Methodology

The authors have chosen a quantitative research approach for this paper to answer the central research question. The causal relationship between the different variables will be investigated using an experiment, followed by a deductive research approach. This paper represents the first pre-study, which helps identify potential problems within the experiment and thus provides the basis for further research. Experiments allow conditions to be varied in a controlled and purposeful manner. Only by purposefully manipulating the independent variable (UV) can the effect on the dependent variable (AV) be represented and measured [7]. The separated component is the Knowledge Nugget in this work, randomly assigned (randomized) to the study groups. This procedure is done keeping the other conditions constant. The present study design is single factorial, with a threefold staging of the Knowledge Nugget factor. That experiment can be divided into a total of five sub-areas. An online questionnaire is used for data collection, which works with closed items. This method is superior to an open-ended question format due to its objectivity, simplified and more precise evaluation options, and high comparability [7]. The online experiment begins with an introductory text, which includes a detailed explanation of the experiment and the study, and lists a set of general instructions on the procedure. It is emphasized that the goal is not to acquire knowledge from other sources outside of the assigned Knowledge Nugget. In the second part of the experiment, subjects are asked to complete the first questionnaire. That deals fundamentally with meta information and picks up variables such as prior knowledge and interest, which have been shown in the literature to be influential factors in the learning process. The third part then appears. Here, everyone has time to acquire knowledge in the topic area of Business Intelligence through the Knowledge Nugget randomly distributed to them. In level 1, the continuous text is presented, while in level 2, the individual slides are played along with the audio track, and in level 3, the video tutorial is presented. Immediately after the knowledge-sharing part, the participants are given a small multiple-choice test to check what they have learned. Four questions, each with four possible answers, are presented to the participant to test the knowledge they have just acquired. No matter which randomized level the person has received, the knowledge questions are identical for everyone. Finally, in the fifth and last part, the data collection of the cognitive load takes place utilizing NASA-TLX, whereby the stress level is to be measured. Since this is a pre-study, a convenience sample of at least 30 persons aimed to

achieve. The minimum age of 18 years was set as a requirement for participation, and no other restrictions were made regarding the target group. Since the participants have different academic and personal backgrounds, another distribution of prior knowledge can be observed. However, in this context, it must also be ensured that novices without an information technology or business background can understand the subject area. The experiment was carried out in May 2021, and the results are shown in Sect. 4.

4 Results

The experiment was implemented with the online tool "SoSci Survey" and 52 participants took part in the experiment. At least 32 participants finished the investigation with all different parts explained in Sect. 3 within 16 min on average. Interestingly most participants not completing the experiment have been found at the slideshow (eight) followed by text (six), and the video had the smallest number of cancellations (three). Within the sample, 59% were female, and 41% were male, with an average age of 27. Checking the existing knowledge of the participants showed that 43% had some current knowledge on the topic of Business Intelligence (BI) and 28,6% ranked the ability at "high" and 71,4% on "low". After consuming the different Knowledge Nuggets, every participant was asked to answer some questions based on the input before checking the knowledge gained and the reach of the learning achievement which was the same for all three different Knowledge Nuggets. A maximum of 16 points were reachable. Based on the median, level 2 was outstanding in the capability of Knowledge Transfer with 84,4%, followed by level 3 (81,3%) and level 1 with 76,1%. The NASA TLX questionnaire involves collecting ratings and weights to calculate the Overall Workload (OW). In the form of pairwise comparisons, respondents are asked to provide a rating of the six indicators (Mental Demand (MD), Physical Demand (PD), Temporal Demand (TD), Performance (OP), Effort (EF), and Frustration (FR)). This result shows that OP and MD received, on average, the highest weighting of the indicators by the respondents. In addition to this, Mental Demand and Effort resulted highest in recording the ratings (Fig. 2).

Ø Value Weighted Indicator

Level	MD	PD	TD	OP	EF	FR
Level 1 - Text	3,8	1,8	1,8	3,7	2,7	1,3
Level 2 - Slideshow	4,0	1,1	1,9	4,3	2,9	0,8
Level 3 - Video	3,6	1,4	1,7	3,7	2,8	1,8
Gesamt	**3,8**	**1,4**	**1,8**	**3,9**	**2,8**	**1,3**

Ø Assigned Rating

Level	MD	PD	TD	OP	EF	FR
Level 1 - Text	68,3	43,3	41,7	56,7	65,8	59,2
Level 2 - Slideshow	63,0	21,0	26,0	42,0	46,0	47,0
Level 3 - Video	56,0	30,0	37,0	53,0	49,0	53,0
Gesamt	**62,8**	**32,2**	**35,3**	**50,9**	**54,4**	**53,4**

Fig. 2. Overall cognitive load

Especially the scores have to be reflected in more detail because, for example, Physical Demand did not occur within the experiment, and the results are

unexpected. The WWL score shows that Level 1 (Text) achieves the highest cognitive load (58.5 points), which classifies this value as "high". Besides, level 2 (slideshow) with 45.1 points and level 3 (video) with 49 points can be interpreted as "rather high" (Fig. 3).

Ø Value product, Workload Calculated Weight, WWL score and Score Interpretation

Themenbereich	MD	PD	TD	OP	EF	FR	Overall Workload (OW)	WWL Score	Interpretation
⊟ Business Intelligence									
⊞ Level 1 - Text	259,5	77,9	75,1	209,8	177,7	77,0	877,0	58,5	high
⊞ Level 2 - Slideshow	252,0	23,1	49,4	180,6	133,4	37,6	676,1	45,1	rather high
⊞ Level 3 - Video	201,6	42,0	62,9	196,1	137,2	95,4	735,2	49,0	rather high

Score Interpretation (Meshkati & Hancock, 1988)
The score interpretation based on calculated WWL is low (0-9); medium (10-29); Rather high (30-49); High (50-79); very high (80-100).

Fig. 3. Overall cognitive load

For using some other statistics, a prerequisite is that the interval-scaled variables at hand are tested for normal distribution. The normal distribution is tested within this work with the Kolmogorov-Smirnov test since this is suitable for small samples. Here, a significant deviation (p smaller than 0.05) means that the null hypothesis can be rejected, and thus, the data are not normally distributed. Suppose the variables cognitive load and learning success (the result of the knowledge check) are tested with regard to their distribution. In that case, a significance of $p = .200$ can be taken from the table for the cognitive load, while a matter of $p = .001$ is available for the variable learning success. Thus, the test results for cognitive load usually are distributed, and a parametric procedure can be used for statistical analysis. As a prerequisite for single-factor analyses of variance, the dependent interval-scaled variable must be normally distributed within each group. For this purpose, the test for normal distribution was repeated. The Kolmogorov-Smirnov test scores for cognitive load were .200 for Level 2 and Level 3 and .139 for Level 1. The group division concerning prior knowledge also shows a normal distribution. The most exciting question to be answered based on our experiment data will be if there is a significant difference between levels in terms of measured cognitive load. Since the samples are not connected, and there is a normal distribution, the hypothesis established is tested by one-factor analysis of variance. After the premise of variance homogeneity has been fulfilled, the Levene metric tests the null hypothesis (H0), formulated as follows: There is no difference between the levels in terms of measured cognitive load. The one-factor analysis of variance yields a significance value of $p = .147$, which means that the null hypothesis cannot be rejected. Thus no significant difference

can be found between the three levels in terms of cognitive load. Level 1 (M = 58.8, SD = 15.6), Level 2 (M = 43.70, SD = 11.17), and Level 3 (M = 49.9, SD = 21.89) do not differ significantly from each other in terms of measured cognitive load. The results of some additional data analysis led to the same situation with no significant correlation tests based on the small N of the pre-study. Overall the testing schema and the first results are promising for further experiments with more significant N. Therefore, the pre-Study itself can be a positive next step in this research field.

5 Discussion

In this study, Knowledge Nuggets, built based on the developed instructional design and cognitive load, were examined first. Thus, the applicability of the developed Knowledge Nuggets and the feasibility of the study could be confirmed utilizing application testing of the overall procedure. First valuable results could be established in this context. Based on this, the developed system and the experimental design need to be improved. The NASA-TLX threw up unexpected results and was confused about how it was presented, leading to a high error rate among participants. This observation can be made based on verbal feedback and mainly refers to the second part of the test when collecting the weights. In addition, adjustments must also be made in the presentation form of the slideshow with the audio podcast, since the design form alone (9 slides one below the other) in the technical implementation in the questionnaire seems overwhelming for the person, and this aspect has an effect on the ratings in the NASA-TLX. To answer the research question, the difference of the three Knowledge Nuggets used was measured in terms of the measured cognitive load, which is not detectable, which can also be attributed to the small sample size. Observing the results of the descriptive evaluation of the NASA-TLX test, slight differences in the achieved cognitive load can be observed. Except for hypothesis 3, which states a correlation between the cognitive load and the achieved learning success. Therefore, a lower cognitive load achieves a higher score in the knowledge test, the evaluation of the hypotheses cannot achieve any significant results.

6 Limitations and Potential Future Work

Since the pre-study was based on a small sample size of n = 32, the significance of the results is minimal. A larger sample would have been required for meaningful results. In addition, a larger sample would have simultaneously helped to show significant values concerning more in-depth analysis. As the experiment was conducted online, it has to be stated concerning the scientific investigation that the learner's learning environment was not controlled. Thus, disturbing external factors and distractions could not be eliminated, which negatively influence the entire learning process. Noise and also distraction by other people are just a few examples of these and prevent concentrated and undisturbed work with all the

necessary learning resources, as can be seen from the causal factors of Cognitive Load Theory [4]. In addition to this, technical problems cannot be excluded from influencing the study. Furthermore, precisely three levels in instructional design were specified in the development of Knowledge Nuggets. That is a limiting factor, as dividing the nuggets into more detailed levels would be possible. However, three levels provide a reasonable basis for comparing the various factors at each level. Also in future a combination of different levels of Knowledge Nuggets has to be taken into consideration. Based on solicited verbal feedback from the experimental participants, the critique of the NASA TLX stood out firmly. The second part of the NASA-TLX includes 15 pairings and thus carries a high risk for "blind ticking" of each item and calls into question the validity of the responses. This conducted study is a pre-study; a follow-up study with a much larger sample size will be conducted in 2022 based on these findings. In addition to modifying the technical representation form of Level 2 within the platform www.soscisurvey.de, a modified form of the NASA-TLX is also being considered. The NASA-TLX would thus only pick up the collection of ratings without the weighting of dimensions. The larger sample size is expected to yield significant results.

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Empowering E-course Effectiveness and Student's Motivation Through Inquiry Based Learning Aligned to ARCS Motivation Model in Moodle Workplace

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Abstract. This quasi-experimental mixed-learning study aimed to measure the impact of inquiry-based learning in line with the ARCS motivational model on the development of students' motivation for the History lesson and the effectiveness of e-learning in general. We adopted a quasi-experimental method with a conceptual framework for blended learning based on pre-testing, during the measurement of experimental procedures, and meta-tests on students in the same group. 4th grade students were selected and formed the experimental group. For the purposes of the research, seven courses were designed and developed on the Moodle Workplace platform, utilizing both the capabilities of this tool (dynamic rules, report builder, programs) and also incorporating a set of plugins (H5P, Game block, Monitoring of Learning plans) for a better and more successful result. In addition, each lesson was developed based on the model of inquiry based learning, orchestrating in each phase the strategies of the ARCS. The results showed that the motivation of the students for the History lesson was strengthened and there were particularly high scores in each indicator of the effectiveness of the e-course.

Keywords: Inquiry based learning · ARCS model · Seamless learning · Effectiveness · e-course · Moodle workplace

1 Introduction

In the Covid-19 era, e-learning has received a tremendous boost as it was necessary to give students the flexibility to study in any place and anytime. New student-centered learning methods are adopted as alternatives to traditional learning methods, to develop new skills based on problem-solving, and collaboration. At the same time, online environments help the smooth transition of learning to the digital age of the 21st century [8]. However, well planning of these environments is required in order to achieve effective learning as students communicate and collaborate. Inquiry-based learning is an approach that encourages teachers to enable students to discover, solve real-life problems and lead to the creation of knowledge [6]. Students have the opportunity to communicate and interact with each other and to improve their inquiry skills [13].

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The use of online environments is still considered effective when instructional designers positively influence the motivations of learners [2]. Furthermore, working in small groups appears to create positive academic outcomes [15]. According to research, motivation is considered as an important factor in learning and has a strong impact on academic performance. Most research uses Keller's ARCS motivation model, which has been applied in a variety of educational frameworks and at different levels of students, provides clear instruction to designers, and motivates students to have a positive attitude towards learning challenge [10].

In terms of History teaching, many studies have been conducted on how educators will transmit socio-cultural values to students and place them in specific views of the past [11]. However, the subject of History is often one of the most difficult and demanding subjects, with the result that students are unable to approach historical issues but also promote their historical/critical thinking [5]. As result, it is deemed necessary to investigate well-designed practices of students about the usefulness of studying history and the way it is taught in school, in the context of a complete educational experience. In the scientific literature, there is research proving the effective role that technology plays in learning history. More specifically, new technologies can develop and cultivate students' historical thinking but also enhance their interest [7]. At this point, it is worth noting that the success of the use of technology is not due to access to equipment, tools, and resources but to its proper use in regular teaching by teachers [14].

In summarizing, from the literature review, research deficiencies were identified regarding the way of teaching and the correct planning of the story in the e-learning environments [16], the lack of motivation of the students for the specific course, and the methods of reducing the dropout rates. Given the effective use of digital technology, this study attempts to propose an e-learning environment based on inquiry based learning aligning with Keller's ARCS strategies as a means of enhancing students' motivation about History as a subject and enhancing e-learning effectiveness. This is an alternative way to focus on learning experience design where complex learning (including cases and scenarios) and access to learner data (user account) is available in the Moodle Workplace. The learning experience design, as a result of ubiquitous access to mobile devices (iPads), is proposed as the key for providing effective seamless learning. This means that learners can learn whenever they are interested in a range of orchestrated scenarios and they can also easily and rapidly be transferred from one scenario to another, using a personal device as an educational vehicle. This is an attempt to provide innovative ways for collaboration in blended learning and support seamless and ubiquitous learning and assessment technologies [17].

2 Theoretical Background

This section presents the theoretical basis of the project which utilizes the principles of the Inquiry Based Learning method in combination with the strategies of the ARCS Motivation Development Model.

Inquiry Based Learning: During the last few decades, there is an increased focus on inquiry-based learning (IBL) in educational psychology. IBL is a method where students are actively involved in the learning process by creating knowledge about a topic

conducting research that follows the stages of the scientific method without constraint. Students delve into an interesting topic; formulate research questions and hypotheses; plan and conduct experiments; draw conclusions based on the collected data; present their results and communicate with others [12]. Because sharing and discussing results with others is considered necessary for a deep conceptual understanding of the "nature of science", almost all inquiry-based learning approaches use small group work [4].

Inquiry based learning is defined as an effective didactic approach to stimulate student interest and enhance motivation. The five general phases of inquiry based learning are *Orientation* (students develop an idea of the topic they are exploring), *Conceptualization* (students formulate questions about the problems presented and then move on to hypotheses), *Investigation* (students collect information from the suggested sources, analyze it, organize it and draw their conclusions, compare it with the results of their classmates and provide solutions to their research questions), the *Conclusion* (students interpret their results by checking their reasoning and the reliability of their findings) and the *Discussion* (students reflect on the process they followed and communicate with their classmates about the relevance, consequences and ethics of these findings). It is believed that inquiry based learning is more effective than traditional teaching as it contributes to the development of knowledge (intellectual stimulation), reasoning skills in all areas of learning, motivation and self-regulation learning [9]. By conducting research using similar methods and practices as professional researchers, students not only acquire basic subject knowledge and skills, but also develop so-called 21st century skills (such as learning and innovation skills, complex communication and social skills, technology skills, and self-discipline and development). These 21st-century skills are considered major in preparing students to participate in a rapidly changing society [18].

Motivation in Learning: There is a wide range of predominant models for motivation, one of them is aligned and applied to technology oriented and educational settings. Motivation can be defined as an individual's effort to accomplish a goal. Keller (1992) argues that strategies based on certain components should be designed to develop motivation. The four components of this model are Attention, Relevance, Confidence and Satisfaction (Keller 1987). Attention refers to the degree to which students' interest and curiosity are stimulated by the lesson. Relevance focuses on the relationship of material and instruction to students' goals during the learning process. Confidence is about enhancing students' perceptual ability to achieve their educational goals. Finally, satisfaction assesses the degree to which students are satisfied with their lesson and achievement. Numerous studies have been conducted on e-learning environments based on this model and supporting its effectiveness [3] (Table 1).

Following the integration of various motivational theories, the ARCS theory was proposed to strengthen the systematic design of learning, which not only serves to provide practical applications and conceptual organization, but also to stimulate student interaction and participation in learning activities.

Table 1. Components of ARCS model

Attention	Relevance	Confidence	Satisfaction
A1. Perceptual Arousal A2. Inquiry Arousal A3. Variability	R1. Goal Orientation R2. Motive Matching R3. Familiarity	C1. Learning Requirements C2. Positive Consequences C3. Personal Control	S1. Natural Consequences S2. Positive Consequences S3. Equity

3 Methodology

The aim of this research is to investigate if this e-course as a case based approach which utilizes the inquiry based learning and the ARCS motivation model contributes to the effectiveness of e-learning and the development of students' motivation for learning history as subject. Case-based approaches help students apply their emerging knowledge by studying ill-structured problems in authentic real-world situations. Working in small groups, in or out of class, gives students the opportunity to discuss cases and questions with each other prior to the whole class discussion [15].

More specifically, a blended learning environment was designed, implemented, and evaluated on the Moodle Workplace. It is based on the key components of Keller's ARCS Motivation Model, developed in accordance with the five phases of the inquiry based learning (Orientation, Conceptualization, Research, Conclusions and Discussion), and it refers to the "Golden Age of Greece".

The educational intervention started with a case study scenario, which said: *Your history teacher gave you a challenge. You are locked in this virtual laboratory which has transported you to Athens in the 5th century. We will be divided into five groups and the members of each group will take on one role. The goal of each team is to overcome all obstacles and manage to escape. From each round, the teams earn points which increase according to the difficulty of the riddle. The adventure begins!*

Students were then asked to complete seven modules. The first and the last were the Entry and Exit in the virtual laboratory while the other five were related to the subject of the chapter. Each module was developed based on the five general phases of the inquiry based learning cycle. In the first phase (Orientation), the students through the Voki digital guide explored the topic of the unit, stated the problems and identified the variables of their research. In the second phase (Conceptualization), they discussed on a virtual platform with their classmates about this challenge, formulated research questions and research hypotheses to begin to implement their research design. In the third phase (Investigation) students collected information through exploratory activities, analyzed it, organized it and drew their first conclusions. The digital tools used were Articulate Storyline 360, Acropolis virtual tour, H5P, Rebus generator, Online Game "Glafka", My Blue Robot, Thinglink, Quizlet, Qr Code generator, Storyfab, Jigsaw Puzzle. In the fourth phase (Conclusion) they interpreted their results by checking their reasoning and the reliability of their findings while in the last (Discussion) they shared the results of their research, formulated their own perceptions, provided feedback to their classmates and pondered.

The research intervention will focus on the following research questions.

RQ1: Can this customized e-course based on the inquiry-based learning and the ARCS motivational model contribute to the effectiveness of the e-courseregarding to the indicators of i) Engagementii) Cooperation iii) Completion iv) Grades?

RQ2: Is it possible for students to develop motivation for the History as subject through this customized e-course based on the inquiry-based learning and the ARCS motivational model regarding to i) Attention ii) Relevance iii) Confidence iv) Satisfaction?

3.1 Design and Process: The specific educational program entitled "*Digital Ancient Athens*" was based on a blended learning environment (Face to face Driver Model). The teacher guided the learning process in the classroom while the trainees attended the course using iPads to access the digital material and complete the online activities. A group of subjects (28people) was used in the research and the measurements were made before, during and after the teaching intervention.

3.2 Educational Intervention: Indicatively, we will focus on the fifth unit. In this section, they will learn that the Classical Period in ancient Greece produced outstanding cultural and artistic achievements. They will also understand how the art of this culture and art movement during this period would influence the importance of art for the rest of time across a myriad of cultures (Table 2).

The **main variables** of the study are the **effectiveness** of the e-course and the **motivations**. Regarding the first research variable, the Bersin e-course effectiveness evaluation model was used (as cited in Poe & Stassen, 2002), which consists of five steps (Enrollment, Activity, Completion, Scores, Feedback / Surveys) and is suggested in "Teaching and Learning Online: A Handbook for UMass Faculty" [1]. In order to better serve the needs of this course, the specific steps in Engagement, Cooperation, Completion, Grade were slightly modified. While, regarding the second research variable, the ARCS motivation model was used with four basic components (Attention, Relevance, Confidence, Satisfaction).

The **Research tools** which used were:

- a *Questionnaire* to investigate prior knowledge and experience of students,
- a *Questionnaire* to investigate students' initial motivation for the e-course,
- a *Digital framework* using the **Monitoring of Learning plans plugin** based on the indicators of e-course effectiveness and
- a *Questionnaire* to explore students' final motivations for e-learning.

The statistical criteria of this research were the Statistical criterion of one sample t-test and the Statistical criterion t-test for paired samples (paired samples t-test).

4 Research Findings

The following were used to display the statistical results of the research:

According to the **questionnaire** for school subjects (Table 3):

Table 2. Educational intervention

IBL	Strategies	Activities		Research	
	ARCS	Description	Tools	Tools	RQ
ORIENTATION	**A1 A3 R1 C1 C2**	**Digital guide** Students are informed about the learning objectives of the unit, the rules of the virtual lab (e.g the time limit of each phase/challenge, how to solve the Rebus puzzle, how to play the online game "Glafka") and generally the flow of activities.	VOKI	Moodle Workplace Log Data Observation	Engagement
CONCEPTUALIZATION	**C3 S1**	**Forum** Students ask questions and queries about the lesson. (*What do you think will happen in this test?* / What keywords come to mind? / Is there anything you would like to know?)	Forum activity	Quality discussions in the forum	Engagement Cooperation
INVESTIGATION	**A1 A3 R3 C1 A2 R2 C2**	Students attend the interactive content Through the web application (https://www.acropolisvirtualtour.gr/index.html), they can comprehend the location of the most discrete monuments – Parthenon, Propylaia, Erechtheion, Temple of Athena Nike- in relation to its surroudings and realize a virtual walk by choosing their own successive viewpoints. Students try to decipher the puzzles. Students individually play an online educational game about the architecture of the ancient Greek temple, Glafka (https://ancienttemple.ysma.gr/) .	Articulate Storyline 360 Acropolis virtualtour RebusGenerator OnlineGame "Glafka"	Moodle Workplace Log Data Observation Quality discussions in the forum	Engagement Completion Grade
CONCLUSION	**R3 S1**	**Padlet** Students post the most important information they have collected.	Padlet	Moodle Workplace LogData	Engagement Completion
DISCUSSION	**C3 S1**	**Forum** Students discuss with their classmates. (Did you find the information you gathered useful?/ What impressed you the most? / Which activity did you like the most and why?)	Forumactivity	Quality discussions in the forum	Engagement
	A2 S1 S2 S3	**Quiz** Students complete a multiple choice quiz to test their knowledge.(Example: There, there is the ivory statue of the goddess Athena (a. Temple of Athena Nike, b. Parthenon, c. Erechtheion)	H5p	Moodle Workplace LogData	Engagement Completion Grade

(*continued*)

Table 2. (*continued*)

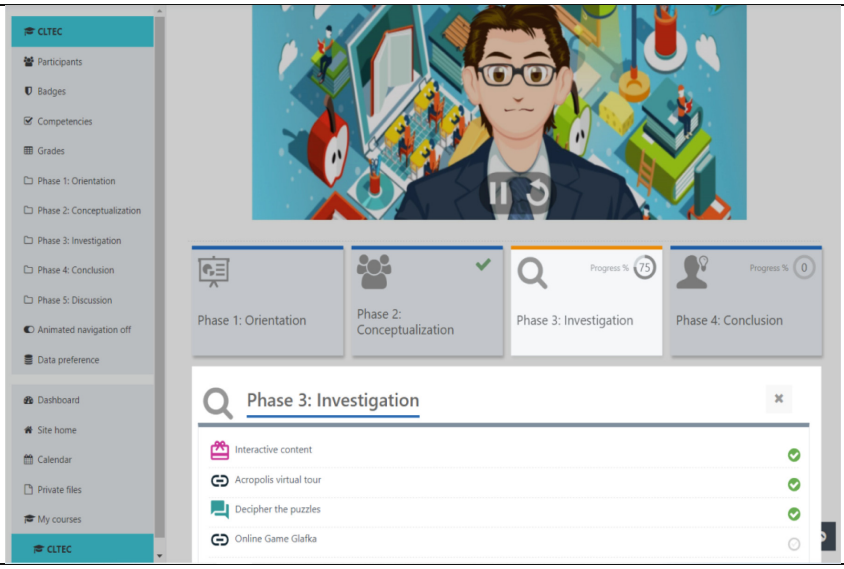
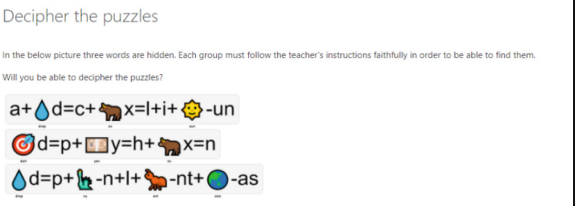
<table>
<tr><td colspan="2">Screenshot: The structure of the course</td></tr>
<tr><td colspan="2"> 
</td></tr>
<tr><td colspan="2">Indicative Activities</td></tr>
<tr><td> 
</td><td>Acropolis virtual tour</td></tr>
<tr><td> 
</td><td>Decipher the puzzles</td></tr>
<tr><td> 
</td><td>Online Game Glafka</td></tr>
</table>

Table 3. Educational intervention

School Subjects					
	IT	**History**	**Maths**	**Environmentalstudies**	**Literature**
Lessons that I like the most	67,9%	7,1%	10,7%	14,3%	0%
Lessons that are more difficult	0%	28,6%	21,4%	14,3%	35,7%
About History					
Degree of satisfaction for the history lesson	No 75%		Yes 17,9%	Indifferent 7,1%	
Suggestions for changes in the lesson	Use of multimedia 42,9%		Teachingmethod 42,9%	schoolbook 14,3%	
Beliefs about the usefulness of the course	No 28,6%		Yes 17,9%	I don't know 53,6%	

To measure the effectiveness of the e-course, (RQ 1) we presented the descriptive data. For each indicator, there were 196 evaluations in our entire sample for the seven modules of e-course. (28 * 7 = 196). The teacher, as soon as the module was completed, graded each student through the digital framework in the Moodle Workplace. The lowest level indicating "Unsatisfactory Performance" was rated with 0 while the highest "Excellent Performance" was rated with 4. The average of each indicator is over 2.90, which proves the effectiveness of the e-course (Table 4).

Table 4. Findings for effectiveness of the e-course

Indicators	Unsatisfactory performance 0	Low performance 1	Moderate performance 2	Good performance 3	Excellent performance 4	Average
Engagement	0–0%	11–5,6%	39–19,9%	89–45,4%	57–29,1%	2,98
Cooperation	0–0%	5–2,6%	37–18,9%	93–47,4%	61–31,1%	3,07
Completion	0–0%	0–0%	59–30,1%	84–42,9%	53–27%	2,97
Grade	0–0%	0–0%	53–27%	76–38,8%	67–34,2%	3,07

Engagement: Depending on the comments and questions they made in the group discussions either voluntarily or at the instigation of the teacher, the time spent in the platform and general his active role in the activities.

Cooperation: The responsibility, the respect and communication with the classmates were taken into account for the evaluation of this indicator.

Completion: Because all students participated in the educational process, the completion rate of both individual and group deliverables was examined. Those who had fully answered the group discussions, who had answered all the quiz questions and the worksheets gathered the greatest score.

Grade: The cognitive performance of students in the educational process (the performance of the students in the individual and group deliverables).

Finally, to measure the motivations change, the inductive statistics was used, namely the statistical criterion t-test for dependent samples (Paired Samples t-test) but also the

descriptive statistical measures of the mean value (mean) and standard deviation of the four factors. Reliability was also checked using the Cronbach's Alpha coefficient as well as the regularity of the sample with Shapiro-Wilk if our sample was less than 50. The research tool used was the questionnaire (pre-test and post-test) which consisted of 36 improvisation test questions concerning the four components (Attention, Relevance, Confidence, Satisfaction). Students answered all the questions on a scale of 1 to 5 (1 = I totally disagree, 5 = I totally agree). According to the scale of answers (1–5) we considered as a control criterion the constant c = 3 (test value) - average value to check if there is a statistically significant effect on motivation. We collected the data from the first and second questionnaire, we calculated the average and the standard deviation of the answers and we observed the minimum and maximum value that they scored.

From the One-Sample t-test analysis, we found that the average **Attention** at the end of the educational process (3.33) was statistically significantly higher compared to its beginning (3.01) in confidence interval 95% ($p < 0.05$). The same was for the **Relevance** factor, where the average at the end (3.89) was statistically significantly higher compared to its beginning (3.21) at a 95% confidence interval ($p < 0, 05$). In the **Confidence** factor the average was relatively high (3.30) therefore it marks a small but at the same time significant increase (3.37, $p < 0.05$). Finally, regarding the **Satisfaction** factor, the largest statistically significant difference was noted with 3.34 becoming 3.99 ($p < 0.05$). That is, there is a statistically significant change in the motivations of learners through this e-course based on the inquiry based learning and the ARCS motivational model (Table 5).

Table 5. One-sample t-test: differences in average incentives

Scale	t	df	Mean dfference	95% confidence interval of the difference		Sig. (2-tailed)
				Upper	Lower	
Attention (pre-test) (post-test)	−2,1	335	−0,1	−0	−0	0,04
	5,9	335	0,2	0,2	0,3	0,00
Relevance (pre-test) (post-test)	2,3	251	0,1	0	0,2	0,02
	13,3	251	0,8	0,7	0,9	0,00
Confidence (pre-test) (post-test)	4,0	251	0,2	0,1	0,3	0,00
	4,2	251	0,3	0,1	0,4	0,00
Satisfaction (pre-test) (post-test)	4,6	167	0,2	0,1	0,3	0,00
	16,6	167	0,9	0,8	1	0,00

After first checking the regularity of the sample, we examined whether our sample came from an approximately normal distribution. In this case because our sample (n) was 28 students, ie $n \leq 50$ we relied on the Shapiro-Wilk criterion with Sig < 0.05 for each dimension of the questionnaire. Based on the following tables, it was shown that the sample comes from an approximately normal distribution ($p < 0.05$ for all variables). Motivational correlations of the incentive model were checked to investigate the relationship between them. The Pearson correlation index was used for the test after a regularity test was performed. This test showed that the results of the second measurement are higher compared to the results of the first and the difference between the two measurements is statistically significant. Below are the results using the statistical test Paired Samples t Test and the correlations between the measurements of the scales before and after the procedure (Tables 6 and 7).

Table 6. Paired sample t-test: differences in average motivation

				95% confidence interval of the difference				
Combination pre-test & post test	Mean	SD	SEM	Lower	Upper	t	df	Sig. (2-tailed)
Attention	0,3	0,83	0,05	0,40	0,23	6,97	335	0,00
Relevance	0,7	1,007	0,06	0,81	0,56	10,76	251	0,00
Confidence	0,1	1,058	0,07	0,20	−0,06	1,07	251	0,28
Satisfaction	0,7	0,991	0,08	0,81	0,50	8,56	167	0,00

Table 7. Paired sample correlations

	N	Correlation	Sig.
Attention pre-test & post test	336	0,36	0,00
Relevance pre-test & post test	252	0,30	0,00
Confidence pre-test & post test	252	0,35	0,00
Satisfaction pre-test & post test	168	-0,05	0,55

In general, there are statistically significant differences between the averages of the motivators before and after the educational process. This customized e-course led to a statistically significant increase in **Confidence**, **Attention**, **Relevance**. However, there did not appear to be a statistically significant improvement in participant **Satisfaction** ($p > 0.05$). *That is, there is a statistically significant change in the motivations of the trainees through this customized e-course based on the inquiry based learning and the ARCS motivational model.* Also, an important finding is that Confidence, Attention and Relevance are statistically significantly correlated with Confidence, Attention and

Relevance after the procedure ($p < 0.05$). Satisfaction before, however, does not affect Satisfaction after, which means that Satisfaction can either be easily shaken or improved.

5 Conclusion

We find that this customized e-course contributes to the effectiveness of the e-course (The average of each indicator was over 2.90 on a scale from 0 to 4), especially if one considers the difficulty of students in the history lesson. Regarding the second research question, there was a statistically significant increase in the mean values in each component of the ARCS model before and after the experimental procedure. The conclusions that emerge from the control of the research questions of this research are categorized:

In terms of effectiveness: A history-based learning curriculum based on inquiry based learning and utilizes the ARCS motivational model:

- minimizes dropout rates encouraging active participation and completion.
- enhances collaborative skills such as responsibility and initiative.
- enhances students' cognitive performance and the comprehension of historical concepts and events.

In terms of incentives:

- The incentives of the trainees are increased when ARCS model strategies and techniques are integrated into a blended learning environment.
- The incentives of the trainees are increased when innovative digital tools are integrated into a blended learning environment that encourage interaction with each other.
- The possibilities offered by the educational electronic platforms and the digital material development tools that can be integrated in them utilize the strategies and techniques of the ARCS model.
- A History-based learning curriculum based on inquiry based learning, utilizing the ARCS motivation model contributes to the development of each component.
- The strategies and techniques of the ARCS model are effectively combined with the inquiry based learning model [12] for the design of an educational program in a digital learning environment.

Moodle Workplace with the integration of plugins emphasizes the superiority of e-learning in the digital age of the 21st century. It functions as a remarkable educational innovation in the school reality where the teacher can directly grade the students and provide them the appropriate feedback. At the same time, the intuitive design of the platform makes the user navigation easy, and the communication with their teacher and classmates is encouraged.

When the evaluation of the results was carried out, after the processing and analysis of the data of the research intervention, some methodological limitations arose.

– *Lack of time:* The experimental process lasted only two weeks, which did not allow us to take more intermediate measurements in the field of motivation and to get an accurate picture of the satisfaction that the students felt.

– *Sample size:* The sample of our research was very small as it consisted of a case study of a school class of 28 people. Therefore, the limited sample size does not allow generalizations about the total number of fourth graders.
– *Motivation tool validity:* The process of completing a questionnaire based on the psychometric five-point Likert scale often does not provide the necessary attention from students and leads in part to unreliable and subjective results.

More specifically, the research intervention could be carried out for a longer period of time with more frequent and accurate measurements. Because of the limited sample size, it would be fruitful to be carried out in a larger number of trainees. Finally, the five-point Likert scale often does not provide the necessary attention from students and leads in part to unreliable results. For this reason, special attention should be paid to the validity of the measurement tool.

Finally, this customized e-course could also be used in various cultural or social subjects where the content is obscure with difficult concepts and definitions and the students without pressure will gather information and delve into each topic.

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Assessing the Performance of Open Contracting in Colombia Through Data Mining

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Abstract. Globally, governments spend an estimated US$9.5 trillion each year through contracts with private companies, amount equivalent to 15% of world GDP due to the resources involved, public procurement is an activity with high risk of corruption [1]. The use of open data in public procurement systems is a powerful tool to increase contract transparency monitoring. This study utilizes and empirically analysis to explore implicit relationships between variables allowing to assess the impact of e-procurement implementation on public contract process in Colombia through data mining tools. The methodology developed was CRISP- DM, using a data base formed by 5.611.700 records of public contracts making through the SECOP Platform since 2013 to 2018. To determine the relation between items an Apriori algorithm of association rules data mining method was implemented in WEKA. Despite the positive impact of the e-procurement platform the results also shows the lack involvement of citizens in the process, and the lack participation of small and medium-sized companies in the public procurement process.

Keywords: Open contracting · Public spending · Data mining · Association rules · Apriori algorithm

1 Introduction

The competitiveness of a country is essential to its overall national prosperity during the contemporary globalized economy. Many researchers, institutions and studies shows the negative direct impact that corruption has on macroeconomic and microeconomic indicators, such as GDP growth, employment, tax revenues, local and foreign investments and in general its negatives effects on the economic environment and its high political and social cost [2].

According to the OECD Anti-Bribery Convention 57% of cases of corruption prosecuted are bribes to get public contracts [3], every year, governments spend huge sums

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of money through contracts, this global spending amounts to over US$9.5 trillion each year, represented 15% of the global GDP. This corruption is partly due to the information about, how, when, and where this money is spent, is often not publicly available.

Frequently, there is limited information in the public record about (a) the planning of public contracts, (b) how public contracts are formed, (c) the content of the agreements; (d) the progress of their performance or (e) the government supervision procedures. This lack of information can make difficult to assess whether the government is getting good value for money or whether the parties to the contract are fully complying with their obligations. It also creates an uneven playing field for private sector actors who are seeking to compete for and get public contracts. At the same time, there is a limited opportunity for citizens and communities to participate and monitoring public contracts or for the private sector to give feedback on public contracting processes [4]. The open publication of the different phases of a contracting process can strengthen transparency, impacting positively the prevention and struggle against corruption [5] besides, it helps to improve the efficiency of public spending. For those reasons the concept of open contracting is emerging as a global strategy to increase contract transparency and monitoring, with major expected benefits in terms of quality of governance, better value for money, corruption prevention, better service delivery and superior development outcomes [6].

2 Open Contracting and E-Procurement in Colombia

Since 2011 Colombia has implemented regulations guided by the open government initiatives, in 2012 the guidelines for the implementation of open data in Colombia, which presents an Open Data Model adjusted to The Online Government Strategy, allows, operating and managing the supply and demand of the public access data currently owned by the entities of the Colombian State [7] in December of the same year the Ministry of Information Technologies established by Decree 2693 of 2012 the general guidelines for the online government strategy of the Republic of Colombia, subsequently repealed by Decree 2573 of 2014. Regarding to transparency, the Law on Transparency and the Right of Access to National Public Information - Law 1712 of 2014 - establishes the procedures to guarantee the right of access to public information, along with exceptions referring to information that is classified public or reserved public information - Decree 1078 of 2015–[8]. Colombia is also member of the Open Government partnership since 2012 [9], and together with other countries concerned as Georgia, Korea, Slovakia, and the United Kingdom are innovatively using technology to increase the transparency and effectiveness of procurement processes through online platforms, other commitments on beneficial ownership transparency at anti-corruption summit in Colombia are mentioned in the Table 1.

Colombia's e-purchase system was created in 2013, this electronic system of public procurement called SECOP, which was improving in 2015 SECOP II it's a platform that allows transactions between buyers and sellers, and manage all the process to get a public contract in order to ensure the efficiency and transparency of the public budget. Currently, more than 1200 entities and 7,900 data sets are part of the platform [10]. According to the External Circular of Colombia Efficient Purchase published in 2018, SECOP is integrated by three components, which are:

Table 1. Colombia commitments on beneficial ownership transparency at anti-corruption summit

Overview	Commitment
Beneficial ownership registers	Colombia commits to create a Central Registry of Beneficial Ownership of National Companies, including those whose parent companies or investment legal arrangements are domiciled offshore, with effective and unrestricted access for local and foreign law enforcement authorities
Global beneficial ownership register	Colombia commits to participate in the Global Beneficial Ownership Register with the information collected in public procurement platforms
Beneficial ownership information collection, sharing, availability	Colombia commits to facilitate access to local and foreign law enforcement authorities on beneficial ownership information with the necessary measures aimed at preventing targeted companies, investment legal arrangements and individuals from being alerted of ongoing investigations
Open contracting partnership	Colombia commits to continue working Partnership, as it has done since 2012 with the Open Contracting
Open contracting data standard	Colombia will join the Contracting 5 group to promote open contracting globally and commits to continue its ongoing effort to fully comply with the highest Open Contracting Data Standards
Public procurement	Colombia commits to continue the deployment of its procurement transactional platform which links with budgetary platforms. Colombia commits to enhance the disclosure of public procurement data at national and subnational levels, focusing on increasing the publication of procurement information at the subnational level and to continue using the Ministry of Technology open-data web site to give standardized information of public procurement that can be easily used by the civil society

Source: Anti-Corruption Summit, 2016 available at www.gov.uk/government/publications/anti-corruption-summit-country-statements

a) **SECOP I:** It is the platform where all the entities that develop contracting with public resources, publish all the documents which are originated in the contracting process, the purpose of this platform is only publishing
b) **SECOP II:** It is a transactional platform, which the public contracting process is developed online, in this platform the state entity and the potential suppliers could interact, besides that in this platform in also allowed follow up the process
c) **VIRTUAL STORE OF THE COLOMBIAN GOVERNMENT** It is a transactional platform of electronic commerce, which the buyers make transactions to

acquire goods and services by framework agreements of prices, by contracts of aggregation demand or acquisitions by minimum amount in large areas.

All entities that use public resources in their contracting are obliged to publish all their contractual processes in the SECOP, this in accordance with the stipulated in the article 3 of Law 1150 of 2007, 223 Decree 019 of 2012 and decree 1082 of 2015.

All of those efforts are materialized in the position gained in rankings and measurements, in Open Data indicators, Colombia ranked 28th in the world and 4th in Latin America by the Open Data Barometer, which measures the impact of open data initiatives in the world, also the Global Index, which measures the current state of data release, Colombia occupies the 4th position after Taiwan, the United Kingdom and Denmark, with a percentage of 68% [11].

Those facts raises the question whether the implementation of open data in public procurement has improved the efficiency of the process, however, few resources are found about the performance of the e-procurement system in Colombia SECOP, the information generated corresponds to scarce indicators produced by the National State Contracting Agency - Colombia Compra Eficiente-, who is responsible for managing the platform. Therefore, the interest of this research is to assess the impact of open contracting and analyze the objectives' compliances of the e-procurement platforms implemented in Colombia thought data mining techniques allowing the generation of a descriptive model and the data analysis to identify possible behaviors regarding to the public procurement and public spending.

3 Methodology

The methodology followed by this research has been CRISP-DM, this model is the most frequently used in practice and cited in literature regarding to the Data Mining, because is complete and especially oriented to specific goals. According to the CRISP-DM concept, the lifecycle of a data exploration project consists of 6 stages (Fig. 1).

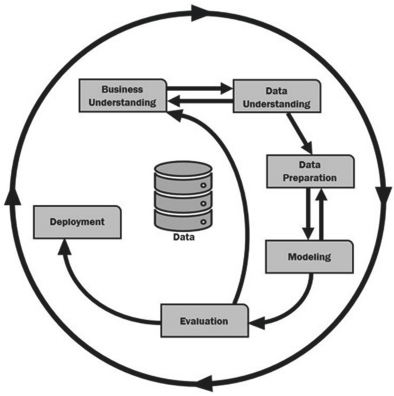

Fig. 1. CRISP-DM methodology stages. Source: Adapted from Manikandan et al. (2013).

According to this methodology, the process to develop this research was:

3.1 Data Understanding

The data of this research thesis was collected from SECOP reports, which is the e-procurement platform for public contracting, thus, it is open access. The Data Base used in this study contained 5.611.700 recorded of public contracts making through the e-procurement platform in Colombia since 2013 to 2018 and the data of 4658 government entities and 378.784 suppliers registered on the platform. The data bases are downloaded in Microsoft Excel files CVS.

The government entities registered consist of municipalities, city halls, hospitals, pensions fund administrators, army, prisons, foundations, public educational institutions, national agencies, etc. The information about the suppliers contain name, Nit, company type (large, medium-sized or small), industrial sector, location (address), country, city, UNSPSC code of the supplier among others (See Fig. 2).

Vista previa de la tabla

Explorar los datos | Crear visualización

Nombre	NIT	Tipo E...	EsPyme	Ubicac...	Fech	Pais	Depart...	Municl...	Codigo...	Descri...
	No Definido	No Definido	No	No Definido	01/01/2001	No Definido	No Definido	No Definido	ND	No Definido
Soporte CCE	000000000	Entidad Est...	No	Colombia, ...	02/13/2015	Colombia	Arauca	Arauca	ND	No Definido
Fundacion ...	900199679	Fundaciones	Si	Colombia, ...	02/16/2015	Colombia	Distrito Ca...	Bogota	ND	No Definido
CREA PROD...	900738098	Sociedad p...	Si	Colombia, ...	02/16/2015	Colombia	Distrito Ca...	Bogota	ND	No Definido
JYF INVERSI...	9004247138	Sociedad p...	Si	Colombia, ...	02/16/2015	Colombia	Distrito Ca...	Bogota	ND	No Definido
Diego Cifue...	16070700	Empresa u...	No	Colombia, ...	02/16/2015	Colombia	Distrito Ca...	Bogota	ND	No Definido
INFORMATI...	8001146721	Sociedad A...	No	Colombia, ...	02/16/2015	Colombia	Distrito Ca...	Bogota	V1.81110000	Servicios in...
DIANA MO...	52981071	Persona Na...	Si	Colombia, ...	02/16/2015	Colombia	Distrito Ca...	Bogota	ND	No Definido
ITO SOFTW...	9003720358	Sociedad p...	Si	Colombia, ...	02/16/2015	Colombia	Distrito Ca...	Bogota	ND	No Definido
CIPSA SAS	8300117251	Sociedad e...	Si	Colombia, ...	02/16/2015	Colombia	Distrito Ca...	Bogota	ND	No Definido
INVERSION...	900206594	Sociedad A...	No	Colombia, ...	02/16/2015	Colombia	Distrito Ca...	Bogota	ND	No Definido
Santo Reflej...	900772557	Sociedad e...	Si	Colombia, ...	02/16/2015	Colombia	Distrito Ca...	Bogota	ND	No Definido
PARTEQUIP...	8301168077	Sociedad A...	No	Colombia, ...	02/16/2015	Colombia	Distrito Ca...	Bogota	V1.22100000	Maquinaria...
EDUCACIO...	8001960748	Sociedad p...	Si	Colombia, ...	02/16/2015	Colombia	Distrito Ca...	Bogota	ND	No Definido

< Anterior Siguiente >

Mostrando Proveedor 1-14 de 378.784

Fig. 2. View of the SECOP suppliers database. Source: https://www.datos.gov.co/SECOP-II-Proveedores-Registrados/qmzu-gj57

The public contract data base content the contract identifier ID, government entity, procurement method, contract object, location, budget, publication date, award date, among others.

3.2 Data Preparation

To select the data is important to assess its relevance to meet the data mining goals. In the case of this study the relevant information was selected according with the main objectives of the open contracting 1) Effectiveness, 2) Efficiency and 3) Transparency. These objectives and its indicators are described in the Table 2.

Table 2. Measures for open contracting

Open contracting goal	to evaluate in terms of	Indicators
Effectiveness	Money Increased value of purchases and public procurement The promotion of competition in public purchase (Participation and disclosure)	Contract published Value of published contracts No. of bidders or participants for contract Type of company Adoption of new suppliers
Efficiency	Time	Time of the selection process
Transparency	findings, corrections and savings	Contracts perfected Modifications request, complaints or claims regarding to a contract Citizens consultations

Source: own elaboration

Thus, the kept fields for each database are the fields related with the indicators and evaluated goals mentioned in the Table 3. After this, the data was integrated emerging the original databases tables, some new fields were generated as Number of bidders (in the original field appear the Bidders IDs), Time of the selection process = award date - publication date (days), among others. For some wide range attributes intervals are calculated to facilitates the handling of the data and reduces the final size of columns and Items in the transactional matrix. In the case of the Contract budget, the ranges are selected according to the legislation. As a result of this selection the number of columns (fields) are 78% reduced. The following table shows a view of the final items and item sets:

Table 3. Final items

Attribute	Description	Item	Attribute	Description	Item
Investment sector	Education	A	**No. bidders**	1	Z
	Health Care	B		[2 – 8)	AA
	Infrastructure	C		[8 – 14)	BB
	Policing and Public safety	D		[14 - 20)	CC
	Housing	E		>20	DD
	Science and technology	F	**Company Type**	Small	EE
	Social services	G		Medium- sized	FF
Budget (COP)	[$172.480.000- $331.972.650)	H		Large	**GG**
	[$331.972.650- $400.400.000)	I	**Perfected Contract**	Yes	HH
	[$400.400.000- $523.600.000)	J		No	II
	[$523.600.000- $616.000.000)	K	**citizens Consultations**	0	JJ
	>= 616.000.000	L		1-5	KK
Scope	Territorial	M		5-10	LL
	National	N		10 -15	MM
Time of selection (days)	[38-44)	O	**Modifications, requests and complaints**	0	NN
	[44-50)	P		1-5	OO
	[50-56)	Q		5-10	PP
	[56-62)	R		10-15	QQ
	[62-68)	S		>15	RR
Year of the supplier register	2013	T	**Contract year**	2013	SS
	2014	U		2014	TT
	2015	V		2015	UU
	2016	W		2016	VV
	2017	X		2017	WW
	2018	Y		2018	XX

Source: own elaboration

The final transactional matrix has as many columns as items, however the items inside each attribute (items-set) are mutually exclusive data. For each transaction just is possible get only one item per attribute, according with this, the levels for the Apriori algorithm in this case is nine, which corresponds to the number of attributes.

The above work is developed using KNIME tool, following the process represented in the next figure (Fig. 3):

The first module reads the file that will be transformed by the second module called "Pivoting". The bitvector, rules and filters, are using to switch information, set grouping rules and ranges, delete data, among others.

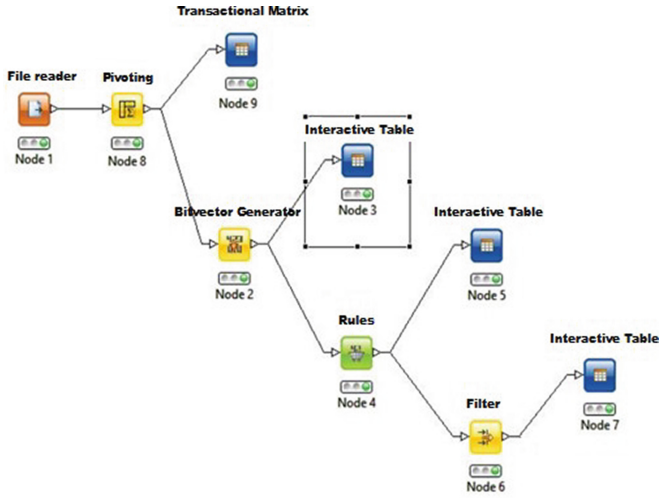

Fig. 3. Knime modules for flat file conversion. Source: own elaboration

The following figure shows the transactional matrix representing each item of the transaction as 0 or 1, to apply the Apriori algorithm (Fig. 4):

Row ID	B	C	D	E	F	G
1	0	1	0	0	0	0
2	1	0	0	0	0	0
3	0	0	0	1	0	0
4	0	0	0	0	0	1
5	0	0	0	0	1	0
6	0	0	1	0	0	0
7	0	0	0	1	0	0
8	0	0	1	0	0	0
9	0	1	0	0	0	0
10	0	0	1	0	0	0
11	1	0	0	0	0	0
12	0	0	0	1	0	0
13	0	0	0	1	0	0
14	0	0	1	0	0	0
15	1	0	0	0	0	0

Fig. 4. View of the Transactional Matrix resulted. Source: Knime Tool

Once the transactional matrix is obtained, it is loaded into WEKA to proceed to apply the data mining algorithm.

3.3 Modeling

The chosen method is Association Rules. The association Method detects ways of match between items that appear together at the same time. For each set of elements, the algorithm creates scores representing the support and the trust. These scores can be used to classify and derive interesting rules of element sets.

Next, the algorithm counts the number of times that each set of elements appears and calculate the relative importance of each of them in all transactions. The algorithm uses this information about element sets, to generate rules that can be used to predict associations or make recommendations. To each recommendation a probability is assigned based on the strength of associations [12].

A rule is defined as an implication of the form A => B, where $A \cap B \neq 0$. The left-hand side of the rule is called as antecedent. The right-hand side of the rule is called as consequent.

In simple words we can say like

- If A and B then C
- If A and not B then C
- If A and B and C then D etc.

The Apriori algorithm begins obtaining the Frequent item sets, which are those sets formed by the items that get a support from the database higher than the minimum support other request by the user. This algorithm gets first, the sets of frequent items of size 1 and then those of size 2 and so on until there are no more sets whose items have no major support to the minimum support.

The parameters of the association rules serve to measure how valid and representative the association rules are in reference to the set of data being analyzed. The main quality parameters of the association rules are [13]:

Support: The support of an item is the frequency which this item is founded in transactions divided by the number of transactions. $$\boldsymbol{Support}\,(A) = \frac{No.\,Transactions\ that\ contain\ the\ item\ A}{No.\,Transactions\ of\ the\ database}$$	**Confidence:** The confidence measure of a decision rule is the division between the support of the decision rule between the support of the antecedent of the decision rule, this is represented by the following equation: $$\boldsymbol{Conf}(A \rightarrow B) = \frac{Support\ (A, B)}{Support\ (B)}$$

A confidence of 0.9 and a minimum support of 0.1 is established for the Apriori algorithm to be implemented, as well as an output of 30 rules. The minimum support and trust value will support that the association rules founded are relevant to the study.

3.4 Results

The data set generates a large number of association rules that are repeated in a certain number of iteration in this case 18, the conceptual filters to validate each rule are confidence and support. In this particular case, confidence is 0.9 and support 10%. Then, the Fig. 5 shows come of the best rules generated by WEKA software.

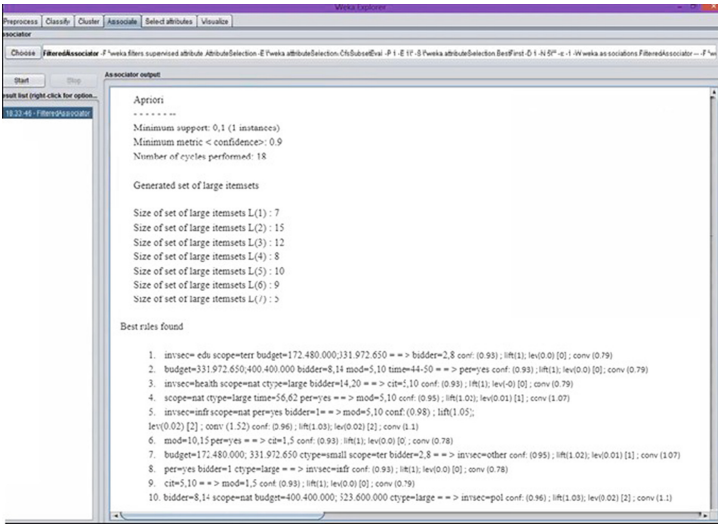

Fig. 5. Best Rules found by Weka. Source: Weka

Thus, the reading of the previous rules is:

- **[budget = 331.972.650;400.400.000 bidder = 8,14 mod = 5,10] = = > [per = yes] conf: (0.93)**

  The procurement with a budget between 331.972.650 and 400.400.000 COP, where involved between 8 and 14 bidders and receive from 5 to 10 inquires of modification, complaints or other request is perfected with a confidence level of 0.93.
- **[invsec = health scope = nal ctype = large bidder = 14,20] = = > [cit = 5,10] conf: (0.93)**

  The procurement regarding to the health investment sector with a national scope, where involved between 14 and 20 bidders and most of them are large companies is consulted by citizens between 5 and 10 times with a confidence level of 0.93.

All the associate rules obtained exceed a confidence level of 0.93 and have a support greater than 50%. The association rules show several patterns and relationships between different variables with levels of confidence and support which validate them within the data set, for this case the got confidence is between 0.93–0.98 and the support since 52 to 61%, as well as the data processing through data preparation and the elaboration of the transactional matrix gives valuable information such as:

I. The majority of citizen consultations carried out are in the range of 1 and 5, with a more probable participation in contracts of national scope in the fields of health and education. Only 21% of citizen inquiries generate some kind of modification, request or complaint. The highest probability of zero participation is shown in the public housing contracts where there is only 1 bidder. Contracts with a budget between $ 331,972,650- $ 400,400,000 are most consulted. In 2017 and 2018, a greater number of citizen consultations are presented.

Although participation has increased in recent years the foregoing evidences shows that the consultation of citizens in SECOP is lack, in the same way it can be inferred that citizens consult more processes on education and health, perhaps because their relevance as fundamental rights.

II. The number of contracts awarded and published has progressively increased in the platform as well as the number of registered suppliers. The number of bidders has increased especially in the education sector at territorial scope in a range 2–8 and in the national health sector in a range 8–15. The lowest number of bidders is found in infrastructure contracts with national scope

In the years 2017 and 2018 there is a greater participation of bidders in the hiring processes, especially in contracts with a budget between 172,480,000 and 331,972,650 and 400,400,000; 523,600,000. The increase in the number of bidders in turn generates an increase in the modifications, complaints or other request made to the process and increases the probability that the contract will be perfected.

In general, 86% of the processes received more than two proposals, a situation that contrasts with the results of years prior to SECOP where more than 70% of the processes were in the hands of sole bidders.

III. In reference to economic participation. The bidders are mostly large companies, especially in health, infrastructure and policing and public safety contracting processes and in national contracts. Small companies participate more in contracts with a budget between $ 172,480,000 - $ 331,972,650 and territorial scope regarding social investment especially in 2015. In 2014, most of the medium-sized registered companies participated in contracting processes the same year, most likely in social investment contracts.

Although the number of bidders has increased, small and medium-sized companies get only 12% of the contracts in public procurement, this because a) the participation processes are unknown or cumbersome, b) the initial investment exceeds the capacity of small and medium-sized companies, or c) ignorance.

IV. In reference to the time, there are only two association rules that show: a) The average selection time is 44–50 days if the contract budget = 331,972,650 - 400,400,000 and the number of bidders is in the range from 8–14 with 5 to 10 modifications, complaints or other request made (confidence level 0.93) and its increases to 50–56 days if there are from 5 to 10 modifications, complaints or other request along with citizen inquiries 1–5 (confidence level 0.96).

V. Most selection processes spent between 44- 50 days ~~for the selection~~. Regarding to the time required for the procurement process, this decreased 32%. Most perfected contracts have a budget of 331,972,650 - 400,400,000 have received 5–10 modifications, complaints or other request, have between 8–14 bidders, and belong to the health sector (confidence level 0.93).

VI. Always if there are between 5–10 modifications, complaints or other request made the contract is perfected. These are mostly done when the process has between 2 and 8 bidders. In 2013, contracts related to social investment did not receive any modifications, complaints or other request. Most modifications, complaints or other request are made by large companies, in contracts of national scope.
VII. Related to de budget the small and medium-sized companies are mostly participated in contract with a budget between $172,480,000 and $331,972,650. Most of the public spending is conducted for territorial contracts by local entities such as municipalities and mayors (around 58.8 billion per year). The sector with the higher budget in its contracts are infrastructure and Policing and Public safety.

3.5 Conclusions

Once conducted the analysis is proved that the implementation of e-procurement platforms in Colombia SECOP has a positive impact in the public procurement process, improving:

a) The average selection time in public procurement processes (reducing it 32%)
b) Participation in terms of number of bidders and the possibility of citizen consultation to involve more oversight and control in the hiring processes. Despite this, citizen consultation is scarce and just a few bidders are smaller and medium-sized companies.

For other hand, was determined than the variables that affect the efficiency and effectiveness of e-procurement are related to money Increased value of purchases, promotion of competition in public purchase (Participation and disclosure), Time, findings, corrections and savings in the contract process.

Additionally, was proved that one valuable bounty of these platforms is the availability of large amounts of historical data and repositories that can provide valuable information to gain a better understanding of the public procurement in Colombia, those results could lead to formulate better policies that encourage open government initiatives to face the corruption and at the same time influence the competitiveness and economic growth of the nation.

As follows, there are some suggestions developed based on the research findings of this study.

1. Create a training plan for small and medium businesses, as well as for citizens to explain the use of the SECOP platform, how to participate in public tenders, and in general, all the process including consultations
2. Generate an advertising campaign or strategy to allow more citizens know about the oversight and control process that they can perform on public spending from SECOP.

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Engineering for Sustainable Development: A Smart Pedagogical Framework for Developing IoT Projects Applied to Climate Action – Practices and Challenges

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Abstract. To promote UNESCO's Sustainable Development Global Goals (SDGs) in Higher Education and document a set of good practices emerging from the construction of Arduino Internet of Things (IoT) projects, particularly as contributions to climate action (SDG 13), authors followed the three-stage design-based methodology. Thus, a conceptual framework was designed and aligned with an educational scenario. The framework was orchestrated with the principles of smart pedagogy aiming at smart learning. Accordingly, an e-lab was developed, incorporating technological platforms/tools, and was delivered as an e-course lab to 67 tertiary education student engineers. Finally, data were collected and analyzed by a Strengths-Weaknesses-Opportunities-Threats (SWOT) data analysis. From the findings (Strengths), authors concluded to a set of strategies that could be used as good practices, emerged from the construction of IoT projects when they are aligned with smart pedagogical frameworks' guidelines. However, Weaknesses, Opportunities and Threats were considered as challenges and thus an impetus for refinement and redesign.

Keywords: Smart pedagogy · Education for sustainable development · Project based learning · Agile Kanban · Design-based research · SWOT analysis

1 Introduction

Nowadays, the humanity faces crucial issues with the sectors of economy, ecology, and equity of all communities. With respect to the environmental pillar, climate change and its dramatic visible consequences, daily shake the sustainability of our planet. Despite the policies and initiatives taken by governments and other international associations like ACCEE and OECD about world sustainable development, it is an individual duty to undertake the responsibility and contribute collectively to integrated solutions.

From the other hand, the digital era provokes every-day challenges. Digitalization is concurrently a trend and a mission, especially, after the Covid19 pandemic, where the term "Digital Transformation" has begun to become more and more a necessity.

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That means that every citizen should be reskilled or upskilled, to come up with cutting-edge digital challenges such as smart applications based on Internet of Things, Machine Learning and Artificial Intelligence, as well.

At this point, education plays the most important role, because it has the strength to cultivate consciousness (not only ecological) and collective intelligence. It has the potential to generate smart students with augmented skills and competences, particularly capable problem-solvers of global critical issues and ambassadors of the global well-being. However, living in a complex and dynamically changing world, the question arises, how could education achieve this demanding accomplishment? The answer is quite complex, too. An about simplistic reply could be that the way one learns must be transformed to keep pace with the current conditions, which means that more emphasis and weight should be given to the core of education, pedagogy. Therefore, modern innovative robust contexts, namely smart pedagogical frameworks must be formulated and implemented at all levels of education, from the lowest to the highest. Particularly, regarding higher education, the burden is even greater as it is the bridge between education, society, and the business world. As such, this paper, as a part of a wider research on the context of smart pedagogy and learning, provides useful guidelines, articulated as good practices and challenges, about the orchestration of smart pedagogical frameworks in higher education. Specifically, it refers on what and how of the framework is perceived, relative to the student engineers' learning experience design. The next section describes the theoretical concepts in detail.

2 Theoretical Background

2.1 Education for Sustainable Development in Higher Education

In 2015, representatives of the state, society, and governments, as well as senior members of the United Nations, came together to set goals for global sustainable development. They managed to create a program with seventeen goals that intersect the four pillars of sustainable development, namely the environment, the economy, society and culture, the so-called Sustainable Development Global Goals (SDGs) [2]. The promotion of these goals is the main concern of all people, as they are typically designed in a program of the people, by the people for the people. However, the role of education is pivotal, as it is the key process for generating sustainable and responsible citizens. Education cultivates skills and competencies to the students in order them to adjust with the everyday changes of the diverse societies, caused by the accelerating digitalized new era. Higher Education has the social responsibility to respond to the complexity of current and future global challenges [19]. Higher Education (HE) prepares students and students for their insertion in the labor market, and specifically the competitive and demanding business world, where soft, life and career skills are necessary. At the same time, universities and higher education institutions are communication and collaboration nodes between the academia and the professional world, bridging this gap through the education for sustainable development.

The international literature [21] highlights the emergence of effectively integrating sustainability in traditional interdisciplinary academic courses in their curriculum, either creating whole programs, or department majors for ESD. The enhancement of the specific

set of skills and competences is achieved when all the above-mentioned teaching entities are supported by well-designed pedagogical frameworks, based on what we call "Smart Pedagogy".

2.2 Smart Pedagogy – The Essence of Smart Learning

Pedagogy is the core of learning. Pedagogy is even more necessary for smart learning when the factor of technology is involved [5]. Hwang [13] typically mentioned that "new learning modes will raise new pedagogic issues" (p11). Emerging technologies and rapid accelerating technological advances, highlight the need of novel, innovating teaching methods, strategies and techniques which can meet the demands of the 21st century [6]. All innovating methods that could transform learning to optimal, are important components of what we call smart pedagogy. Smart pedagogy is the essence of smart learning, as such the instructors, the instructional designers, and the practitioners, even the educational technologists by different perspectives should focus on applying it in teaching practice. Three years ago, Uskov et al. [23] defined Smart Pedagogy (SmP) as "…a set of instructor's teaching strategies, activities and judgements to a) understand the student/student profile (background, goals, skills, competencies and capabilities), and b) provide optimal learning processes and environments with corresponding smartness features to help students to achieve their goals" (p2). They also proposed six features of smartness of smart education, which are included by SmP, as follows: 1. Adaptation, 2. Sensing (Awareness), 3. Inferring (logical Reasoning), 4. Self-learning, 5. Anticipation and 6. Self-organization. Moreover, according to Zhu et al., [25] smart pedagogy is articulated by a four-tier architecture. At the first layer of "Class-Based differentiated Instruction", strategies should empower students to cultivate basic knowledge and core skills by getting engaged in different tasks according to their learning preferences. At the second layer of "Group-based collaborative learning", strategies should enhance students' comprehensive abilities, by getting engaged in collaborative tasks, following the scripting of CSCL. At the third layer of "Individual-based personalized learning", strategies should enforce students' personalized expertise, namely, students' pace of learning, the selected method, and the tools according to their interests and needs. Finally, at the fourth layer of "Mass-based generative learning", strategies should enhance students' collective intelligence. This means that students are active participants in constructing relevant content and have acquired metacognitive abilities.

There is much discussion in academia about the concept of smart learning, which is directly linked with the concepts of smart learning environments, smart pedagogy, and smart students [25]. Many definitions have been proposed, although they are mixed, from different perspectives, obscured by ambiguity. Smart learning is described as context-aware and ubiquitous [13], by the utilization of digital devices and social media. Adu, & Poo [1], set smart learning in the highest level of evolution of the e-learning paradigm, when social technologies [15] were added to the existing sensor technologies, making learning ubiquitous, given the use of mobile phones and the wireless communication. Kwon and Bhang [16] (as cited in Budhrani et al., [5]) define smart learning as an aspiration of making learning more effective and efficient. Lee et al. [17], mention that learning occurs in formal and informal settings, social and collaborative learning, personalized and situated learning, and application and content focus. Middleton [19] also focuses

on smart learning from its student-centered approach and how it could be benefited by the smart technologies. Gros [11] according to Zhu [25] enumerated ten key features, which are the focus of smart learning, characterizing it as a "system", distinguishing its advisory role, specifically with the prediction and guidance of students in the real world. Budhrani, [5] mentioned that smart learning consists of how the three elements of smart learning – environment, pedagogy, and student – are represented in those definitions. From all the above, it is obvious that smart learning arises from optimal blends of smart technology and smart pedagogy. However, smart learning refers less on devices or IT infrastructure, than students and the way they learn, namely the pedagogy. Summarizing, to provide opportunities for smart learning, pedagogical innovative methods (strategies/techniques) should be orchestrated appropriately in well-designed pedagogical frameworks and be implemented by a set of technologies. Thus, a set of educational affordances [14] stand out as services to students, aiming at their learning enhancement.

2.3 Innovative Teaching Methods (ITM), Project Based Learning (PjBL) and Agile Methodologies

What could be described as an Innovative Teaching Method (ITM) in the age of digital learning? Innovative means anything that goes against to the established, stable, and consolidated, and therefore, innovative teaching methods are far from traditional didactics. ITM spring off Constructivism, Constructionism and Connectivism, aiming at better support students' acquisition of demanding 21st century skills and competencies. Across that line, the Project-based Learning (PjBL) theory, includes a set of innovative features, such as the establishment of a student-centered environment, collaboration and social interaction, authentic tasks based on real-world problems, comprehension of the curricular content, multiple modes of expression, emphasis on time management and authentic assessment [12]. From the other hand, agile methodology, came to fit properly into the puzzle of teaching practice. Although the agile methodology was built to handle software development processes in the early 2000s [4], over the years, it has been adopted by other industries, especially education [20]. The emergency of adapting learning to the evolution of the learning environments from technology penetration as well as students' competencies empowerment to a demanding changing society, led agile to be established as an innovative concept for redesigning the teaching approaches, supporting, and reinforcing the principles of social constructivism [18]. According to Chun, [7] agility means the adaptation and change of course pace or structure to students' needs and abilities, where the syllabus is open to students and can be adapted based on their interests and performance. Since agility aims at supporting teamwork, groups are formed and the communication and the collaboration among students is encouraged. They acquire roles of active students, while teacher is the facilitator of the learning process. However, this doesn't mean that individualized learning is not supported. Not only, students learn following their learning path, but also, they are supported by continuous feedback. Besides, authentic assessment is a key feature in the whole learning picture. The international literature deals with several agile models, with the leading role of those of Scrum and Kanban [18]. While Scrum describes the whole learning process in detail [22], Kanban, helps students better visualize their work and acknowledge the workflows, as well as it shows the ownership of the tasks [18]. Therefore, students focus

on decreasing the workload that have in. By using Kanban, students are better time and effort managers in contrast with Scrum processes, where they need to expend effort on constant task switching [18].

3 Method

3.1 Research Questions

In the wider context of authors' research, regarding the complex problem of the potential of smart pedagogical frameworks for smart learning, two research questions have driven the current study:

RQ1: *What are the strengths, weaknesses, opportunities, and threats of a delivered e-course for IoT projects as contributions to climate action (SDG 13), when it is based on a conceptual framework designed for smart learning?*
RQ2: *Which good practices and challenges emerge from a delivered e-course for IoT projects as contributions to climate action (SDG 13), when it is based on a conceptual framework designed for smart learning?*

To give answers to the previous research questions in this paper, the design-based research methodology is utilized and described in the next paragraph.

3.2 Design-Based Research Methodology

Since this study concerns both the design and the research of technology-enhanced learning environments (TELEs) such as e-courses for IoT projects, the design-based research methodology is demonstrated as a very suitable methodology for this purpose [24]. In design-based research, researchers as well as participants or practitioners, collaborate aiming at the improvement of initial designs and development of knowledge for other designers with redesign, after enactment, analysis, and their refinement [9], both in theory and practice [8]. At the same time researchers make claims about interactions, that cause and then observe [3]. Consequently, the current study is aligned with the three stages of a mini-cycle of Design-based research methodology (Fig. 1).

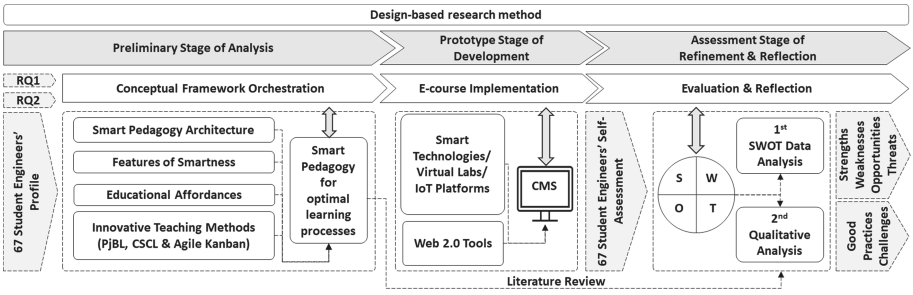

Fig. 1. The three stages of design-based research methodology of the current study

At the first stage of the analysis, the literature review highlighted all the pedagogical approaches needed for the design of a conceptual framework, which at the second stage will be transformed into an authentic learning environment. In accordance with the principles of smart pedagogy, the profile of students was analyzed so that the design and orchestration of the conceptual framework incorporates the appropriate methods. The goal of this venture is an optimal learning environment with quality educational affordances for students' competencies enhancement and high performance. At the second prototype stage of development, an e-lab was constructed to a Custom Management System (CMS) platform, integrating a set of technological tools and IoT platforms, and was delivered as an e-course. At the third assessment stage of refinement and reflection, empirical data were gathered through a self-assessment questionnaire, which were analyzed by qualitative methods. Firstly, a SWOT data analysis was applied for Strengths, Opportunities, Weaknesses and Threats. Secondly, the previous results were combined with features of smartness for SmP, educational affordances and tailored strategies, leading to a set of good practices and challenges.

3.3 Analysis Stage: Conceptual Framework Orchestration

To orchestrate the conceptual framework, authors took into account the following components of smart pedagogy: A) students' profile; B) the learning design, including strategies (techniques) stem from constructivism in accordance with PjBL teaching model for the facilitation of the learning process [12]; and C) the features of smartness, [23] corresponding to the four-tier architecture of Smart Pedagogy [25], which be integrated by an optimal learning environment, to provide educational affordances as smart services [14]. A brief description is following for each component.

A. Students' Profiles Analysis: The participants were student engineers in an ICT university department. They had basic knowledge of structural/object-oriented programming languages (e.g., JAVA, C, C++, PHP, Python etc.) and experience in STEM concepts (Microbit and EV3 robotic systems through block-based programming environments like Scratch) in previous academic courses. However, they had partially or never been involved with Arduino IoT Projects in the past, while had little knowledge on Sustainable Development Issues. At the same time, it was taken in account the fact that the study took place during the pandemic of Covid19. Thus, students were in a state of lockdown, and they had never met face to face, neither had attended previously or currently an academic course with a form of a smart pedagogical orchestrated e-course.

B. Learning Design: Prior to the design of the conceptual framework and with the desire to give this study an added value in the specific research area, a literature review was conducted to identify gaps, problems, and research issues [10]. Smart learning has starred in the research scene for almost the last decade and as a recent and unexplored interdisciplinary research area, it offers the opportunity to investigate new emerging challenges. However, in the context of smart learning there are few conceptual frameworks for constructing Arduino IoT projects. Starting with this assumption, it was considered wise to design a pedagogical framework, using an innovative instructional model suitable for creating projects, namely the Project-based Learning (PjBL) model. It was also considered necessary to incorporate strategies, either to enhance or to facilitate the learning

process for example progress monitoring methods (i.e., Agile Kanban boards) and motivating techniques (i.e., an educational scenario/narrative, content unlocking, quests etc.), collaborative strategies (i.e., Brainstorming and Think-Pair-Share/TPS) and evaluation techniques (i.e., Plus-Minus-Intersting/PMI, peer assessment etc.). According to Han and Bhattacharya [12], three phases take place when PjBL is applied to the instruction (Table 1).

Table 1. Learning design of the smart pedagogical conceptual framework

Educational scenario (homer's odyssey variation)	PjBL Phases [12]	PjBL Subphases	Procedure	Activities
1. Troy	1. Planning Phase	1.1. Overall Climate	P1. Instructions	A1.1 Digital learning environment exploration A1.2. Profile customization A1.3. Welcome (personal) info into a forum post
2. Kikones		1.2. Inquiry	P2. Study for Climate action	A2.1. Videos about UNESCO's SDGs A2.2. Climate change and action investigation
3. Lotus Eaters			P3. Introduction to Arduino and Tinkercad	A3.1. Arduino Basics study A3.2. Breadboard & Sensors study A3.3. Arduino IDE study
4. Cyclops (optional) 5. Aeolus (optional) 6. Laestrygonians (optional) 7. Circe (optional)			P4. Activities	A4.1. Activities with LEDs A4.2. Activities with sensors/activators A4.3. Activities with LCD
8. Hades	2. Creating Phase	2.1. Analyzing Data	P5. Brainstorming (PMI technique) – TPS (Think)	A5.1. Solutions proposals A5.2. Individual thinking
9. Seirines		2.2. Collaboration	P6. Find solution – TPS (Pair) – Agile Kanban	A6.2. Group of pairs (roles assignment) A6.3. Project management
10. Scylla & Charybdis				
11. Helios		2.3. Developing Thoughts	P7. Test Solution – TPS (Pair)	A7.1. Solution's test (Thingspeak) A7.2. Video construction
12. Calypso	3. Processing Phase	3.1. Presenting Knowledge	P8. Share Code – TPS (Share)	A8.1. Code sharing (Github)
13. Phaeacians			P9. Present your video – TPS (Share)	A9.1. Video sharing (Youtube/Vimeo)
14. Ithaca		3.2. Reflection	P10. Assessment (Rubrics)	A10.1. Projects' Porfolio - Peer assessment A10.2. Self-reflection/Self-assessment A10.3. Assessment by instructors A10.4. Course grades

The first phase of "Planning" includes two subphases, the "Overall Climate" and the "Inquiry". In the first subphase, the development of an environment that promotes challenges for research is achieved. Students are instructed on the learning context, namely the educational scenario, the pedagogical concepts, the learning objectives, the process, the activities (compulsory/optional), the interaction (individual/group/plenary), the communication and cooperation methods, the technological infrastructure, the estimated duration, the types of evaluation (diagnostic, formative, cumulative), the forms (self, peer to peer and evaluation by the instructors) and the evaluation criteria (rubrics and scores). In the second subphase, students study the UNESCO SDGs, and explore all factors related to climate change. At the same time, they experiment with the Arduino through the Tinkercad virtual lab or a physical Arduino board and its peripherals. The second phase of "Creating" includes three subphases, the "Analyzing Data", the "Collaboration", and the "Developing Thoughts". In the first subphase all previous data collected are analyzed to sum up, to make predictions and design plans. Groups are formed, roles with tasks are assigned, solutions are proposed, and project management takes place, collaboratively. Finally, students create all the artifacts (Arduino IoT project, including construction – circuit and code – as well as a promotive educational video). In the end, the phase of "Processing" includes the subphases of "Presenting Knowledge" and "Reflection". In the subphase of "Presenting Knowledge", the main idea is students to monitor what is known by presenting their artifacts of the project. In the "Reflection" subphase students reflect their own learning and get total feedback for their effort.

C. The Features of Smartness, Corresponding to the Four-Tier Architecture of Smart Pedagogy: It was considered necessary to take into account the four-tier architecture, the features of smartness and the features of PjBL (described in literature review section) regarding Smart Pedagogy (SmP), in order to construct a well-design smart pedagogical framework, as to increase the potential of providing students educational affordances for achieving their goals and a high performance. The table (Table 2) describes the proposed strategies, incorporated overall the learning design (Table 1), creating a robust smart pedagogical conceptual framework.

Moreover, the features of smartness were exploited as indicators for the second qualitative analysis, in order to arise good practices (namely, the strategies that should be incorporated, and the educational affordances that could be enhanced).

3.4 Development Stage: E-course Implementation

For the e-course implementation, a website was created following the learning design. As such, the WIX platform was preferred among others, due the ease of website building via drug and drop procedure, the free edition, and the number of utilities, supplied to administrator and end-user. Webpages were matched to distinct teaching units and adapted through narration to the stations of the educational scenario of Odyssey's variation (the wanderings of King Odysseus from Troy to Ithaca) in 21st century where climate change encumbers humans' well-being. Some other pages were constructed to contain the additional information about the course goals, the given educational scenario, the teaching approaches, the required technological infrastructure, the course calendar,

Table 2. Strategies adapted to SP architecture, smartness features, affordances and PjBL

Smart pedagogy (SmP) architecture [25]		Smartness features [23]	Educational affordances [14]	PjBL features [12]	Strategies
Layer 1	**Class-Based differentiated Instruction.** Students are engaged in different tasks according to their learning preferences	**Adaptation:** Strategies that allow students to quickly adapt (individually) to the learning process by motives' stimulation	Individualization/Personalization Motivation/Engagement Inquiry/Action Pervasiveness Authenticity	Student-centered (Voice and Choice) Multiple ways of Expression	• Provide alternative tools and materials as well as activities (optional learning units/activities, variety of tools for projects' construction – IoT Boards/Platforms and Web 2.0 video editing tools) • Embed Gamification components (narrative – Odyssey's educational scenario/content unlocking – protected with passwords units/quests – individual learning activities related to students' needs)
		Sensing (Awareness): Strategies that utilize ICT which can be used as science toolkits for data collection and experimentation		Authentic Tasks	• Configure your personal "authentic learning environment" (Embed Virtual IoT platforms – Tinkerkad/ThingSpeak) • Provide opportunities for "inquiry and action" (Real world problem – SDG13 Climate Action)
Layer 2	**Group Based Collaborative Learning.** Students are engaged in CSCL tasks	**Self-learning:** Strategies that help students to learn from others	Motivation/Engagement Inquiry/Action Pervasiveness Authenticity Sociality/Collaboration	Collaboration	• Provide opportunities to learn from peers/learn from experts (Integrate Plus – Minus – Interests (PMI)/Integrate modelling strategy) • Provide students the CSCL scripting (Explain the Brainstorming and Think Pair Share process) • Emded an Agile Kanban Board in a workgroup

(*continued*)

Table 2. (*continued*)

Smart pedagogy (SmP) architecture [25]		Smartness features [23]	Educational affordances [14]	PjBL features [12]	Strategies
		Adaptation: Strategies that allow students to quickly adapt (collaboratively) to the learning process by motives' stimulation		Student-centered (Voice and Choice)	• Embed Gamification components (Teams/Cooperation)
		Self-organization: Strategies that provide students self-organization in learning communities		Collaboration Multiple ways of Expression Innovative Assessment	• Provide opportunities to select roles with specific tasks in workgroups tailored to students' profile (In group of pairs, there were two different roles for each project artifact: programmer and analyst for the IoT project and data analyst and multimedia creator for the final video) • Peer Assessment
Layer 3	**Individual Based Personalized Learning.** Students adjust pace/method/tools according to their interests/needs	**Self-learning:** Strategies that help students to learn individually	Individualization/Personalization Inquiry/Action Reflectiveness Motivation Authenticity	Time Management	• Provide students opportunities to customize their learning environment (customize profile page) • Clearly present the structure and components of the educational process (timetable, learning goals, expected effort/results)

(*continued*)

Table 2. (*continued*)

Smart pedagogy (SmP) architecture [25]		Smartness features [23]	Educational affordances [14]	PjBL features [12]	Strategies
		Inferring (logical Reasoning): Strategies that provide students data visualization and feedback about their outcomes		Innovative Assessment	• Embed an Agile Kanban Board (Trello Board) • Provide real time feedback (through forum/chat and live meetings through Big Blue Button teleconference platform) • Provide students' work to the community through portfolios
		Anticipation: Strategies that provide students the current outcomes and help predict their final score			• Embed an Agile Kanban Board (Trello Board) • Provide real time feedback (through forum/chat and live meetings through Big Blue Button teleconference platform) • Provide students' work to the community through portfolios • Provide the assessment criteria for the final score by using rubrics and marking guides
Layer 4	**Mass Based Generative Learning:** Students active participate in constructing relevant content	**Self-learning:** Strategies that help students to learn	Content Enrichment Inquiry/Action Authenticity	Analytical Content Innovative Assessment	• Provide students opportunities to create projects that will enrich learning content in the future and cultivate metacognitive abilities

and the timetable, even the formats and types of assessment. Furthermore, extra functionalities of WIX were installed, for synchronous communication, such as chat with instructors, chat in groups, videoconferences via BigBlueButton virtual sessions, as well as a page forum and member pages for communication in asynchronous mode. From the other hand, a set of Web 2.0 tools were embedded through HTML iframes, or linked buttons and hyperlinks, aiming at collaboration, data collection and evaluation (Padlet), project management through Agile Kanban boards (Trello), project test and delivery (Github, Thingspeak, Tinkercad, Video Editors).

3.5 Assessment Stage: Evaluation and Reflection

Even though design-based research methodology utilizes mixed methods to maximize the credibility of ongoing research, the current study attempted to answer the research questions by using only qualitative methods. As such, for the first research question (RQ1) a SWOT data analysis was utilized.

Table 3. Questions' allocation to SWOT analysis

S/N	Question	Answer	SWOT
Q1	"What do you think is the most important thing you gained after participating the e-course lab?"	Positive (P)	Strengths
		Negative (N)	Weaknesses/Threats
Q2	"What do you think was the most interesting part of this e-course lab?"	Positive (P)	Strengths
		Negative (N)	Weaknesses/Threats
Q3	"What do you think was the least interesting part of this e-course lab?"	Positive (P)	Weaknesses/Threats
		Negative (N)	Strengths
Q4	"What are your suggestions for improving the e-course lab in the future?"	Positive (P)	Opportunities

A self-assessment was carried out and a questionnaire with 4 open-ended questions (Table 3) was completed by 67 student engineers, during different cohorts in an academic course. As it can be seen, students answered either positive or negative. For the first three questions the positive answers were perceived as strengths, when the question had a positive meaning, while the negative ones either as weaknesses or as threats and vice versus. The fourth question corresponds to the opportunities. The results of the SWOT data analysis are presented to the table below (Table 4).

Table 4. SWOT data analysis

Strengths (S)	Weaknesses (W)	Opportunities (O)	Threats (T)
(S1) Knowledge acquisition about Arduino (Coding/Circuit & project construction) **(S2)** Value of collaboration/Collaborative Learning **(S3)** Enhancement of Social/Interpersonal skills/Teamwork **(S4)** Enhancement of Creativity/Innovation/Problem Solving **(S5)** Knowledge acquisition about video editing/construction **(S6)** Environmental consciousness/Climate change awareness **(S7)** Interactive way of teaching and learning **(S8)** Theme (authentic task) and tools selection /Educational scenario alignment **(S9)** Pedagogy (PjBL/strategies) application in teaching practice, relation with technology & tools **(S10)** Interesting and unusual way of an academic course delivery	**(W1)** Tinkercad virtual lab utilization, instead of the Arduino physical board and its components in a blended learning environment **(W2)** Boring narrative in contrary with the interesting educational scenario **(W3)** Several protected with password webpages **(W4)** Lack of data analysis strategies and relative technological tools **(W5)** Few practical (Arduino) activities in contrast with long-text instructions	**(O1)** Content delivery through multiple and more interactive methods (e.g., audiovisual tools) **(O2)** Narration through a virtual instructor or story hero **(O3)** Improving time management strategies and tools **(O4)** Increase of collaborative activities and integration of members in joint groups. Coordinator role selection **(O5)** E-course alignment in an educational scenario chosen by the students (e.g., other myths suggested by the students)	**(T1)** WIX functionality & slow webpage loading rate (even through mobile devices) **(T2)** External platforms' & tools integration **(T3)** Real-time evaluation (especially in collaboratively activities) and progress visualization **(T4)** E-course delivery in a form of video on-demand for working students **(T5)** Much personal effort for the individual inquiry-based activities

For the second research question (RQ2) the Table 2 was combined appropriately with Table 4, regarding smartness features, educational affordances, and strategies, in order to provide useful information about good practices and challenges (Table 5).

Table 5. Good practices and challenges emerged from strengths, opportunities, weaknesses, and threats

S.	Smartness features	Educational affordances	Good practices
(S1), (S4), (S5), (S9)	Analytical Content	Content Enrichment, Inquiry/Action, Authenticity	**Strategies**: Provide students opportunities to create projects that will enrich learning content in the future and cultivate metacognitive abilities. **Discussion**: Students can apply their acquired knowledge about pedagogical concepts (PjBL, strategies), IoT/programming with Arduino and video construction to relative subjects, empowering their creativity, innovation, and problem-solving competencies
(S2), (S3), (S7)	Self-learning Adaptation Self-organization	Motivation/Engagement, Collaboration	**Strategies:** Provide opportunities to select roles with specific tasks in workgroups tailored to students' profile. Provide opportunities to learn from peers/learn from experts. Embed Gamification components (Teams/Cooperation). Provide students the CSCL scripting. Provide opportunities to select roles with specific tasks in workgroups tailored to students' profile. **Discussion**: The incorporated strategies help students develop collaborative skills and enhance motivation. Working in teams increase the level of interactivity between members, while effort and workload decrease
(S6), (S7), (S8), (S10)	Adaptation	Motivation/Engagement, Individualization/Personalization, Inquiry/Action, Authenticity	**Strategies:** Provide alternative tools and materials as well as activities. Provide opportunities for "inquiry and action" (Real world problem – SDG13 Climate Action). **Discussion**: Investigation and solution proposal over an authentic task, such as a real-world problem could empower emotional factors and help students form new perceptions
W. O. T	Smartness features	Educational affordances	Challenges
(W1), (T1), (T2)	Sensing (Awareness)	Motivation/Engagement	**Strategy:** Configure your personal "authentic learning environment. **Discussion:** Blended environments are better learning environments than virtual labs and simulations when students experiment with Arduino IoT projects, because they provide real-time measurements. From the other hand, an optimal learning environment should deliver knowledge fast and efficient, therefore there is a risk of students dropping out

(*continued*)

Table 5. (*continued*)

W. O. T	Smartness features	Educational affordances	Challenges
(W2), (W3), (O1), (O2), (O5)	Adaptation	Motivation/Engagement	**Strategy:** Embed gamification components (narrative – educational scenario/content unlocking – protected with passwords units. **Discussion:** While gamification components stimulate motives, designers should be careful with the style of the narrative (humorous, surprising, or admirable compatible with students' personal style and interests) as well as the number of constraints. Moreover, audiovisual tools provoke perception arousal
(W4), (W5)	Self-learning	Individualization/Personalization, Collaboration	**Strategy:** Provide opportunities to learn from peers/experts. Provide alternative tools and materials as well as activities. **Discussion:** PMI is an evaluation technique used for collaborative data analysis. However, a set of evaluation techniques should be set and implemented by corresponding tools, in order students have the option of selection according to their style. From the other hand, A repository with graded and themed Arduino activities should be provided to students to choose according to their degree of familiarity
(O3), (O4), (T3), (T5)	Self-learning, Inferring (logical Reasoning)	Reflectiveness, Motivation, Authenticity	**Strategy:** Clearly present the structure and components of the educational process. Embed an Agile Kanban Board. Provide real time feedback. **Discussion:** Optimal learning environments should be fast and efficient, aiming at guiding students to their goals. Plainly, Kanban boards are visual tools for self-monitoring, however a set of scaffolding strategies and tools for time-management, goal orientation and progression are needed. Concurrently, collaborative process could be improved by using the agile Scrum Model and Jigsaw collaborative strategies instead of TPS

4 Conclusion

From the findings the authors summarized a set of good practices and challenges. Examining the strengths of this framework, it is obvious that based on the students' answers, the part of acquiring new knowledge and skills was strengthened, mainly through the collaborative process while the students showed to participate actively. Regarding the smartness features, the findings showed an excel of analytical content and adaptation

perceived as strengths, in contrast with sensing, self-learning and inferring, perceived as opportunities, weaknesses or threats. However, the last are focused on the technology used, the way the supporting material is delivered, but also the way in which they can constantly monitor their progress in individual activities, receive guidance and feedback at any time and automatically, both by the instructor as well as by the learning environment. Emerging challenges are causing redesign, according to design-based research. The study used only qualitative analysis, and therefore has several limitations. However, as design-based research provides guidelines for technology-enhanced learning environments (TELEs), consequently smart learning environment designers (SLEs) in smart pedagogical approaches and smart utilized technology, while enhancing the international literature with practical data [24].

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Knowledge Management Model in Telework

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Abstract. Today telework has become increasingly important after the boost that ICTs have given to society, since thanks to its implementation, a job can be carried out from anywhere without the need to be in the physical space in question. It should be noted that this way of working has been strengthened after the shaking that the planet has suffered with the appearance of Covid19, but it must be borne in mind that not all organizations have the appropriate infrastructure and organizational management for the development of telework, affecting to people not only in a social way but also in their physical and/or emotional health.

A literary review about telework and knowledge management was carried out in this: search in the databases of Mendeley, ScienceDirect and ProQuest, as well as the use of the Google Scholar search engine. Following this, the main topics were selected for the adaptation of the knowledge management model in telework.

The proposed model focuses on knowledge management for teleworking, taking into account the importance of human, technological and organizational resources.

There is evidence of the need to develop a knowledge management model applied to Telework in order to minimize the direct and indirect implications generated by this type of work, as well as the commitment to teleworker learning so organizations are more productive.

Keywords: Telework · ICT · Physical space · Technological · Human resources

1 Introduction

The global economy is demanding improved competitiveness in both businesses and countries with the aim of competing in the market. This global market has been made possible by Information and Communications Technologies (ICT'S), these have given way to a new way of understanding the company and work, as well as the way of life.

Telework and the conditions inherent have changed in industries, offices and homes, increasing the number of remote employees and extending to a new category of workers [1]. These conditions provide to some extent autonomy and flexibility that can play for or against employees, as it allows employees to have family and leisure time, but it can also be cause them to end up working longer hours than expected, generating personal and/or health conflicts [2]; these effects, both positive and negative, may be promoted by the conditions under which the telework is performed.

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In itself, telework is defined in Law 1221 of 2008 as a form of labor organization, consisting of the performance of paid activities or the provision of services to third parties using information and communication technologies (ICT'S) to support the contact between the worker and the company, without requiring the physical presence of the worker in a specific workplace [3].

Given the competitiveness needs, the high development of ICT's and the society of the future characterized by the potential of knowledge of people interacting in work environments based on the intensive use of digital technologies, knowledge management is of great importance in organizations because it helps generate sustainable changes and results, optimizes resources, employs existing knowledge and implements lifelong learning for the improvement and innovation of organizations. These and other reasons arouse the interest of knowing the relationship between knowledge management and all those factors that influence telework and organizations.

2 Background of Knowledge Management in Telework

Telework has been developed thanks to the current social context in which the Information Society is located, which allows access to universal information, infrastructure and technologies. Information and how it is managed is a strategic resource for organizations, as is organizational culture, as awareness is made of environmental issues, transparency, development and innovation [4].

2.1 Knowledge and Knowledge Management

Today knowledge and information are a fundamental aspect for every company, but it is only achieved thanks to human capital being the differentiating component. Technological advancement has been an enhancer because it facilitates the acquisition and transmission of information in an effective way, for this it must be done a good management of knowledge to maintain and expand its capabilities and competencies [5].

A knowledge management model to support pedagogy at the university seeks to improve the dynamics of the processes of creation and dissemination of knowledge through research. Conversion from tacit to explicit and from explicit to tacit (investigative knowledge of researchers) to achieve efficiency and the collective use of its results in the process of searching for and transferring knowledge through linkage solutions with the productive world and the research [6], p. 58.

Intangible assets are due in knowledge, skills, values and attitudes of people. These intangible assets are called Intellectual Capital. Intangible assets capacity generated in the organization, when resources begin to work together [7], p. 36.

2.2 Telework

Telework is characterized by being that activity that runs outside the organization where the processes of the company are centralized, which needs ICT and a different organization than traditional, to achieve the control and monitoring of the tasks to be carried out by the human resource.

After slow growth in telework, this modality has become a routine for the majority of the world's population, this growth is due to various factors, referring to the continued digitization and rapid dissemination of ICTs as facilitators of telework [1] and today, due to the Covid19 pandemic that has been presented worldwide, forcing a transition to telework and the virtual world.

The execution of this type of work brings benefits for both the company and the worker. The first increases its productivity and quality by reducing costs and absenteeism; and employees have greater job flexibility, better reconciling family life with work and are more motivated [4], On the other hand, there are barriers such as the lack of confidence of managers in their adoption, spending on training and telematics tools or that workers do not get to reconcile family life with the professional:

– *Balance between telework and personal life:* The relationship between work and personal life affects both directions, i.e., the effects of work on personal life and the effects of personal life on work can be seen; In addition, the distribution of the physical workspace where the telework is executed should be considered, since depending on its delimitation the working life may be separated from personal life [1, 2].

  The negative effects that the teleworker has to endure will bring negative consequences from having to work more hours than necessary to serious problems in their health, affecting the quality of life. But not everything is bad, since according to studies presented in [1, 2] those who spend more hours in telework present a better work family balance, a low level of stress, as well as flexibility for better programming of their tasks, thus generating less work interference with the family and greater tranquility.
– *Confidence in the teleworker:* It should be understood that trust in the work context refers to the ability to voluntarily depend on the words and actions of others, being important in the management employee relationship [8]. Although improving remote monitoring and control is an important factor in telework, it should be noted that confidence gives rise to whether or not confidence results in testing this mode of work depending on the performance that workers have shown their supervisors [1, 8].

3 Model Development Methodology

Designing the knowledge management model in telework required research on tele working and knowledge management in the Mendeley, ScienceDirect and, ProQuest databases, as well as the use of the Google Scholar search engine, to achieve the main characteristics and needs in today's society and to adapt this in the aforementioned model.

First, the main thematic axes on which telework is currently developed were established, i.e., the nodes that underpin knowledge in the organizational systems of the information society, in addition to the digitization and use of ICTs in the development of this modality of work. Hence, the proposed model constituted a graphical representation of Knowledge Management in organizational processes in the teleworking modality, with the aim of achieving integration between internal and external organizational knowledge.

In order to obtain the definitive representation of the model, it began with an application of the Models of Nonaka and Takeuchi and KPMG Consulting, which provided the

basis for the definitive consolidation of the four nodes: knowledge in the organizational systems, organizational commitment, human and technological resource, as well as their respective facilitators.

After obtaining the graphical representation of Fig. 1, a survey was continued to be formulated and applied with the aim of anticipating the satisfaction of current and future teleworkers with respect to the content of the model, focusing on the first questions to know the population surveyed, followed by questions focused on the topic of each node, to end with the question of implementation of the model. To measure the opinion and perception of the people surveyed, Likert scales were used, which allows to discover the degree of opinion and identify aspects of improvement in the model evaluated in the survey.

It should also be noted that this survey was divided into two parts, the first dedicated to people currently working under the telework modality and the second for people who are not working in this modality but would like to apply it in their future company. The application of this survey was carried out through a Google Forms, in which 49 responses were obtained in total, where 44.9% were women and the remaining 55.1% men, and 63.3% of this population is not currently working and the remaining 36.37% are workers, it should be noted that 27.8% are not in telework and 11.1% are in alternation.

In order to verify the validity of the model and with the help of the data collected through the survey, a descriptive analysis was carried out, where the results produced by the two parties surveyed were crossed, managing to describe the relationships that were presented between this data and the same model, reflecting on its meaning and achieving the response to the verification of this and the degree of contribution of knowledge management in telework.

4 Knowledge Management Model Applied to Telework

The model presented below is an adaptation of the KM-U model [9], which allows to reflect the management of knowledge in organizational processes in the teleworking modality, to integrate organizational knowledge, both in internal and external relationships, and to be able to obtain competitive advantages (make the organization more productive). In addition, to contribute to the increase of knowledge assets, in organizations that make use of telework, through the management of the same.

This model consists of a central axis called Knowledge in Organizational processes (towards the culture of knowledge), with three interconnected nodes: Human Resource, Technology and Organizational Commitment, which will be in continuous contact with their respective indicators and facilitators. This model is part of the current information and use society of ICT 'S, which is depicted in Fig. 1 and explained below.

Before explaining the model, it should be noted that, in order to achieve the central axis and the three nodes mentioned above, a widespread application of the Nonaka and Takeuchi (1995) and KPMG Consulting (1998) models was carried out.

4.1 Nodes

The *first node* is called Knowledge in organizational systems, which corresponds to the main axis of the proposed model. This axis is focused on the development of a culture of

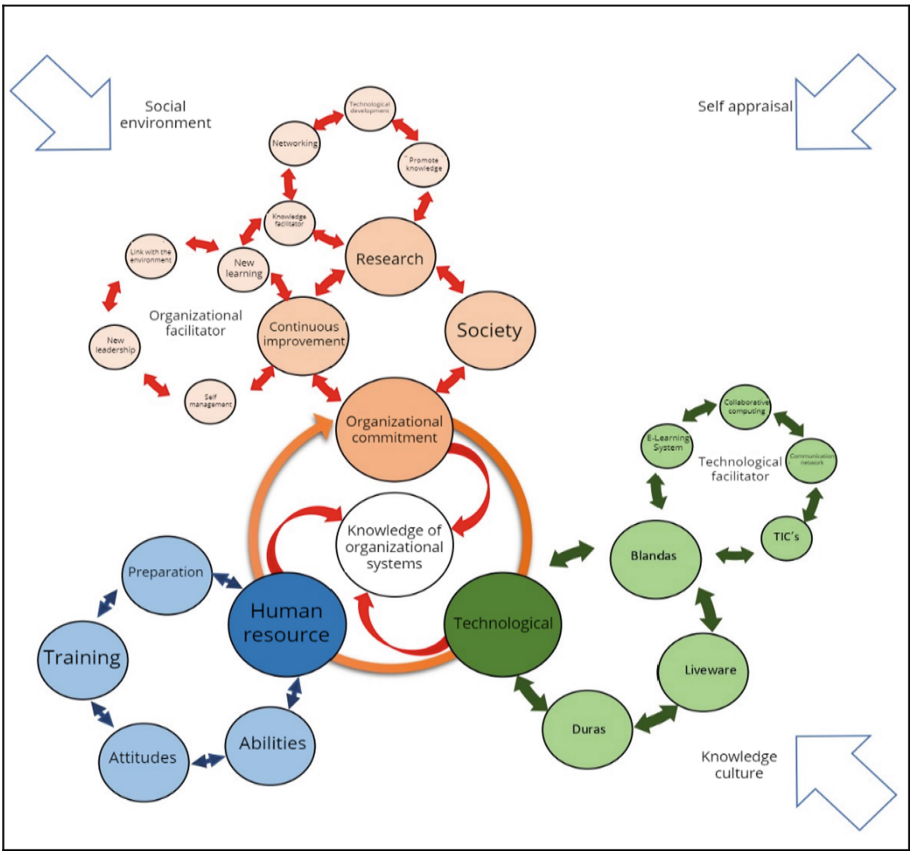

Fig. 1. Model of knowledge management in telework. Source: The authors.

knowledge, understanding it as the way an organization acts and that serves as a mediator between the internal and external relationship.

The internal relationship depending on the development of the human resource that is at the service of the productive improvement of the organization and promotes the process of research and technological development, in order to reduce the disadvantages, present in telework and thus obtaining a knowledge management between the members of the organization and related agents.

As for the external relationship, it is in the process of offering the acquired knowledge of the knowledge management model, to other organizations that are in the telework mode or want to enter it.

As a *second node*, represented in Fig. 2, and called human resource, which refers to the necessary training and continuous training activities for the development of the human resource of organizations. This, in order to improve the knowledge, attitudes, skills and interests of all staff in the organization and that results in a competitive organization.

In addition, to encourage the sharing of information through the outsourcing of knowledge and the permanent process of the production and assimilation of knowledge.

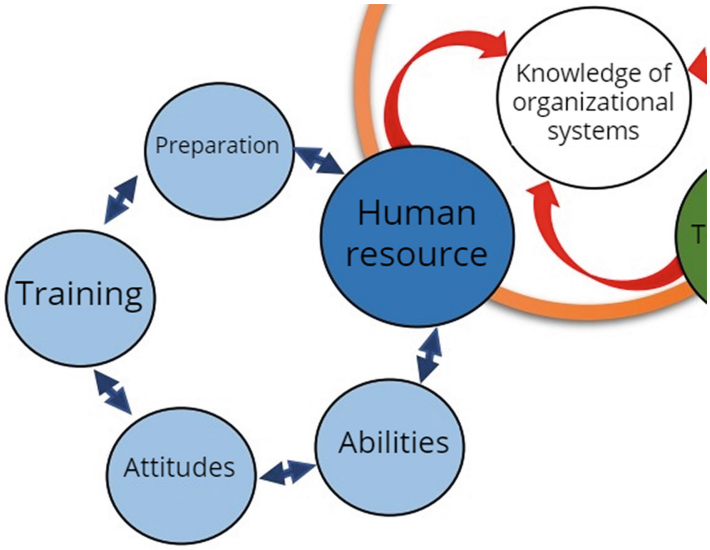

Fig. 2. Representation of the human resource node. Source: Authors

In a *third node,* represented in Fig. 3 and denoted as the technological node, is all the infrastructure that empowers the creation, access and dissemination of information relevant to the activities to be carried out in the telework mode, that is, that tool that allows the human resource to participate, communicate and share the contents in the daily work processes.

The basis of telework is given by the management of ICTs for communication at all levels of the organization, which presents the following functions [9]: to codify knowledge, to identify the characteristics that make it relevant, distribute knowledge in order to ensure rapid access to it, facilitate the transfer and allow the analysis and interaction necessary for its development.

This node has three components supported for knowledge management:

- Soft technology or software which is represented by applications and suites for the processing of information in digital communication formats.
- Hard technology or hardware, being a multimedia set that is represented in audiovisual and digital processing machines and equipment.
- Living technology or liveware, which is composed of all actors in the organization, especially carriers, transmitter and users of knowledge.

The *fourth node* is called Organizational commitment, and is related to R&D research and technological development and the organization's commitment to continuous improvement. This continuous improvement is related to new ways of learning,

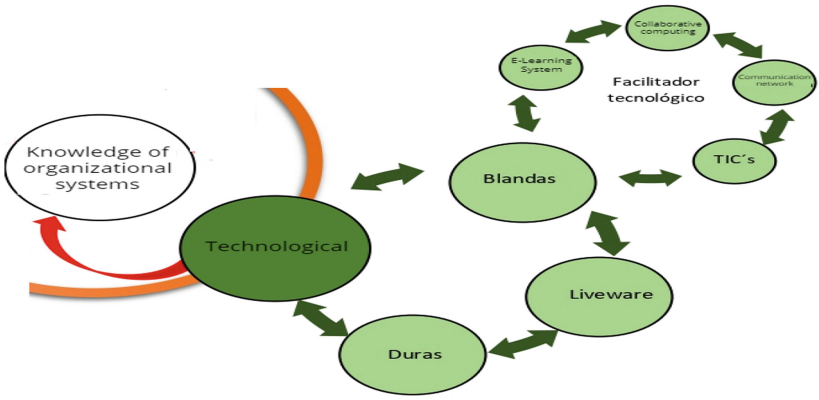

Fig. 3. Representation of the technology node. Source: Authors.

linking with the environment, new leadership and, work processes, as well as creating a cognitive environment to facilitate and promote knowledge, and not just focus on the administrative field. This will support the orientation, control and monitoring activities of the economicadministrative and labor part of the organization, so many of the fears mentioned by managers about telework will be diminished (Fig. 4).

Fig. 4. Representation of the organizational commitment node. Source: Authors.

4.2 Facilitator Agents

There is talk of the staff's actions and the functioning of the organization's processes, from which results are obtained for this [9]. Below is the classification of facilitator agents for the knowledge management model in telework.

- *External facilitatrs:* they relate to the social, cultural and interorganizational environment, which must be oriented towards business know how.

  Culture of knowledge: encourage it to be typical of each actor within the organization (of the human resource) to project better people and professionals in soft or interpersonal skills such as communication, teamwork, time management, patience, etc. in the challenge of telework and knowledge generated by colleagues.

  It also encourages the culture of sharing as a personal growth strategy in order to optimize the activities executed.

  Social environment: organization of work sessions between the actors of the organization with external actors (suppliers, contractors, etc.) in order to gain the maximum transfer of knowledge first hand, and not just documentary guides. Memories of these meetings, the recording of lessons learned and the knowledge repository must be generated to link them to the self assessment facilitator agent.

  Self assessment: conduct focus group sessions by department of the organization, in order to gather the knowledge of the actors involved in the specific operations, and to be able to make a comparison with organizations in the same sector and that are in the telework mode.
- *Internal facilitators:* These facilitators are specific to each organization so below it will define the most relevant nodes presented in the knowledge management model in telework.

  Organizational Commitment Node (Organizational Facilitator):

  – Modernization and continuous improvement.
  – Organizational competencies and their performance.
  – Technical innovation through modern and cuttingedge technologies.
  – Information of projects carried out, reports of research and developments depending on the organization and quality of them.

  Technology Node (Technological Facilitator):

  – Contemporizing of ICTs.
  – Collaborative computing.
  – e-learning systems, which contain the knowledge obtained through research through the activities that are carried out in the organization. (Learning Management Systems SGA).

  Human Resource Node (Human Facilitator):

  - Personal competencies.
  - Investigative work productivity.

4.3 Indicators

It is understood as indicators, the unit of measurement of the facilitators, which allows the recording of the dynamics of performances and verifies the fulfillment of the objectives of the organization, these indicators being a source of information additional to the periodic diagnosis of the state of knowledge management in the organization [9] (Table 1).

Table 1. Indicators of the management model in telework. Source: Authors

Node	Indicators
Organizational commitment node (process indicator)	• Growth profile • Coordination and cooperation profile • Organizational climate • Physical/virtual space • Policies and guidelines
Technological node (technological indicator)	• Hardware, Software and Telecommunications • Collaborative computing • E-learning system • Technology transfer
Human resource node (human indicator)	• Self management • Entrepreneurship and initiative • Abstraction and synthesis capacity • Effective communication • Network work and experience learning

5 Validity Results of the Knowledge Management Model Applied to Telework

With the need to move forward and adapt to a changing society, telework has generated different reactions among the actively economical population, so the need for a knowledge management model applied to telework became relevant, the above in order to minimize the direct and indirect implications of this modality and improve the productivity of organizations. In view of this, the proposed model here has a great satisfaction demonstrated in the results of the applied survey to predict its respective implementation and to know the satisfaction of the content of the same.

In the first instance, in general, if you are to achieve an adequate implementation of a knowledge management model, it is important to know if the people who are going to be sheltered with the implementation of it, have worked with one before or have prior knowledge. Considering this, we can appreciate that 66.7% of people currently working or working in an organization that has seen great importance the implementation of a Knowledge Management model; otherwise, it is the case with the population that is not currently working, where 87.1% do not know or have not worked in an organization that implements a model, giving foundation to think that these organizations do not denote importance to this issue or do not implement it properly.

Similarly, with the nodes of the model proposed and based on the results of the survey it can be observed that the item on the fostering of the research process and technological development denotes a great importance for respondents in general, as this projects the organizational commitment to continuous improvement by linking research and technological development (R&D); on the contrary it can be thought that those who believe it is of minor importance is because they are satisfied with what their organization currently does and with its competitive level.

As for the outsourcing of knowledge, most respondents denote that they are willing to socialize the knowledge acquired through the implementation of the knowledge management model applied to telework. Primarily this result is beneficial for the effective communication of the model to other organizations, whether it works properly within it or if it fails in its implementation, giving ideas of improvements in the model to make its implementation contribute to the increase of the competitiveness of organizations in the market.

Considering that knowledge is an intangible and important resource for an organization, it is essential to store and update it in organizational use systems that allow access to each of the workers, considering this point relevant to an adequate productive process at work and, determining that the information generated through the knowledge and experience of the officials, plays an important role for competitive positioning and advantage in each of the markets, since sharing experiences and knowledge helps to improve and avoid making the same mistakes repeatedly, giving an endorsement to the human resource node of the model posed by the group.

On the other hand, in order for there to be a good organizational climate, several factors must be incurred, where good teamwork within the company is of great importance, and one way to improve this organizational level is through training and methods to link workers more closely, i.e., continuous training and regular monitoring of staff.

This is based on the survey itself as it reflects that essential impact with a valuation of 94.5%, where this percentage shows that people agree that there will be an improvement in their organization and points out that this corresponds to a base pillar of knowledge management and, therefore of the same proposed model linking the nodes presented in it, both that of human resource, organizational and technological commitment, to be the basis of knowledge in the organizational systems, especially those in which they execute the teleworking modality.

Moreover, as a result of the implementation of the survey, it is noted that only 18.7% remain in a neutral position with respect to the adoption of a knowledge management model in telework, reflecting that it does not affect it in any way whether or not the implementation of the model within your organization is carried out, so we see the need to publicize the concept of a knowledge management model, as well as its importance in work environments. Similarly, 81.3% are willing to implement the model reflecting the interest to improve together with your organization.

In short, it can be shown that all people in general recognize the importance of recording key processes and learnings, ensuring availability and timely communication of the strengths and weaknesses that are in order to manage the knowledge obtained in the daily work of the organization and, of the trainings or transfer of knowledge of the external parties that are integrated into the organization. On the other hand, we

appreciate the importance of the use of ICTs and their respective training to make current organizations at the forefront, and that no process in information management is affected by misinterpretation or manipulation of technology.

It should be noted that there is currently a percentage of people who have not yet interacted with a knowledge management model, however, they show a great interest in the participation, adoption and implementation of it. Taking into account that not having model of Knowledge Management in telework can affect the proper strategic address of the organization that has implemented or this mode of work, whether its value chain is interrupted or damaged due to poor communication and management of information, managing to confirm that the model proposal of this article satisfies and supports the needs evident in the application of the survey.

6 Conclusions

It is possible to conclude two important aspects where one relates to those who currently work and another to those who do not. For people currently working, it is observed that most understand the importance of knowledge management models within an organization and the requirement to start managing one immediately. On the other hand, for those who are willing to implement the telework model in their company or potential company, they note that telework to some extent is a new form of work that is guided not only by a labor obligation but also by the results that it can offer to the company itself in a more effective way to which it is traditionally used, opting to implement it or in a structured way and not by conditions external to its own.

It can be concluded that when analyzing the results of the survey, it is clear that the nodes and their interactions are appropriate for this modality, but it takes an appropriate simulation or followup to observe whether the models satisfactory as expected or on the other hand complicates a good fluctuation of information and knowledge itself, obtaining advantages or disadvantages, not only of good management of information but also the importance for its positioning and competitive advantages in the face of a market as changing as that faced by companies today.

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Learning Technologies

The Importance of Tasks and the Use of Digital Technologies Affordances in Mathematical Problem-Solving Approaches

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Abstract. In a problem-solving approach to learn and develop mathematical knowledge, the type of tasks and the tools that students use to solve them become essential for developing robust mathematical thinking. Students delve into tasks or problems and, in this process, they rely on concepts, look for different ways to represent them, and identify patterns, formulate and explore conjectures and relations that are important to approach and solve the tasks. The use of digital technologies opens up new routes for learners to represent, explore, and review concepts and to reason about ways to solve the tasks. In this study, we discuss a word problem that appears in the study of school algebra to characterize how the use of a Dynamic Geometry System offers a set of affordances to reason and solve the problem. In this context, secondary teachers could themselves experience the extent to which the systematic use of technologies contributes to extend their practices and student problem-solving reasoning.

Keywords: Mathematical tasks · Problem solving · Digital technologies · Dynamic representation and reasoning

1 Introduction and Background

Mathematics Education is a research and practicing discipline that has provided bases and conceptual frameworks to understand and explain what mathematics learning entails and how teachers and students engage in the construction of mathematical knowledge to formulate and solve problems [1]. The recent edition of the Encyclopedia of mathematics education offers a comprehensive panorama and scope of the field. It includes around 180 entries that provide an overview of themes, theories, methods, and almost every topic in the field and shows the richness and constant developments of the discipline [2]. Likewise, international research handbooks and thematic books continually

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published extended reviews of research results, advances, and emerging topics in the field [3, 4]. The wide variety of perspectives, theories, methods, and themes that appear in the mathematical education agenda makes it important to identify what referents are essential and characterize the identity of the discipline. Cai & Lester ([5], p. 1) affirm that "In general, when researchers use the term *problem solving,* they are referring to mathematical tasks that have the potential to provide intellectual challenges that can enhance students' mathematical development".

What types of problems do researchers and teachers select or design to foster students' learning and how those problems are implemented in learning scenarios? The discussion of this question provides relevant information about what type of mathematical experiences and competencies students could develop in learning environments. In framing a problem-solving approach, it is recognized that for teachers and students to understand and develop mathematical knowledge, they need to address and solve non-routine problems [6]. That is, tasks in which learners are required to activate conceptual understanding of the discipline to solve and extend the tasks [7]. Understanding and developing mathematics is conceptualized as a problem-solving activity and Halmos [8] stated that "what mathematics *really* consists of is problems and solutions" (p. 519) and recognizes that "problems are the heart of mathematics" (p. 524). Cai & Lester [5] acknowledge that "such tasks—that is, problems—can promote students' conceptual understanding, foster their ability to reason and communicate mathematically, and capture their interests and curiosity" (p. 1).

Thus, both posing problems or questions and looking for different ways to solve problems are key activities in learning mathematics. Further, to understand and document what the process of dealing with mathematical problem entails has been an important research area in mathematics education [1]. Pehkonen [9] pointed out that "The development of pupils' problem-solving abilities is not only an essential part of learning mathematics within different content areas, but also it is the central part of learning mathematics at all class levels" (p. 116).

Recently, significant developments and availability of digital technologies are transforming the way people interact and communicate with others. Likewise, in education, the use of communication apps and those to represent and explore mathematics concepts provide novel routes for students to learn mathematics and solve problems. Leung & Baccaglini-Frank [10] present and discuss the importance of designing teaching and learning tasks the involved the use of digital technologies.

In this study, we analyze and discuss how the use of a Dynamic Geometry System (DGS) such as GeoGebra and online developments could provide teachers/students a set of affordances to think of mathematical problems in terms of geometric meaning of involved concepts. Interpreting concepts geometrically might require that learners revise and extend previous knowledge and the use of selected online platforms and encyclopedias become important to extend their concepts understanding [11]. Thus, the research questions that guided the development of this study was: *To what extent specific online developments or mathematics learning platforms, and the use of DGS provide teachers/students a set of affordances to frame and extend learning environments in order to engage students in problem-solving activities to learn the discipline? And what*

type of mathematical reasoning can teachers and students develop with the use of a DGS (GeoGebra)?

2 A Conceptual Framework

Two interrelated research domains provided conceptual elements to frame this study: (a) The importance of focusing on problem-solving activities [12–14] to support and foster teacher/students' development of mathematical knowledge, and (b) the use of digital technologies to extend learning environments and to enhance students' ways of reasoning to solve problems.

The accumulated research and results in the mathematical problem-solving domain provide bases to include the use of digital technology in conceptual frameworks [15]. Tasks or problems become relevant in the construction of a such conceptual model. Thus, conceiving of a task as a departure point to engage learners in productive mathematical discussions is essential to characterize learning as a continuous process in which students pose and pursue questions to understand concept and to solve problems. In terms of teaching strategies that are important in problem solving approaches, Cai & Lester [5] suggested that learning environment should be framed around activities that include: "(a) finding multiple solution strategies for a given problem, (b) engaging in mathematical exploration, (c) giving reasons for their solutions, and (d) making generalizations" (p. 6).

Schoenfeld [16] focused his attention to the construction of a model of the decision-making process that subjects exhibit consistently while working on complex and rich domains such as mathematics, engineering, or medicine (medical diagnosis). He proposed three intertwined elements to model subjects' behaviors:

- resources (especially their knowledge but also the tools at their disposal),
- orientations (a generalization of beliefs, including values and preferences), and
- goals (which are often chosen on the basis of orientations and available resources) ([17], p. 406).

The roots of Schoenfeld's conceptual frameworks can be traced and explained in terms of teachers' conceptualization of the discipline, teachers' instructional goals and actions, and the students' opportunities to engage in productive mathematical discussions.

We argue that the incorporation of online developments (Khan Academy and Wikipedia) and apps (such as a DGS) in learning scenarios demands that teachers make explicit what goals they aim to achieve during instruction and the role that the tools play during the students' construction of knowledge to solve problems. "Teachers need to know not just the subject matter they teach but also the manner in which the subject matter can be changed by the application of technology" ([18], p. 1028).

In addition, Santos-Trigo [14] proposes a framework to design and implement interactive activities in a problem-solving approach to learn mathematics and to solve problems. Figure 1 shows the main elements to take into account in designing and implementing a problem-solving approach that incorporates digital technologies and online developments.

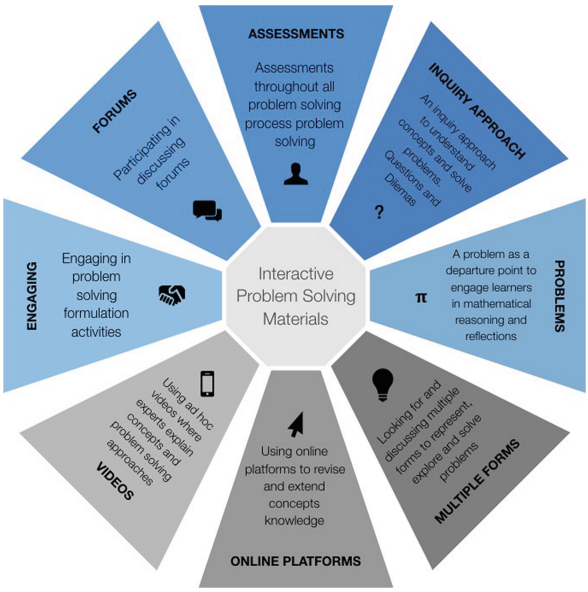

Fig. 1. Core activities in a problem-solving approach that involves the use of interactive materials ([14], p. 186).

In this context, core activities in a problem-solving environment are structured around an inquiring or inquisitive approach where teachers recognize and value that posing and pursuing questions are a vehicle for students to understand concepts and to solve problems. Hiebert et al. [19] pointed out that "students should be allowed to make the subject [mathematics] problematic…[problematic] means allowing students to wonder why things are, to inquire, to search for solutions and to resolve incongruities" (p. 12). Furthermore, problems situated in different contexts including mathematical and realistic situations become a departure point to engage students in problem-solving behaviors to find solutions and to extend initial statements.

3 Design, Methods and Procedures

The research design of this study lies in a qualitative stand since it focuses on analyzing and documenting the extent to which a group of fourteen participants relied on digital technology affordances to reason and solve mathematical problems. The Participants were part of an open research seminar that included weekly sessions of three hours each during one semester. The aim of the seminar was to discuss ways to incorporate the systematic use of digital technologies in learning environments and included the participation of two doctoral students, two mathematics education researchers, and 10 practicing high school teachers. During the seminar sessions, the group reviewed current publications related to the use of digital technologies and discussed ways of reasoning that emerge to solve problems based on the activation of technology affordances. Thus, during the sessions, a participant presents a task or coordinates a discussion regarding

a specific publication previously selected by the research group that coordinated the seminar. All sessions were videotaped and were available to all participants. In addition, material for the seminar was shared through a webpage and questions and ideas were posed in the online platform and participants continuously uploaded comments, ideas, questions, and problem solutions.

In the last three sessions, the group discussed themes related to the study of algebra and a question that emerged during the seminar was: What type of representation could be generated with the use of GeoGebra to approach word problems? This question was addressed during some sessions of the seminar and participants shared their ideas and discussed the extent to which the use of GeoGebra provided new strategies to represent, explore, and solve word problems. Thus, to illustrate what GeoGebra affordances were activated to reason and approach word problems, we chose a task that involves a typical problem that students work on their secondary school algebra courses. In the discussion of this task, questions that were addressed include: What concepts and strategies are relevant for students to approach word problems? Is there a way to categorize a word problem as a realistic problem? Can you identify examples of word problems through the history of mathematics and how they were approached? What goals are important for students to achieve in the study of word problems? what students' difficulties have been reported in the implementation of this model? How do students rely on key words associated with word problems to find their own ways to solve these problems? Etc.

4 Findings: A Characterization of a Way of Reasoning that Emerges with the Use of a DGS

The group's work was analyzed in terms of identifying what the participants focused on during the initial stage of making sense of the task and the use of the tool. Further, GeoGebra affordances that the group relied on to represent, explore and solve the task were explicitly identified.

The first phase includes the way in which some participants represented the task geometrically through a dynamic model that eventually led them to work on the problem in terms of finding mathematical relations to solve the problem. Thus, the group work included a discussion of main problem-solving episodes that includes (i) understanding and making sense of the task in terms of geometric meaning, (ii) the use of a cartesian system to build a geometric model of the task, (iii) exploring the behaviors of elements of the model while moving them within the model, (iv) looking for mathematical relationships, and (v) solving the task.

The Task: *Find how many liters of a solution that is at 15% of alcohol need to be added to another solution that is at 6% of alcohol to get 180 liters of a new solution at 10% of alcohol?*

4.1 Understanding and Making Sense of the Task Geometrically

To think of this task in terms of a Dynamic Geometry System's (DGS) affordances implies that problem solvers rely on a Cartesian system to geometrically represent data

and involved concepts. What concepts are involved in the task? What does it mean that a solution is at 15% of alcohol and how to represent this geometrically? How the concept of ratio is related to this task? In addressing these types of questions, it became important to decide what units to consider in both axes of the cartesian system. In this case, units associated with percentage of alcohol, defined as the ratio of liters of alcohol and the total liters of the mixed solution; liters of the solution as a whole that includes the entire solution; and liters of pure alcohol (not diluted) are the candidates to consider as coordinates for each axis of the Cartesian System. Figure 2 shows three possible ways to assign coordinates to the Cartesian system to represent the problem.

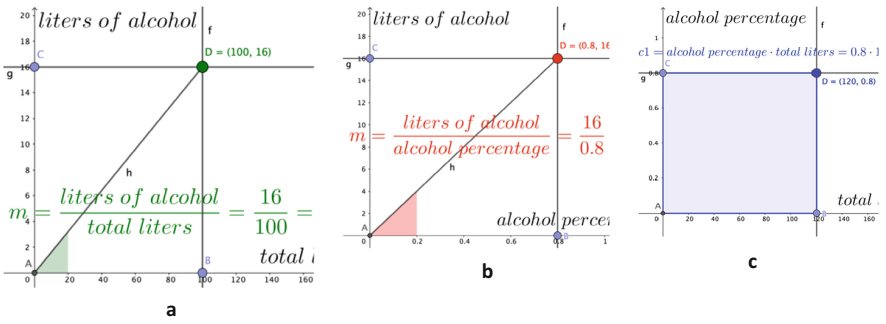

Fig. 2. Different ways to assign coordinates to the Cartesian system. **a.** x-axis: total liters, y-axis: liters of alcohol. **b.** x-axis: alcohol percentage, y-axis: liters of alcohol. **c.** x-axis: total liters, y-axis: alcohol percentage

Comment: In this GeoGebra approach, it becomes evident that the goal or focus was not on representing the problem algebraically, rather the initial stage was to represent embedded objects geometrically. In this context, the use of a Cartesian system was crucial, and the discussion was on what units to consider in each axis in order to connect concepts and represent initial relations in the system.

4.2 Geometric Meaning of Involved Objects Within Each Coordinate System.

What does it mean the coordinates of a point in each system in terms of the problem? In Fig. 2a, the coordinates of point D (100, 16) means that for 100 L of solution that includes 16 L of alcohol and this means that the percentage of alcohol of the substance is at 16%. The slope of AD is the percentage of alcohol of the solution. In Fig. 2b, the coordinates of point D (0.8, 16) means that for a percentage of 80% of alcohol of the substance and 16 L of alcohol, we have a total of 20 L of solution. Finally, in Fig. 2c, 120 L of solution with 80% of alcohol implies that the solution includes 96 L of alcohol (area of rectangle $ABDC$).

Based on these coordinates systems, how can we represent the concepts and data of the problem?

In the coordinate system of Fig. 3a, the horizontal axis represents the total liters of the solution while the vertical one the liters of alcohol. Thus, the length of segment AB

represent the total of liters included in the entire solution, in this case 180 L. On the y-axis the units correspond to the amount of alcohol that the solution includes for specific amount of substance. It is important to observe that points B and C can be moved on the corresponding axis and thus represent different types of substance concentration.

4.3 Construction of a Dynamic Model

Let point C (Fig. 3a) be any point on segment AB, lengths of segments AC & CB represent the amount of solution at 6 & 15% respectively. We draw two lines L_1 & L_2, one that passes through the origin with slope of 0.06 and another that passes through point C with slope of 0.15 (Fig. 3a). These lines intersect the perpendicular line to AB that passes through C and the perpendicular line to AB that passes through B at D and E respectively (Fig. 3b).

We draw segment EF in such a way that has the same length as CD. What do the coordinates of points $D = (80, 4.8)$ and $F = (180, 19.8)$ represent and mean in terms of the problem? The first value 80 of the coordinate of D means that the solution has 80 L (segment s_1) from which 4.8 L (second coordinate, segment a_1) corresponds to the amount of alcohol and the solution is at 6% of alcohol. Similarly, the coordinates of point F means that when the solution includes 180 L of alcohol (segment $BF = a_1 + a_2$), the solution is at 11 percent of alcohol (slope of segment $AF = m_3$).

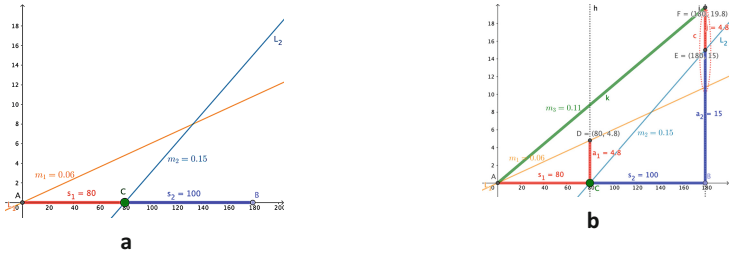

Fig. 3. **a.** The horizontal axis represents liters of the solution and the vertical liters of alcohol. **b.** Connecting key information of the task geometrically. https://www.geogebra.org/m/nz26h3xd

Comment: The concept of ratio (slope) was essential in constructing a dynamic model of the problem. Thus, lines L_1 & L_2 are associated with the percentage of alcohol of substances s_1 & s_2 and point C (that can be moved along segment AB) is a key element in the model to connect geometrically initial conditions of the problem. It is observed that segments CD, BE & BF (Fig. 3b) provides crucial information to solve the problem.

4.4 The Task Solution

To solve the task, it involves finding out at what position of point C the total of alcohol $(a_1 + a_2)$ reaches 18 L, that is the 10% of 180. Thus, by moving point C on segment

AB, we find a position of point C in which the length of segment BF reaches the length of 18 (Fig. 4a). At this position we also observe that slope of segment AF is 0.10 that corresponds to the 10% of alcohol of the total of 180 L. In terms of the problem, we need to add 80 L of the solution that is at 15% to the 100 L of the solution that is at 6% of alcohol to get a solution with 10% of alcohol.

In a dynamic model, it is always important to explore how some elements behave when another is moved within the model. How does the slope (m_3) change when point C is moved along AB? To explore the slope behavior, we rely on a Cartesian system that has the total of liters as the horizontal axis and the values of slopes as the vertical or y-axis (Fig. 4b). Here, we define point G in such a way that its x-coordinate is the first x-coordinate of point C and its second y-coordinate as the slope of AF (m_3).

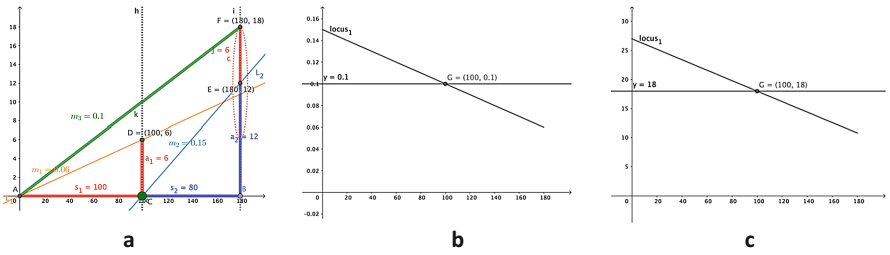

Fig. 4. Finding the position of point C to solve the problem. **b.** G is defined as (s_1, m_3) and the solution is the intersection of the locus of G and $y = 0.1$ https://www.geogebra.org/m/uhrez7mp. **c.** G is defined as $(s_1, a_1 + a_2)$ and the solution is found at the intersection of the locus of G and $y = 18$ https://www.geogebra.org/m/nz26h3xd

The locus of G when point C is moved along segment AB is shown in Fig. 4b. The intersection of this locus with the line $y = 0.1$ is the solution of the problem. Likewise, in another system with x-coordinates the total of liters of the substance and the y-coordinate as liters of alcohol, G can be defined as its first coordinate the x-coordinate of point C and its second coordinate the sum of $a_1 + a_2$. Then the intersection of the locus of point G when point C is moved along AB and the line $y = 18$ gives the problem solution (Fig. 4c).

Comment: Figure 3b shows a robust model of the problem where data and conditions are part of the model. Thus, slopes of lines L_1 & L_2 represent the percentage of alcohol of substances s_1 & s_2 respectively and the slope of line AF depends on the position of point C. That is m_3 changes when point C is moved along segment AB. Indeed, to find the problem solution implies moving point C on AB at the position in which the slope of point AF reaches the value of 0.1. Similarly, Fig. 4b & 4c show two different ways to achieve the solution, first (Fig. 4b) by graphing the slope variation and identifying the point where the slopes reaches the value of 0.1. Secondly, in Fig. 4c, the solution is achieved when the y-value of G is 18 L of alcohol which corresponds to the 10% of 180 L.

4.5 A Second Approach that Involves the Use of Areas

In this case, we maintain the horizontal axis with the total of liters of the substance and consider the vertical axis as the percentage of alcohol of the substance (Fig. 2c). Thus, in Fig. 5a, the length of segment AB represents the total of liters of the solution. C is any point on AB and lengths of segments AC (s_1) and CB (s_2) represent the liters of the first solution ($s_1 = 80$) at the 6% of alcohol and 100 L of the second solution that is at 15% of alcohol respectively; lengths of p_1 and p_2 represent the percentages of alcohol of s_1 and s_2 respectively and correspond to the y coordinate of points D & E. In Fig. 5b, the area of quadrilaterals $ACFD$ and $CBHG$ (q_1 & q_2) represent the liters of alcohol contained in s_1 & s_2) that produce solutions at 6% and 15% respectively.

Fig. 5. Representing the problem data geometrically https://www.geogebra.org/m/qsuxx5bn. **a.** representing the percentage of alcohol as units in the vertical axis.. **b.** Using the areas of involved rectangles to find the solution.

It is observed that when point C is moved along segment AB the values of q_1 and q_2 (that represent the areas of $ACFD$ and $CBHG$) change (Fig. 6a). When segment AC takes the value of 100 L, then the sum of q_1 and q_2 is $6 + 12 = 18$ and corresponds to 10% of 180 (Fig. 6a). That is, for 100 L of solution at 6% of alcohol, we need to add 80 L of solution at 15% to get 180 at 10% of alcohol (Fig. 6a). ¿How the sum of the areas associated with rectangle $ACFD$ & $CBHG$ behave as point C is moved along AB? To explore these area behaviors, we rely on a Cartesian system with a vertical-axis unit the value of area.

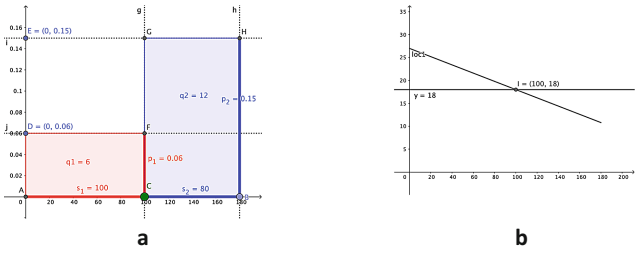

Fig. 6. Moving point C to find the solution. **b.** The intersection of locus of point I when point C is moved on segment AB and line $y = 18$ provides the problem solution.

Furthermore, point I is defined with its x-coordinate as s_1 and as a second coordinate the sum of q_1 & q_2. Thus, the intersection point of the locus of I when point C is moved along segment AB and the line $y = 18$ provides the coordinates of the solution point. That is, when s_1 reaches 100 L the solution that represent the sum of s_1 & s_2 will be at 10% of 180 (18) (Fig. 6b).

Comment: This model involves the concept of area of two rectangles, one with sides s_1 and p_1 and another with sides s_2 & p_2. Thus, the area of these rectangles is associated with the liter of alcohol of each substance s_1 & s_2. Thus, the solution is reached when point C is at the position in which the sum of q_1 and q_2 gets 18 L that corresponds to the 10% of 180.

5 Discussion of Results and Remarks

Mathematical tasks played a crucial role in designing and structuring learning environments in fostering students' comprehension of mathematical concepts and mathematical problem-solving competencies. Thus, teachers' goals can be traced in terms what tasks or problems their students work and how they are implemented during instruction. Thus, revisiting the study of word problems via the use of digital technologies led the members of the seminar to characterize a technological approach to approach and solve these problems in terms of:

1. **The use of a Cartesian system** to represent concepts that are involved in problem statements. Thus, the selection of units becomes important to coordinate the corresponding horizontal and vertical axes. In this task, the concept of solution at certain percentage of alcohol is related to the ratio concept of two quantities. Thus, the total liters of the substance, and the amount of alcohol are key elements to define the percentage of alcohol of the solution. Furthermore, liters of the substance, liters of alcohol, and percentages of alcohol are plausible candidates to coordinate the system. Figure 2a, 2b, & 2c shows coordinates of possible systems to represent the problem.
2. **The construction of a dynamic model of the problem**. In each cartesian system shown in Fig. 2, points B & C can be moved along the corresponding axis. Thus, drawing perpendicular lines to each axis from each point A & B, point D is the intersection of these points. The ratio of the coordinates of point D (slope of h) in Figs. 2a provides information regarding the percentage of alcohol of the substance. A movable point C on segment AB (Fig. 3a) determines two segments AC & CB associated with the amount of substance s_1 and s_2 at 6 and 15% of alcohol (represented by the slopes of line L_1 and L_2). When point C is moved along segment AB, the length of segment BF changes and the solution is achieved when the slope of line AF is 0.10 (10%) (Fig. 4a).
3. **The exploration of slope m3 and the problem solution**. The idea at this stage was to trace the variation of slope m_3 when point C is moved along segment AB. A point G is defined having x-coordinate equal to the x-coordinate of point C and its y-coordinate the slope of line AF. Figure 4b shows the locus of point G when point

C is moved along segment AB and the intersection of this locus with line $y = 0.1$ provides the problem solution.

4. **The geometric meaning of area and the problem solution**. Choosing the coordinates of the Cartesian system total liters vs percentage of alcohol (Fig. 2c) led the participants to focus on the area variation of two rectangles (Fig. 5b). Again, by moving point C along segment AB, it was possible to identify a position of C on AB such as the sum of the rectangle areas was 18. At this position of C, it means that 80 L of solution at 15% need to be added to 100 litters (that is at 6%) in order to get 180 L at 10% of alcohol (Fig. 6a).
5. **The locus solution that involves parameter variation**. An emergent theme that appear in solving word problems via dynamic models was the concept of variation. That is, to represent geometrically the variation of a slope associated with the percentage of alcohol or the area of involved rectangles led the participant to focus on a particular value of the slope or area that was connected to the solution.

In terms of the research questions, there is evidence that platforms and online developments offer interesting resources for teachers and students to contextualize, review, and extend information and concepts that are embedded in the problem statement. In this perspective, teachers need to problematize information and concepts information included in online resources in such a way that students have an opportunity to review, extend, and respond to questions that are important to the theme and problems to solve. Likewise, there is indication, that the use of a DGS demands that students focus on geometric meaning to construct a dynamic model of the problem. Furthermore, this model is explored as a means to find relationships among objects attributes or patterns of objects behaviors that became important to solve the task.

Finally, a digital application such as a DGS offers a set of affordances for students to model problems dynamically. The exploration of the models involves the use of affordances that include moving or dragging objects orderly, quantifying or measuring objects attributes, tracing loci of particular parameters, using sliders, and to graph relations. As a result, they look for patterns and mathematical relations that later are validated through visual and formal arguments. These relations are essential to solve and extend the problems. In this perspective, the use of the tool contributes to engage learners in a way of reasoning that privileges interpreting concepts geometrically and the construction and exploration of dynamic model of problems.

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Assessing Teachers' Use of English E-Textbooks over Time: A Technology-Mediated Learning Perspective

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Abstract. E-textbooks are learning solutions that apply technology-mediated learning (TML) in primary education environments. However, longitudinal research on the potential impact of e-textbooks on TML effectiveness and learning effectiveness for students is rare. This study explores the initial and long-term effects of differences in the degree of teachers' use of e-textbooks in class on students' subjective perception of TML effectiveness (i.e., learning motivation) and objective learning effectiveness (i.e., test scores). A quasi-experimental method was used, and the subjects were third-grade students at a primary school in Taiwan. The experimental and control groups each included 56 students. The researcher administered 11 learning motivation questionnaires and 10 tests during the 11-week experiment. Hierarchical linear modeling revealed the following: (1) The degree of teachers' use of English e-textbooks had no statistically significant effect on the students' initial learning motivation and test scores. (2) Over a long time frame, teachers' full use of English e-textbooks led to higher student learning motivation but had no statistically significant effect on test scores. (3) Prior knowledge was found to have a positive and statistically significant effect on students' initial learning motivation and test scores.

Keywords: Electronic textbooks · Learning motivation · Learning effectiveness · Longitudinal analysis · Hierarchical linear modeling

1 Introduction

Many schools have invested in computers and iPads (and other tablets), providing students with more access to e-books, apps, and online resources [1]. Among these resources, the use of electronic textbooks (e-textbooks) or academic e-books has become more popular and helpful in supporting student learning [2]. Students can read e-textbooks on a computer, an e-book reader, a smartphone, or a tablet [3, 4]. E-textbooks

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are one of the most promising areas of e-books [5], bringing about changes in how students learn to read and how they read to learn [6]. When an e-book is used as an instructional or educational book, it is often called an e-textbook [3]. E-textbooks have changed the instructional model teachers use in courses and transformed the way students learn [5]. In this study, an e-textbook is defined as a student-centered textbook that contains a complete curriculum and provides additional teaching resources, such as video, interactive learning activities, and evaluation tools, through the functions of the electronic interface, such as pronunciation audio, highlight-stroke, copying, clipping, pasting, erasing, accessing the Internet, quizzing functions that provide differentiated teaching content, and game-based and cooperative learning models. An e-textbook provides functions for teacher–student interaction and real-time feedback, so that digital learning is more effective and livelier.

E-textbooks are popular in education systems in many countries as a method for integrating technology into primary schools [7, 8]. Finding an effective way to help teach English seems inevitable because learning a second language is a relatively important educational task [9]. According to the cognitive scholar Piaget, who distinguished children's development into four stages, middle-grade students in primary schools are in the concrete operational stage. In this stage, students rely on specific physical thinking, such as electronic picture cards, word cards, picture cards, to make links and to understand and organize single words and sentence patterns. These advantages have led to more and more teachers using e-textbooks in English teaching in primary schools. However, not all students are satisfied with this technology [10]. For instance, some students have pointed out that reading large amounts of text on small computer screens is tiring, inefficient, and even painful compared to text on paper [11]. Some students may have reading habits by using printed materials [12]. This leads to several interesting questions: Does teachers' use of English-language e-textbooks in class increase primary students' learning motivation and effectiveness? Do students' learning motivation and effectiveness show sustained positive growth, or are they weakened by elastic fatigue over a long time frame? In this study, we investigated the effect of teachers' full and partial use of e-textbooks on technology-mediated learning (TML) effectiveness (which is reflected in learning motivation) and learning effectiveness (which is reflected in test scores) of beginner English-language learners over a long time frame. The analysis was conducted using hierarchical linear modeling (HLM). The research questions are as follows:

1. Does teachers' full use of e-textbooks in class affect primary school students' initial learning motivation and test scores?
2. Does teachers' full use of e-textbooks in class affect primary school students' learning motivation and test scores over a long time frame?
3. Does prior knowledge affect primary school students' initial learning motivation and test scores?

2 Literature Review

2.1 Electronic Textbooks

E-textbooks are called web-based textbooks, online textbooks, or digital textbooks [13], are presented in digital or electronic form, and can be used on various carriers and platforms, such as desktop computers, laptops, tablet computers, smart phones, e-book readers (e.g., Amazon Kindle readers), web browsers, and e-book platforms (e.g., ebrary). E-textbooks have been implemented for instructional and learning purposes [14] and are divided into two categories according to differences in carriers and formats: page fidelity and reflowable [15]. For page-fidelity e-textbooks, the content storage format is mostly a PDF file. It is only a scanned file of the textbook, and the device used is very simple. As long as the PDF function is enabled, the device can be used only to turn pages. The file cannot be annotated, bookmarked, or linked to the Internet. For reflowable e-textbooks, the content storage format is HTML or XML, and the devices that can be used are very diverse, such as desktop computers, laptops, tablet computers, smart phones, and e-book dedicated readers. This type of e-textbook has various functions, such as linking to the Internet, watching animation and video, editing content, and other interactive functions. The e-textbook characteristics are as follows:

1. E-textbooks are dynamic and interactive combinations of all types of media: video, audio, text, photos, animation, search, and sharing [16].
2. They can include interactive activities, such as games [8] and editing functions, for example, text tracking [17], copying, pasting, annotation, searching, bookmarking, and hyperlinks.
3. They can be used to take notes [4]. Notes can be created that display directly in the text or in a separate window [5]. Students can highlight key points with different colors [18] or personalize their text [7].
4. Some authors and publishers supplement textbooks with websites that provide additional information and resources [5].
5. They quickly access the content of the teaching materials and are easy to carry [7, 19].
6. With a mobile device, the teacher can control students' learning progress online at any time.
7. Students can be provided with flexible learning and immediate feedback to track their progress.
8. They can record the quiz scores. Teachers can develop customized teaching according to students' learning levels.
9. They lighten and simplify students' school bags. E-textbooks contribute to the green environment trend [20].

2.2 Technology-Mediated Learning Perspective

The use of TML has increased dramatically. It is defined as "an environment in which the learner's interactions with learning materials (readings, assignments, exercises), peers, and/or instructors are mediated through advanced information technologies" [21]. The

key components of the TML context are technology features, instructional strategy, psychological processes (e.g., motivation and interest), and learning outcomes in a given learning context [21]. Concerning the discussion above, drawing on TML, in this study, we explored and assessed whether the degree of e-textbook use in the English instructional process influences TML effectiveness (which is reflected in learning motivation) and learning effectiveness (which is reflected in test scores).

3 Research Model and Hypotheses

3.1 Research Model

Figure 1 illustrates the relationships that reflect a multilevel view of students' subjective measure of TML effectiveness and an objective measure of learning effectiveness. The data observed over time were regarded as event-level data (level 1), and the data that included the teacher's full or partial use of e-textbooks in class and prior knowledge at the beginning of the experiment were regarded as student-level data (level 2). Additionally, the degree of teachers' use of e-textbooks in class could moderate students' perception of TML effectiveness and learning effectiveness over time (cross-level).

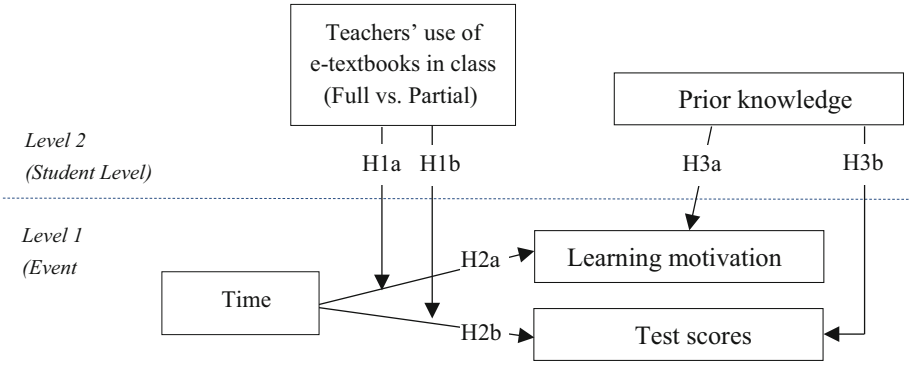

Fig. 1. The research model

3.2 Research Hypotheses

Level 2 Model: The Effect of Teachers' Use of E-Textbooks at the Initial Time Point. Digital books and e-books can be used in the learning environment, and scholars have shown that students who use academic e-books have higher motivation levels than students who use printed books [12]. Academic e-books also facilitate student learning and achieve higher achievement [12, 22]. In a study on electronic storybooks, Kao et al. [23] found that students who read high-interactive electronic storybooks have higher learning motivation than those who read low-interactive electronic storybooks. Similarly, increasing the interactivity of e-textbooks can improve student learning [5]. Especially for beginning readers, e-books enhance learning motivation [24]. Students who use e-textbooks in class are likely to show enhanced involvement, and their learning

experiences are promoted; thus, the possibility of the student succeeding in learning increases [14]. We inferred that a teacher's full use of English e-textbooks can create a multimedia situation with high interactivity, high entertainment, and a high sensory stimulation effect. Thus, we propose the following hypotheses:

H1a: The degree of teachers' use of e-textbooks has a positive and significant effect on students' learning motivation after controlling for time; that is, there is a significant difference between teachers' full and partial use of e-textbooks and students' initial learning motivation.
H1b: The degree of teachers' use of e-textbooks has a positive and significant effect on student scores after controlling for time; that is, there is a significant difference between teachers' full and partial use of e-textbooks and students' initial test scores.

Cross-Level Model: The Effect of Teachers' Use of E-Textbooks over Time. According to Wongwiwatthananukit and Popovich [25], "motivation is something that gets a person going, keeps the person moving, and helps the person to get the accomplished jobs" (p. 188). Teachers must create a sense of satisfaction to maintain students' learning motivation [25]. There is also a learning curve for students' use of e-textbooks. Once students become familiar with reading textbooks on a computer, their effectiveness may increase [26]. Thus, student learning effectiveness may change over time. E-textbooks are widely used in teaching sites. E-textbooks provide many resources, and help students learn vividly and happily, so that they are more interested in learning. Interactive textbooks are a type of e-textbook that involves students more in the textbook content. For example, the app and slides have related links to provide additional information. Video animation has sound, tips, and texts with pictures that can attract students' attention, and digital game–based evaluation engages students deeply in classroom activities. These elapsed-time catalysts make learning lively. Thus, we hypothesized that teachers' full use of e-textbooks leads to a higher rate of increase in learning motivation than low use. Similarly, students' scores increase at a higher rate with teachers' full use of e-textbooks than with teachers' partial use. This led to the following hypotheses:

H2a: Over a long time frame, the degree of teachers' use of e-textbooks has a positive and significant effect on students' learning motivation; that is, teachers' full use of e-textbooks leads to a higher growth rate in students' learning motivation than teacher' partial use of e-textbooks.
H2b: Over a long time frame, the degree of teachers' use of e-textbooks has a positive and significant effect on student test scores; that is, teachers' full use of e-textbooks leads to a higher increase in students' test scores than teachers' partial use of e-textbooks.

Level 2 Model: The Effect of Prior Knowledge at the Initial Time Point. Individual differences play a vital role in student learning [27]. An important individual difference is students' prior knowledge, as it relates to a specific domain of the lesson [28]; prior knowledge can maximize the effectiveness of any specific learning instance [29]. Additionally, Sweller [30] pointed out that prior knowledge can increase learners' skills

and enable learners to use their memory more in the learning process to deal with more elements. Therefore, based on the arguments above, we propose that prior knowledge can enhance initial learning motivation and test scores.

H3a: Prior knowledge directly affects students' initial learning motivation.
H3b: Prior knowledge directly affects students' initial test scores.

4 Methodology

4.1 Experimental Design

In this study, we adopted an 11-week quasi-experimental design, with one of the authors teaching English to third-grade students. Four classes participated in the study. Two of the classes were randomly selected for the experimental group and two for the control group. In the experimental group, the primary school teachers fully used e-textbooks; that is, the teachers used e-textbooks to transmit knowledge, class interaction (i.e., electronic flash cards, apps, slides, video animation), and student evaluation (an e-textbook game). In the control group, the primary school teachers partially used e-textbooks; that is, the teachers used e-textbooks to transmit knowledge. However, the teachers used traditional teaching methods for class interaction (i.e., flash cards, pictures, sentence patterns, and blackboard) and student evaluation (i.e., a physical game and a paper-and-pen test). A comparison of teaching procedures for the experimental and control groups is shown in Table 1. Figure 2 and Fig. 3 show photos of the experimental and control groups. Questionnaires were sent to 116 students. After four invalid questionnaires for students who did not participate in the entire process were excluded, 112 questionnaires were collected: 56 in the experimental group and 56 in the control group.

Table 1. Comparison of teaching tools for the experimental and control groups.

Teaching procedure	Teaching tools	Experimental group	Control group
Transmitting knowledge	E-textbook materials	✓	✓
Class interaction	E-flash card	✓	
	App (application)	✓	
	Slides	✓	
	Video animation	✓	
	Flash card		✓
	Picture, sentence pattern		✓
	Blackboard		✓
Student evaluation	E-textbook games	✓	
	Physical game		✓
	Paper-and-pen test		✓

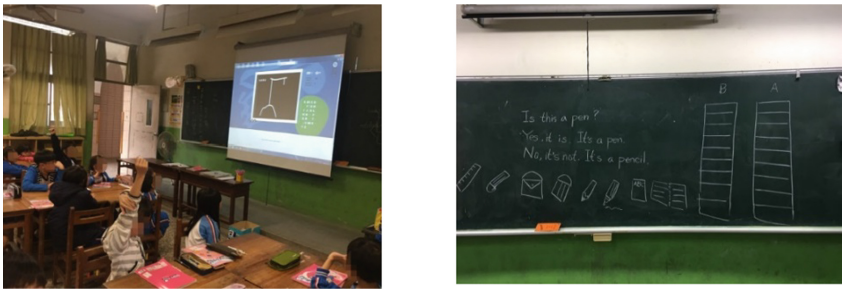

Fig. 2. Video animation (experimental) vs. Blackboard (control).

Fig. 3. E-textbook game-style evaluation (experimental) vs. paper-and-pen evaluation (control).

4.2 Duration of Experiment, Teaching Materials, and Environment

This study was conducted in a field teaching environment with a total teaching time of 11 weeks. Classes were held twice a week for a total of 22 lessons, each lasting 40 min, and students were asked to answer a questionnaire after class every week for 11 weeks. Students were asked to complete the prior knowledge test in the first week and then complete exams in the following 10 weeks. Figure 4 depicts the data collection timeline. The e-textbook teaching materials were the first volume of Story.com, Unit 3, Unit 4, and Unit 5, published by HESS International Educational Organization, which was approved by the Ministry of Education in Taiwan. Regarding the teaching environment, the teaching progress and the instructor for the experimental group and the control group were the same. The instructor had been trained on the use of e-textbooks for teaching. Both student groups were taught in English-speaking classrooms. The classroom arrangement and the environmental layout of the classrooms did not differ from one group to another. Single-shot projectors in front of the classrooms were used for both groups.

4.3 Variables

Teachers' use of e-textbooks in class represents the degree to which teachers fully or partially use e-textbooks to teach third-grade students in English lessons. We randomly selected two classes as the experimental group and the other two classes as the control group. The experimental group fully used e-textbooks, and the control group partially

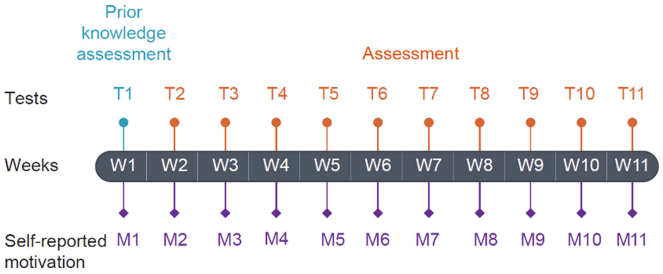

Fig. 4. Data collection timeline.

used e-textbooks and the traditional teaching method. We measured the variables by adopting existing scales from previous research. Time refers to the 11 weeks of testing from November 5, 2018, to January 18, 2019, and the longitudinal time of 11 tests performed for both groups. Prior knowledge was measured with the students' understanding of Aa to Zz to examine students' English proficiency before they participated in the teaching experiment. TML effectiveness was measured subjectively with a self-reported scale by asking students to respond about their learning motivation, and it is defined as students' perception of the goals, values, and skill beliefs for a course [31]. We asked the students to rate their learning motivation on three items with a five-point Likert scale (1 = strongly disagree; 5 = strongly agree) adopted from Artino [31]. Cronbach's alpha value for learning motivation was 0.916, indicating sufficient reliability. Learning effectiveness was measured with objective data from English achievement tests, and we used 10 tests after the teaching experiment from the 2nd to the 11th week.

5 Results

The results showed that the experimental effect did not affect the difference in learning motivation between students ($\beta_{01} = 0.202$, $t = 1.154$, $p = 0.252$); thus, H1a was not supported. The experimental effect over time had a statistically significant impact on students' learning motivation ($\beta_{11} = 0.067$, $t = 3.685$, $p = 0.001$); H2a was supported. Prior knowledge affected learning motivation ($\beta_{02} = 0.007$, $t = 2.330$, $p = 0.022$); H3a was also supported. Appendix A presents the HLM results for learning motivation. The results showed that the experimental effect did not affect the difference between the test scores ($\beta_{01} = 3.928$, SE = 2.451, $t = 1.602$, $p = 0.112$); thus, H1b was not supported. The experimental effect over time had a statistically significant impact on the test scores ($\beta_{11} = -0.039$, SE = 0.199, $t = -0.195$, $p = 0.846$); H2b was not supported. Prior knowledge affected the test scores ($\beta_{02} = 0.317$, SE = 0.048, $t = 6.654$, $p = 0.000$); thus, H3b was supported. Appendix B presents the HLM results for the test scores.

6 Discussion, Implications, and Limitations

6.1 Discussion of Findings

The results showed that at the initial time point, the degree of teachers' e-textbook use did not positively impact students' learning motivation or scores. A possible explanation is that third-grade students in primary schools have just moved from the junior- to middle-grade stage, and the curriculum has gradually deepened from simple to complex, coupled with the addition of new courses. At the beginning of the semester, students are still adapting to new courses, new technologies, and new instructional methods. English e-textbooks are different from other subjects, a new curriculum that takes time to explore, and at the beginning of the semester, students are just beginning to learn a foreign language. It may cause worry and fear, because the new exposure can create a sense of strangeness. In addition, Gu,WuXu [7] argued that students may not immediately recognize the value of using e-textbooks. Teachers should assist students in adapting to the learning process for new technologies.

The results also show that both groups' growth curves for learning motivation were linear. The growth rate reached a statistically significant difference: The growth rate for learning motivation for the full-use e-textbook group was higher than that of the partial-use e-textbook group. That is, over a long time frame, the experimental group of students used English e-textbooks more frequently, and the e-textbooks attached to the animations, games, and app functions were full of entertainment and interaction. Some students may be attracted to these new technologies, which increases their motivation and willingness to use them [18, 32]. The present results indicate that the full use of e-textbooks to transmit knowledge, class interaction, and student evaluation can gradually enhance students' learning motivation. Combining the full use of e-textbooks with gaming seems to improve learning motivation. Figure 5 depicts the experimental effect of learning motivation across 11 weeks.

In addition, the results showed that the growth curves of the test scores for both groups were linear. However, the growth rate did not reach a statistically significant difference: The growth rate of the students' test scores in the full-use e-textbook group was not higher than that of the partial-use group. One possible reason is that the students used the computers at school and could not bring the e-textbooks home. Previous researchers have pointed out that unless students have laptops, they cannot study with e-textbooks at home or in dorm rooms [26]. This result suggests that account permission is an important setting. Teachers must set up accounts so that students can store their learning results, which are conducive to students' learning at home or elsewhere. Figure 6 displays the experimental effect of students' scores across 10 weeks.

The results showed that prior knowledge had a statistically significant positive effect on students' initial learning motivation and test scores. Students' prior knowledge determines how they learn and process information and link it to the framework of knowledge they already know [33, 34]. The results confirmed that prior knowledge exerts an effect on initial learning motivation. The results also showed that prior knowledge enhances initial test scores. These results are consistent with several previous studies that showed prior knowledge enhanced learning performance [29, 35].

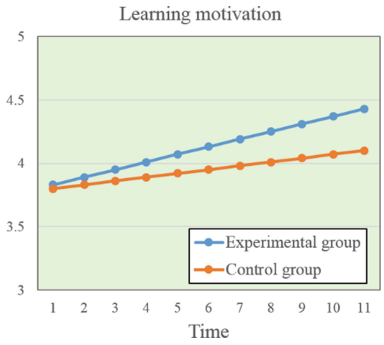

Fig. 5. Experimental effect of learning motivation.

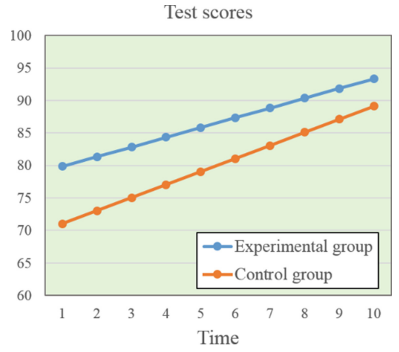

Fig. 6. Experimental effect of test scores.

6.2 Implications

This study has implications for future research in this subject area that may highlight the study's contributions. First, most previous research on e-textbooks used cross-sectional designs, and a longitudinal study that tests the long-term effects of e-textbook use has not been conducted. We added a time factor to the experimental process, through the 11-week teaching intervention, to observe students' learning motivation and test scores in the long term. Second, the present study compared teachers' full and partial use of English e-textbooks. We explored the influence of teachers' full use of e-textbooks in all steps in teaching procedures (transmitting knowledge, class interaction, and student evaluation) or partial use of e-textbooks (used only in the transmitting knowledge step) on students' learning motivation and test scores. This comparison enriches understanding of teachers' e-textbook use, especially for students who are starting to learn a second language, further implying that teachers' full use of e-textbooks leads to high learning motivation in the long term but has no significant impact on learning motivation at the initial time point. Finally, technology will continue to exist, and the pragmatic question is how to make the best use of many technologies [36]. This study contributes to the theoretical understanding of e-textbook use in class. In particular, drawing on the TML perspective, we explored the effect of the degree of teachers' use of e-textbooks on TML effectiveness (motivation) and learning effectiveness (scores). Helping students engage in learning is an important issue in innovative instruction technology [37]. This study offers insights into the best use of e-textbooks for beginner English learners. These insights were obtained through practical teaching and empirical examinations of primary school teachers' use of e-textbooks.

This study has implications for practice for e-textbook teachers and publishers. First, the results showed that using e-textbooks in all steps in teaching procedures can lead to high learning motivation. In this study, an e-textbook game was used for student evaluation. The use of educational digital games has grown considerably [36], and games have features that can facilitate language learning [38]. According to Korat [17], providing children with written text and synchronized narration accompanied by animated pictures and sound effects benefits children's literacy development. In the ideal educational game environment, the game usually starts at an easy level and then gradually becomes difficult [27]. Thus, we suggest that e-textbook publishers should design game content ranging from simple to difficult, allowing students to understand the course content through exploration and reflection gradually. Second, the present study results suggest that a pedagogical design for e-textbook use to support class interaction and student evaluation can include e-flash card, apps, slides, video animation, and e-textbook games, which are useful for motivating beginning English-language learners. This study provides insights into the use of e-textbook functionality to clarify its influence on learning motivation. It is important for teachers to learn how to incorporate function into their teaching [39]; thus, schools should provide appropriate training, and teaching demonstrations are needed. In this way, teachers can utilize available functions to facilitate English learning. Finally, full use of e-textbooks in class can enhance students' motivation to learn over a long time frame. E-textbooks should be prepared in cooperation with teachers and publishers. Publishers can provide opportunities for teachers to create their textbooks [39] or incorporate their resources in an e-textbook, such as uploading a file or annotating related text [40].

6.3 Limitations

The contributions of this study should be considered in light of its limitations. First, we conducted experiments only for selected third-grade students in four classes of a primary school in Taiwan in a single English course; thus, there were several limitations. Research participants from more schools could be included to increase the generalizability. Second, there are possible student characteristics that affect students' learning effectiveness in an IT-enabled learning environment [21]. However, to avoid a lengthy questionnaire that might affect participants' willingness to respond, only e-textbook use and prior knowledge were included. Future researchers could include other variables that may influence learning motivation and test scores, such as student characteristics. Finally, the test scores were assessed by one teacher for each class. It is possible that another teacher would assess scores differently. However, given that this teacher assessed all students, the potential bias was uniform across all classes.

Appendix A. HLM Results for Learning Motivation

Coefficient	Null model	First-order curve model	Second-order curve model	Intercept effect model	Experimental effect over time model	Hypothesis results
Fixed effect						
Mean score (β_{00})	4.064***	3.769***	3.735***	3.769***	3.769***	
Time$_1$ (β_{10})		0.049***	0.065*	0.049***	0.049***	
Time$_2$ (β_{20})			–0.001			
Experimental effect (β_{01})				0.492**	0.202	H1a not supported
Prior knowledge (β_{02})				0.007*	0.007*	H3a supported
Experimental effect over time (β_{11})					0.067**	H2a supported
Random effect						
Level 2 ($\tau 00$)	0.761***	0.746***	0.863***	0.733***	0.713***	
Level 1 (σ^2)	0.441	0.336	0.317	0.336	0.336	
Time$_1$		0.007***	0.057***	0.007***	0.006***	
Time2			0.000**			
Deviance	2824.386	2654.735	2632.218	2653.775	2645.409	

Note. ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.

Appendix B. HLM Results for Test Scores

Coefficient	Null model	First-order curve model	Second-order curve model	Intercept effect model	Experimental effect over time model	Hypothesis results
Fixed effect						
Mean score (β_{00})	85.387***	85.387***	85.387***	85.387***	85.387***	
Time$_1$ (β_{10})		0.695***	1.316**	0.695***	0.695***	
Time$_2$ (β_{20})			–0.056			
Experimental effect (β_{01})				3.746	3.928	H1b not supported
Prior knowledge (β_{02})				0.317***	0.317***	H3b supported
Experimental effect over time (β_{11})					–0.039	H2b not supported
Random effect						
Level 2 ($\tau 00$)	271.786***	272.532***	272.915***	160.959***	161.178***	
Level 1 (σ^2)	75.259	67.835	63.995	68.192	68.194	
Time$_1$		0.338**	9.299***	0.299**	0.309**	
Time2			0.052**			
Deviance	8417.047	8319.247	8302.855	8280.522	8280.022	

Note. ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

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A Review on the Training Effects and Learners' Perceptions Towards Asynchronous Computer-Mediated Peer Feedback for L2 Writing Revision

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Abstract. Few review studies have been conducted to systematically examine how asynchronous computer-mediated peer feedback affects students' revision quality and perceptions in L2 writing contexts after training. This study thus aims to fill the research gap by investigating the training effects of asynchronous computer-mediated feedback with regards to (1) the quality of peer comments, (2) the adoption rate, and (3) quality of student revision in L2 writing revision. In this paper, the researchers qualitatively examined related empirical studies based on three variables. The process of analyzing the refined corpus led the researchers to identify the following findings. First, it was found that asynchronous computer-mediated communication could lead to an enhancement of peer comments quality and a primacy of global-oriented and revision-based peer comments, with comment type focusing on 'suggestion' and 'evaluation', though the adoption rate of the revision-oriented comments was usually less than fifty percent. Nevertheless, once learners practically adopted the peer comments with the acknowledgement of their effectiveness, successful revisions for both local and global issues and the development of writing performance could be expected. In addition, it was also elicited that students generally appreciated the great convenience and anonymity of the computer-mediated technology; however, online distractions and the lack of face-to-face communication and verbal interactions might also negatively influence students' revision quality. Given this, some suggestions for future implementations of asynchronous computer-mediated peer feedback was proposed, in the hope of shedding some light for educational practitioners and scholars interested in the incorporation of computer-mediated communication and peer reviewing in L2 writing.

Keywords: Training effects · Peer comment · Computer-mediated communication (CMC) · Asynchronous computer-mediated peer feedback · L2 writing revision

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1 Introduction

"Peer feedback, a reciprocal activity in which students respond to one another's writing and produce oral and/or written feedback to express their opinions and suggestions" (Min and Chiu 2021, p.2), has been recognized for its multitudinous benefits among ESL/EFL instructors (Chen 2016; Min and Chiu 2021). Previous research has indiated that with strategic design and implementation, peer feedback could engage students in the writing and revision process (Yang et al. 2006), enhance audience and metacognitive awareness (Ion et al. 2019; Zhang and McEneaney 2020), and develop L2 writing competence (Alharbi and Al-Hoorie 2020). Findings from multiple empirical studies have also shown that through explicit and systematic training in revising and editing peer's texts, trained students were able to provide and incorporate more revision-oriented comments at the meaning level (Cui et al. 2021; Liou and Peng 2009), thus resulting in an enhancement of revision quality (Min 2018).

With the accelerated evolution of computer-mediated communication (CMC) and the learning opportunities its supports, computer-mediated peer feedback has gained significant popularity in L2 writing classrooms (Li and Li 2017; Pham 2020; Yang 2016). With the assistance of technology in peer feedback, writing teachers could closely monitor and observe students' learning processes and provide appropriate scaffoldings during peer feedback activities (Chen 2016; Yang and Meng 2013). Students could also observe how their peers detected and corrected errors via CMC and reflect on their own revision processes (Yang 2016) without the constraints of time and space. Given the affordances of CMC, the training effects of computer-mediated feedback on the facilitation of revision quality and learning attitudes have been well acknowledged by several previous research publications. It has been posited that compared to the traditional face-to-face mode, trained computer-mediated written peer feedback could generate a larger number focused and revision-oriented comments, contributing to successful revision outcomes of written products (Chang 2012; Liu and Sadler 2003; Pham 2020). In addition, CMC may also enable students to take a more active and autonomous role as well as making writing classes more collaborative (Hyland and Hyland 2006), ensuring task discussion, equal participation, and a development of students' motivation (Chang 2012; Chen 2016; Pham 2020). Some researchers also claimed that it could also encourage group knowledge, leading to greater participation and less learning anxiety, especially for less proficient learners, due to the convenience and anonymity of online feedback (Alharbi and Al-Hoorie 2020; Li and Li 2017; Pham and Usaha 2016).

However, there are also some concerns regarding the incorporation of CMC peer feedback in L2 writing classes. For example, Liu and Sadler (2003) compared the comments from peer reviewers in traditional face-to-face contexts and real-time online chat rooms and found that although students using synchronic commenting produced a greater number of comments, most of them were superficial rather than substantive.

Despite the challenges and criticisms, the potential afforded by CMC in peer feedback is promising, with significant possibilities to be explored, especially in the form of asynchronous computer-mediated peer feedback (Loncar et al. 2021). Recent years have witnessed the adoption of various asynchronous CMC tools, such as Turnitin (Alharbi and Al-Hoorie 2020; Li and Li 2017), Google Docs (Pham 2020), blogs (Liu and Sadler 2003; Pham and Usaha 2016), researchers-designed computer supported collaborative

learning (CSCL) systems (Yang 2016; Yang and Meng 2013), and wikis (Bradley 2014) in peer feedback. However, most of the review studies have already delved into the general analysis of the research orientation or methodology of technology-mediated feedback in L2 writing scenarios, with few papers systematically examining the effects of L2 writing revision based on the training effects of asynchronous computer-mediated peer feedback.

1.1 Purpose and Research Questions of This Study

The purpose of the present paper, thereby, aimed at investigating the effects of trained peer-written feedback with different asynchronous CMC tools, utilizing criteria proposed by Liou and Peng (2009) which were later adapted to fit the purpose of the study. Given this, the results synthesized in this paper was based on (1) the quality of peer comments, (2) the feedback adoption rate, and (3) the students' revision quality in L2 writing contexts. Furthermore, learners' perceptions towards asynchronous computer-mediated peer feedback were also explored. Finally, some suggestions for the successful implementation of asynchronous computer-mediated peer feedback for L2 writing were generated as well.

2 Method

A systematic content analysis was employed in this research in order to gain comprehensive insights regarding the effects of the incorporation of asynchronous computer-mediated peer feedback on learners' text revision. Nine articles were selected from both ISI Web of Science and Google scholar for further analysis. Keywords such as CMC, peer review, and asynchronous communication, and L2 writing were used to search for papers for further synthesis. For final paper selection, each paper was required to meet the following criteria. First, the document types should be empirical studies in English, with sufficient information about the use of asynchronous tools to offer written peer feedback to foster L2 writing revision and interactions. In addition, all students should have undergone systematic training on giving written feedback and text vision and correct use of the commenting tools. Finally, the paper selected should consist of rigorous research design, with in-depth methodology, discussion, and analysis.

2.1 Term Definition

This section defines the three main variables analyzed in this study, i.e. peer comment quality, the feedback adoption rate, and students' revision quality.

Firstly, the quality of peer comments was evaluated in accordance with comment area, comment nature, and the type of feedback. First, comment area was categorized into global (content and organization) and local issues (vocabulary, grammar, or punctuation) (Min 2018); comments on global issues may affect overall meaning, but those on local areas dealt with language issues without changing writers' attention (Pham and Usaha 2016). Comment nature was also an important indicator to judge student reviewers' quality of comments. Therefore, comment nature was subdivided into revision-oriented and

non-revision-oriented comments. The former were operationally defined as "comments indicating reviewers' intention of asking for trouble source revision" whereas the latter were defined as "comments irrelevant to making any suggestions for revision" (Chang 2012, pp. 67–68). Finally, comment type pertained to the function of revision-oriented comments, including suggestion, evaluation, clarification and alteration (Liu and Sadler 2003).

Regarding the feedback adoption rate, it referred to the number of comments incorporated in proportion to the total number of revision-oriented comments (Liou and Peng 2009). Lastly, students' revision quality meant the number of adopted comments leading to successful revisions (Liou and Peng 2009). Here, successful revisions were made when comment receivers successfully repaired the errors in alignment with the reviewer's intention (Loewen 2004; Ruegg 2015). Table 1 summarizes the main categories analyzed in the present paper.

Furthermore, in accordance with these three categories, Table 2 illustrates the specific findings of each paper reviewed. In addition, a systematic synthesis of the results and discussion is also provided in the following sections.

Table 1. Main categories analyzed

Category	Sub-category/definition	
Comment quality	Comment area	Global and local issues
	Comment nature	Revision-oriented and non-revision-oriented comments
	Comment type	Suggestion, evaluation, clarification and alteration
Feedback adoption rate	The number of comments in proportion to the total revision-oriented comments	
Revision quality	The number of adopted comment which led to successful revisions	

3 Results and Discussion

3.1 The Quality of Peer Comments

Overall, it is believed that high quality peer feedback was generated via asynchronous CMC, and an important finding from the analysis was the ascendency of global-focused and revision-oriented peer feedback (Loncar et al. 2021), with comment type focusing on 'suggestion' and 'evaluation' (Bradley 2014; Liou and Peng 2009). As several scholars (Lundstrom and Baker 2009; Min 2005; Rahimi 2013; Zhu 1995) have pointed out, explicit global comments could enhance the quality of student writers' essays; consequently, the ability to offer comments on content and organization on L2 writing could be considered features of effective peer comments (Rahimi 2013). Given this, the primacy of global comments played a seminal role in the facilitation of peer comment quality. More information was also identified in the studies of Bradley (2014) and Li and Li (2017).

Bradley's (2014) descriptive study investigated the educational design of a wiki-based online writing environment where 26 non-native English master's students from Sweden and 16 native English undergraduates from America exchanged ideas through giving and receiving peer review on three different assignments for the development of language, discursive, communicative, and intercultural communication competence. Findings were positive with respect to the use of trained asynchronous written peer feedback and intercultural collaboration to encourage comments on the meaning level and revision-oriented feedback. It was found that comments on global issues (80%) significantly outnumbered those on local areas (20%), with the majority (87%) of comments regarded 'suggestion' and 'evaluation' of the content aspect, and most of the linguistic revision (75%) categorized as 'alternation'. Concerning comment nature, 90% of comments were revision-oriented, mostly (72%) focusing on 'suggestion' and 'evaluation'.

Table 2. An analysis of asynchronous computer-mediated peer feedback on learners' text revision

Paper title/Author	Comment quality (comment area, comment nature)	Feedback adoption (uptake)	Revision quality	Perception
Turnitin peer feedback: controversial vs. non-controversial essays (Alharbi and Al-Hoorie 2020)	Controversial topics could generate more global comments, not coming at the expense of local comments	N/A	N/A	The participants remarked on the convenience and anonymity of online feedback, which enabled them to express their ideas more freely on controversial issues and improve critical thinking skills
Peer-reviewing in an intercultural wiki environment-student interaction and reflections (Bradley 2014)	Global comments (80%) outnumbered local ones (20%). The former focused on 'suggestions' and 'evaluation', whereas the later on 'alternation' More revision-oriented (mostly on suggestion and evaluation; 90%) peer comments than non-revision oriented (evaluation; 10%) ones	The students claimed that they embraced most of the received comments when revising their texts	N/A	Learners were engaged in an intercultural peer review exchange via wikis, which provided them with insights from different disciplines and from another country. This enhanced students' diversity of text revisions, together with linguistic and intercultural competence

(*continued*)

Table 2. (*continued*)

Paper title/Author	Comment quality (comment area, comment nature)	Feedback adoption (uptake)	Revision quality	Perception
Peer review via three modes in an EFL writing course (Chang 2012)	More revision-oriented (87%) comments than non-revision ones were identified via asynchronous modes (13%)	N/A	N/A	Students commented that the asynchronous PF helped to enhance the overall writing quality and was more convenient and efficient; however, they were concerned about the lack of interactivity with comments in asynchronous mode. This delayed time mode afforded students to give insightful PF and gave detailed sentence-level corrections
Online peer review using Turnitin in first-year writing classes (Li and Li 2017)	The ESL learners made more global revisions (71.2%) (57.7% on content) than local ones (28.8%) (9.4% on grammar) in argumentative papers The revision-oriented peer comments comprised up to 97.4% of the total (74 out of 76)	N/A	N/A	Learners liked the convenience, efficiency, and anonymity for reviewers and writers by using *Turnitin*. However, the incorporation of synchronous is suggested

(*continued*)

Table 2. (*continued*)

Paper title/Author	Comment quality (comment area, comment nature)	Feedback adoption (uptake)	Revision quality	Perception
Training effects on computer-mediated peer review (Liou and Peng 2009)	Global comments 84.5% (rather than local ones 15.5%) dominated students' evaluation More revision-oriented peer comments (evaluation, clarification and suggestion) than non-revision oriented ones (chatting, complimentary)	Less than 50% (47.7%) of the comments were adopted for revision (unsure if the suggestions were helpful) Incorporated a higher percentage of the global comments (65.7%) as compared to the local comments (34.3%)	More successful revision, rising from 83.3% to 85.7% More effective revisions (91.8%) than ineffective ones (8.2%) The revisions mainly focused on global rather than local issues, although the proportion of global revisions made on the 4th assignment declined compared to those made on the first one (72.3% → 65.7%)	Affective: blog-enhanced instruction enhanced students' interest in improving their writing Not all of the participants felt confident about or eligible to provide useful peer feedback Enjoyed reading rather than providing peer comments
Computer-mediated and face-to-face peer feedback: student feedback and revision in EFL writing (Pham 2020)	Written asynchronous computer-mediated communication (WACMC) form had more local revision-oriented comments than globalized ones. The reason is that Google Docs automatically highlighted the language errors. However, global revision-oriented comments from this form were still more than those from OF2F	Compared to oral face to face (OF2F) peer feedback, WACMC was perceived to be more helpful since more comments on local and global issues from this form were incorporated more frequently for revision, given that Google Doc is designed to make revision easy	N/A	Commenting online was very convenient because learners could consult the online dictionary and corpora, making their comments more helpful. The incorporation of WACMC followed by OF2F was suggested Asynchronous affordance of Google Docs gave students more time to provide thoughtful and detailed comments. Students tended to complete their reviewing task in several sessions rather than at one go

(*continued*)

Table 2. (*continued*)

Paper title/Author	Comment quality (comment area, comment nature)	Feedback adoption (uptake)	Revision quality	Perception
Blog-based peer response for L2 writing revision (Pham and Usaha 2016)	Comments given on global issues were significantly more common than those on local issues Most self-initiated revisions focused on local issues, revisions on global areas were mainly from global revision-oriented comments	Less than 50% of the comments were adopted for revision For levels of non-revision comments, the three least incorporated levels were "sentence," "word," and "phrase"	The quality of the revision oriented comments on global issues was not guaranteed to be better in the global areas (more local revision-oriented comments (51.5%) than global ones (48.5%)	N/A
The effects of online feedback training on students' text revision (Yang and Meng 2013)	N/A	More proficient learners did not accept the comments after online feedback training (due to their peers' limited writing knowledge), while the less-proficient learners adopted most of the peer comments Less-proficient learners made more local (word, sentence) and global revisions (substitution, reordering, and consolidation), with the development of revision quality, whereas the more proficient made more significant improvement on global issues (substitution)	N/A	Both groups agreed about the effects of online peer feedback (PF) The less proficient students recognized the effects of online PF since they could observe how more proficient learners detected errors. With the enhancement of revision quality, they became more confident Most of the more-proficient students (92%) did not trust their peers' revisions much, and consequently, did not raise their writing quality

(*continued*)

Table 2. (*continued*)

Paper title/Author	Comment quality (comment area, comment nature)	Feedback adoption (uptake)	Revision quality	Perception
Transforming and constructing academic knowledge through online peer feedback in summary writing (Yang 2016)	N/A	Learners in the online PF group outperformed their counterparts receiving paper-based PF by making more local (word, sentence) and global text revisions (substitution, reordering, and consolidation)	N/A	Conducted reciprocal learning with more proficient learners by interacting and observing other peers' summaries/summary revisions Leaners felt less anxious, less afraid of "losing-face" when providing conflicting PF

N/A = not applicable

This suggested that peer review of comment area primarily revolved around idea development and organization; on the other hand, the local comments focused on the alternation of wording, grammar, and punctuation. Moreover, more explicit comments triggering writer revision were found, meaning that potentially more useful advice was seen for more text revisions. This result was also supported by Liou and Peng (2009), who asserted that blog-based peer review and training in peer feedback might contribute to an increased number of comments on global issues (84.5%) and revision-oriented comments (68.7%) on 'suggestion', 'evaluation', and 'clarification', which significantly enhanced the quality of peer comments. In addition, it was also shown that students were less likely to be off-task during blogging-enhanced peer review activities.

Likewise, Li and Li (2017) explored the use of PeerMark modules in Turnitin for peer feedback in first-year ESL classes for English academic writing on genres including argumentative, and summary and response. Thirteen ESL learners with an intermediate or advanced English level underwent training in the use of different functions of Turnitin and a trail activity for peer review before conducting a double-blind peer review of three writing assignments. Students were not only allowed to read the comments on their own paper but also view all their peers' work and feedback. Analyses of eight students' summary and response papers revealed that Turnitin could scaffold learners to produce a large number of revision-oriented feedback comments (97.4%) and switch learners' attention on peer feedback from local to global areas, with global comments soaring from 35.6% to 71.2%, while the local comments remained similar in number, declining from 37.8% to 34.3%. This indicated that students' critical thinking skills in addressing content and organization were becoming more sophisticated. The finding echoed the study of Loncar et al. (2021), who also recognized the great affordance of network-based computing technologies, the importance of asynchronous written feedback in global-based peer review, and its potential in cross cultural collaboration.

3.2 Feedback Adoption

In spite of the high quality of asynchronous computer-mediated peer feedback, it was revealed that the peer feedback adoption rate was usually low, indicating that these revision-oriented comments might not always be helpful or informative enough for text revision. Some insights from Pham and Usaha (2016) are provided below.

Pham and Usaha (2016) examined the training effects of blog-based peer feedback on comment area and nature, together with adoption rate of peer feedback. Thirty-two Vietnamese second-year students with intermediate levels of English proficiency from the department of foreign languages received training both in the use of blogs and two phases of peer response training, including an in-class training session and a one-on-one teacher-student conference after the first draft of their writing assignment. The result of the final draft explicated that although approximate 75% of peer comments were revision-based, merely 38.7% of students' revisions were either partly or fully made based on these comments, and 61% of the revisions were made in accordance with learners' independent decisions. These findings were congruent with the research of Liou and Peng (2009), in which less than half (47.7%) of peer comments were adopted for revision, albeit a high rate of (68.8%) revision-oriented comments was identified.

Despite the low rate of feedback adoption, Pham and Usaha (2016) asserted that, most revisions incorporated at the higher levels of 'sentence' (57%) and 'paragraph' (53%) were based on peer comments, while those at lower levels of 'word' and 'phrase' were self-initiated. This illustrated that students still needed more meaning-level peer feedback while making revisions in global areas.

It could be argued that the incorporation of peer feedback is a complicated cognitive process affected by different reasons, including peer feedback training (Min 2005, 2006; Rahimi 2013) and age (Liou and Peng 2009). Additionally, learners' English proficiency could also be an overarching factor. For example, in Yang and Meng's (2013) research, researchers explored the extent to which online feedback impacted peer feedback adoption and text revision, targeting students with lower and higher proficiencies in English. All participants were offered appropriate scaffoldings and training in text revision through the CSCL system, and had the advantage of observing how their more proficient learners detected and corrected errors online. The final result revealed that after feedback training, the less-proficient group of students adopted and made significantly more local revisions to 'words' and 'sentences' and global revisions to content through 'substitution', 'reordering', and 'consolidation' than their counterparts in the more-proficient group. That is to say, the training effects of using asynchronous written feedback tended to be more beneficial for less-proficient learners regarding feedback adoption and revision. Explanations for the results could be that (1) the advanced learners may not make as many local and global errors as the less-proficient learners or (2) most of the more-proficient students (92%) distrusted their peers' suggestions even though their peers had undergone online peer feedback training.

3.3 Revision Quality

Notwithstanding a low rate of peer comment adoption, it was shown that the adopted peer feedback was usually effective, thus leading to successful local and global revisions

and the development of revision and writing quality. Liou and Peng's (2009) research contains further details.

Liou and Peng (2009) uncovered the training effects of blog-enhanced peer feedback on students' peer comments and revision quality. Given peer feedback training with guiding sheets and specific examples of effective peer comments, thirteen EFL Taiwanese college freshmen gave peer suggestions based on four formal writing assignments. The results revealed that although the adoption rate was less than half (47.7%), most of the incorporated feedback (85.7%) contributed to successful and effective revisions, among which 65.7% and 34.3% were global and local revisions respectively. It was suggested that once the learners recognized the effectiveness of peer comments, the feedback direction could help raise revision quality and final writing performance.

3.4 Students' Perceptions Towards Asynchronous Written Peer Feedback

In general, students' positive attitudes towards asynchronous written peer feedback were observed in most of the previous research conducted on the topic (Alharbi and Al-Hoorie 2020; Pham 2020; Yang 2016). Given the affordance of asynchronous E-learning technology, learners could conveniently view all of their peers' typed-up comments and papers and receive teachers' scaffoldings with no spatial and temporal constraints, which was not only beneficial for the facilitation of students' peer comment/revision quality and writing performance, but also for fostering student-student and student-teacher interactions (Li and Li 2017), collaborative learning, and intercultural competence (Bradley 2014). The asynchronous peer feedback mode also afforded students to give more thoughtful and detailed suggestions in several sessions instead of merely one (Chang 2012; Pham 2020).

Furthermore, the anonymity of online discussion may also engage students in a double-blind peer reviewing environment, allowing students to be more assertive and less anxious while expressing their opinions on controversial topics and thus enable the development of critical thinking skills (Alharbi and Al-Hoorie 2020; Liu and Sadler 2003). As Carson and Nelson (1996) pointed out, Chinese students tended not to precipitate conflicts and avoid criticism and disagreement over their peers' writing, a less face-threatening online context would enable students to talk more freely and engage more with the peer reviewing activities (Liu and Sadler 2003).

However, some scholars also reported challenges in asynchronous computer-mediated peer feedback. For example, the lack of face-to-face interactions and prompt verbal communication in asynchronous CMC might be a hindrance for comment receivers to clarify student reviewers' intention without delay (Chang 2012). Therefore, the combination of face-to-face or synchronous CMC with the asynchronous mode was suggested by some researchers (Chang 2012; Li and Li 2017; Pham 2020), with the purpose of encouraging more revision-oriented comments to obtain a higher uptake rate. In addition, online distractions could be another pitfall of CMC. For example, Liou and Peng (2009) argued that the 'chatting' function on web-blogs could distract learners' attention and lead to non-revision- oriented comments and ineffective revisions. Some students might still consider a web-blog to be a social-networking service system to maintain friendships with peers rather than a medium for peer review (Liou and Peng 2009); consequently, explicit and strategic training based on asynchronous CMC was a

prerequisite to help students more focused on learning tasks and improve the quality of their writing.

3.5 Suggestions for Future Implementation

In accordance with the synthesized findings, to achieve the successful implementation of asynchronous computer-mediated peer feedback in L2 writing, the following suggestions are provided.

Firstly, considering the technical benefits afforded by different modes of communication, it is suggested that the use of two-stage peer reviewing, including asynchronous CMC followed by face-to-face discussion could be ideal for student feedback and text revision (Pham 2020). To this end, students not only gain more access to read their peers' comments and writing with greater convenience and anonymity, but also enjoy the advantages that verbal communication can offer (for example, the clarification of writers' or student reviewers' intention).

Furthermore, systematic and explicit training in giving qualified peer feedback and conducting successful text revisions, as well as on the correct and effective use of different functions of the new technology should be provided before the actual practices of online peer feedback. The training could be offered via tutorial videos, followed by clear and specific steps based on a research-proven revision model for learners to follow. In addition, a trial session with teacher modeling, guidance sheets and a well-established rubric for learners to acquire hands-on experience of the practice of commenting on their peer's paper would also be helpful for the development of students' comment and revision quality (Li and Li 2017).

4 Conclusion

Under the trends of globalization and digital advancement, a paradigm shift of peer interactions has gradually changed from face-to-face to computer-to-computer mediated ones (Chen 2016). Given this, the present review study aimed to discover the training effects and student perceptions towards asynchronous computer-mediated peer feedback on text revision in ESL/EFL writing contexts. Three categories including the quality of peer comment quality, the feedback adoption rate, and students' revision quality were evaluated. From the research synthesis, it was revealed that for peer comment quality, the identified primacy of globally focused and revision-oriented comments with comment types of 'suggestion' and 'evaluation' illustrated that peer feedback training and asynchronous CMC could lead to qualified peer comments (Bradley 2014; Loncar et al. 2021). However, despite the large number of content-related and revision-oriented comments, the adoption rate of these comments was rather low, less than fifty percent (Liou and Peng 2009; Pham and Usaha 2016). Nevertheless, it is worth mentioning that once students chose to adopt their peers' comments, successful local and global revisions and high revision quality could be expected (Liou and Peng 2009).

In terms of student perceptions, both positive and negative responses were obtained from students. It is argued that although asynchronous affordance provided learners with great access to learn from their peers with great convenience and anonymity, the lack

of timely face-to-face communication and distraction online can jeopardize the final review quality (Li and Li 2017). It is hoped that with the synthesis of this research, this study could shed some light for education practitioners or scholars interested in the incorporation of asynchronous written peer feedback for the development of L2 writing revision.

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Compensatory Skill: The Dyslexia's Key to Functionally Integrate Strategies and Technologies

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Abstract. Dyslexia is a theme that commits teachers to define strategies and methodologies suitable for guaranteeing educational success even for dyslexic students. In this sense, the development of teaching technologies has supported teachers on the one hand and (dyslexic) students on the other hand: this does not mean that technology is the solution to teaching/learning problems. The purpose of this article is to build a table of process indicators that can be useful to teachers as a guide for designing the learning process. Process in which learning experiences, supported by new technologies, can be organized in different ways, in order to meet the needs of the entire class group, intended as a group of heterogeneous students as far as learning (dyslexic and not dyslexic students), but also personal life styles are concerned. Schools will increasingly face these problems in the future, and should be able to solve them with major changes in their identity.

Keywords: Compensatory skill · Didactic · Dyslexia · Learning strategy · Technology

1 Introduction

In the school of the twenty-first century, there is still a conception of teaching (that even if formally repudiated, continues to prevail in teaching practice) in which the fundamental concern of the teacher is to lecture, to explain, present, demonstrate, describe the concepts, in the best possible way. Each discipline has its own difficulties and this is the reason why students sometimes "experience" a feeling of inability that can lead to a drop in self-esteem and a drop in performance [1, 2]. A problem that concerns students in general but which takes on a particular significance considering an increasingly widespread reality in schools: students with Specific Learning Disorders (SLD).

The teacher finds himself first of all facing the problem of "diversity" (and therefore of "inclusion") within the class group [3] and must implement all those actions that tend to enhance the different individual situations, avoiding that the difference is transformed into inequality [4]. The didactic activity, in consideration of all the regulatory aspects, should not be seen as a "risk" but on the contrary "enhanced".

This is a clear example in which the pedagogical-educational aspect assumes the utmost importance compared to the regulatory one. From the history of pedagogy it

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emerges that the teacher must not only know the subject to be taught but also the most appropriate methods to teach it: according to Rousseau it is necessary to know the pupil [5], according to Pestalozzi it is essential to know the methods, and according to Dewey it is necessary to know the models of society [6].

In this sense, the development of teaching technologies supports teachers on the one hand and (dyslexic) students on the other hand: multimedia technologies can be used to improve teaching processes or to improve learning processes, or to improve both. The new technologies make it possible to transform teaching/learning methods, creating the best conditions for pupils to activate their mental abilities (imagination, fantasy, creativity, analysis, synthesis, induction, deduction, inference…) and consequently develop them [7].

This means that adopting innovative solutions regarding the tools with which to teach, inevitably produces the opening of major problems on the fronts of the "what" to guarantee with one's teaching (epistemology), of the "how" to guarantee it (teaching) and of the "why" to propose it in a certain way rather than another (technology).

From all this it follows that both the teacher and the student must have the skills regarding the technologies used in the learning process: skills and not just knowledge. Epistemological conceptions lead teachers, often unconsciously, to inadequate teaching practices (through an improper use of technologies) that send the student in difficulty back to a very tiring personal learning that distances him from the learning process.

The present research takes place within this whole context and investigates part of the problem, that means, it focuses on the teacher and the good practices he/she should follow in order to make compensatory tools (such as new technologies) effective tools for the dyslexic student during the learning process. Therefore, some indicators for monitoring the learning process are proposed. The use and analysis of these indicators can allow the teacher to define patterns and trends in the use of technologies by the dyslexic student, allowing him/her to develop a **compensatory competence** that allows him/her to integrate strategies and technologies together, based on of his/her learning style.

This paper is organized as follows.

Section 2 presents a brief introduction about the concept of dyslexia. Section 3 illustrates the concepts of compensatory tools and compensatory skills. Section 4 presents possible process indicators. Section 5 presents some important reflections related to the learning indicators. Finally, in Sect. 5 the paper ends with concluding remarks.

2 Who is the Dyslexic Student?

The school should help dyslexic students to live an educational path that is not conditioned by the difficulties due to dyslexia: a learning disorder that affects reading and writing, key skills in school. Reading and writing are considered to be so simple and automatic that it is difficult to understand the fatigue of a dyslexic student. Dyslexic students can write and read, but they manage to do so using their capacities and energies at the maximum, given that they cannot do it automatically [8]. They grow tired quickly, they make errors, fall behind, do not learn [9].

The reading difficulty of the dyslexic student may be more or less serious [10] and it is often accompanied by a disorder of the speed and accuracy of writing that is manifested

by frequent orthographic errors (dysorthographia) and/or difficulty in the execution of the graphic motion of such kind as to make the text become incomprehensible even to its own authors (dysgraphia) [11].

The dyslexic student appears disorganized in his activities both at home and at school. He has difficulty copying from the board and taking notes. He can't take notes, because he can't listen and write at the same time.

When he gets distracted from what he is reading or writing, he has great difficulty finding the point.

Direct consequences of all this are demotivation, low self-esteem, elusive behavior, oppositionality [12].

The teacher, in the planning of the learning process, can foresee specific compensatory tools and/or dispensative measures to support the student [13]: didactic and technological tools that replace or facilitate the performance required in the deficient skill (use of the computer, of visualization programs with spell checker, speech synthesis,…, not to perform some performances that, due to the disorder, are particularly difficult and that do not improve learning, longer times for checks,…).

It is important to emphasize that compensatory tools and dispensatory measures can improve the student's academic performance, but they are not an effective or sustainable long-term strategy.

What will happen when the student has to use a new technology?
What will happen when the student has finished their studies and will have to face the world of work?

Despite everything, the dyslexic student has all the potential to face school with satisfaction and success and, by taking advantage of the measures provided to overcome the obstacle of reading difficulties (compensatory tools and dispensatory measures), he/she can certainly achieve excellent results.

However, it is important to help him/her develop skills that allow him/her to acquire his/her own autonomy [14].

For a dyslexic student, learning one's own study method (learning to learn) means possessing the fundamental compensatory tool to which technological and didactic ones are added. Therefore, it is necessary for the teacher (together with the family) to help him/her develop a metacognitive approach to study [14, 15]: a setting that allows him/her to achieve good compensatory skills.

3 Compensatory Tools vs Compensatory Skills

Compensatory tools are all those tools, IT and otherwise, which aim to compensate for the disorder by supporting the student in his weaknesses. Under this large category can therefore appear video-writing programs with spelling checker, speech synthesis, the calculator, concept or mental maps, the multiplication table, the digital dictionary, etc. The compensatory instruments are however personalized and chosen by the student (or recommended by the teacher) on the basis of his needs and peculiarities [16].

In general, the maximum potential of compensatory tools is highlighted when, through the use of the digital textbook, different technologies can be used to access the text in an alternative way. The use of the tools, however, implies a training course, which takes into account not only the computer skills of the child but also the school and family context in which he finds himself. Technologies can be a valid support for one's profitable course of study, but they must be used with an active role not only by the child, but also by the school itself. The ideal would be to include them in a "compensatory teaching" [17] that provides for a teaching activity that can take into account the different individual learning styles and can thus promote an effective and adequate study method.

From the point of view of the study method, we can speak of "compensatory strategies" [18], that is all those procedures, expedients and techniques that can help to overcome the limits of the disorder. These strategies are very varied and variegated [19], and can be classified according to their objectives:

- strategies that integrate the written code with other codes, for example graphic-visual (concept maps, diagrams, graphics) [20, 21],
- strategies for storing and organizing information (tables, audio recordings,…) [22]
- strategies to enhance listening and concentration skills [21].

Compensatory strategies are highly individualized and are often personally identified by the student. The use of technologies, in this context, must be functional to the identified strategy, otherwise it loses its meaning and does not maintain the compensatory value it may have [23, 24]. In other words, the student must know how to use the tools really well, autonomously and effectively.

Based on all the above considerations, Table 1 summarizes the main operational differences between the approach to compensatory technologies and that to compensatory strategies.

Table 1. Differences between compensatory technologies and compensatory strategies.

Compensatory technologies	Compensatory strategies
Badly administered technologies can be seriously counterproductive: lengthening of time, loss of motivation and self-esteem	They rarely have contraindications. They can be more or less effective but it is very rare that they can be considered harmful
The use of technologies could only be useful to the dyslexic student and become a complication for other students	Often the strategies are useful to all students and therefore can be proposed to the whole class
Attitudes of rejection/acceptance can occur, which can be reduced, if not overcome, with serious pedagogical support both at home and at school with peers (peer-to-peer)	They have no stigmatizing characteristics and are much more easily accepted by the dyslexic student
Some technologies require the use of licensed software which may limit their use by students	The strategies have no cost and can be used with all students without problems

(*continued*)

Table 1. (*continued*)

Compensatory technologies	Compensatory strategies
A training course is required to acquire some basic skills and ensure the conditions for effective competence	They can also be introduced or suggested informally
Continuous personal research is necessary to find out about the news and the possibilities of application	They can also be acquired by the teacher/student by comparing them with colleagues
They are very difficult to monitor because the student's usage patterns should be observed continuously (at school and at home) Even at school the student is not alone in the classroom and the teacher cannot always and only be at her side	They can be easily monitored and modified/improved through specific indicators

Focusing once again on technologies, it is possible to state that from simple use to "competence" when you do not have a simple and generic ability to use, but a real mastery that allows you to use the tool in a way that is functional to one's own study method. With competence, strategies and technologies are integrated in a functional way, in a way that respects one's own learning style. Achieving good compensatory skills is therefore the goal that every student (dyslexic or otherwise) should achieve, with the help and support of all the reference figures around him, first and foremost the school.

4 Process Indicators

The use of technologies with appropriate strategies by the dyslexic student represents an important step in achieving the learning objectives.

It is important to underline that it is not enough to have a new technology, because the delicate transition between the acceptance of the technology by the student and the development of a real competence (in its active and conscious use) is an essential step towards a real autonomy. For this to happen, it is not only important for the dyslexic student to know the practical utility of technology, but it is essential for the student to understand that the use of technology will open up to him a world of experiences that will allow him to integrate into society and live peacefully (motivational drive).

In this new context, the teacher plays a fundamental role because she must know the technologies that the student will have to use to achieve the educational objectives, teach the student how to use technologies effectively and consciously, and above all monitor the correct use of the technologies by the student.

The operations of monitoring and analysis assume an indispensable role: without them the technologies will barely be able to emancipate from a perception that envisages it only in ancillary terms with respect to the education system and not, as it should be, as an element integrated into it and, actually, able to guarantee added value to it [23].

Monitoring must concern the way in which the dyslexic student uses technologies based on the teacher's instructions, but also through the observation of the attitudes and

Table 2. Process indicators.

INDICATORS RELATING TO THE INTERNAL PROCESS	
LEARNING RESULT AND/OR PROCESS REQUIREMENTS	INDICATORS
Social skills	• Increase in student loyalty • Increased empathy among class group members • Awareness of each student's skills, experience and work styles
Critical thinking	• The student describes the ideas clearly • The student understands which knowledge has been acquired and which has not
Inclusiveness of the student	• The student is able to participate in group work in an active way (recognizes the tools used) • The student identifies a need or opportunity from the context and problem indicated • The student demonstrates curiosity
INDICATORS RELATING TO THE LEARNING AND GROWTH PROCESS	
LEARNING RESULT AND/OR PROCESS REQUIREMENTS	INDICATORS
Communication	• The student is able to use technology as a tool for communication skills • The student uses images, links and text in the messages
Behavior	• Increased ability to independently search for relevant information • Increased ability to recognize relevant information and use it effectively in business • Increased ability to process and share ideas verbally and in writing • Increased ability to organize and give meaning to visual information • Increased ability to relate ideas from multiple topics in different contexts • Increase of the ability to reuse resources and knowledge • Ability to use information in different activities • The student demonstrates the ability to identify a need or opportunity from the context and problem indicated • The student is able to use technology to increase collaboration with other classmates • The student is able to select relevant technology tools and resources for learning • The student asks the teacher to help him/her: Never, Almost Never (1-2 times per lesson), A few times (3-5 times per lesson), Often (more than 5 times per lesson)
Acquisition of knowledge	• The student formulates hypotheses on the choice of tools to be used • The student identifies what is still needed to know • Reduction of confusion in the use of different tools

(*continued*)

Table 2. (*continued*)

	• Number of new tools used during work and communication • The student is able to develop skills to undertake independent learning • The student applies knowledge (about of the technological tools) outside of the classroom • The student is able to combine parts of school subjects with one another (multidisciplinary approach) • The student identifies the problem and recognizes the useful tools to solve it • The student is able to combine different tools to solve the problem, to reach the goal
Communication skills	• The student is able to use technology to develop ability to generate ideas and perspective to solve problems • The student is able to use technology to develop ability to investigate problems • The student is able to use technology to evaluate different sources of information
Involvement	• Increase of group approaches to problem solving • Number of approaches with a new perspective
INDICATORS REFERRED TO THE STUDENT'S PERSPECTIVE	
LEARNING RESULT AND/OR PROCESS REQUIREMENTS	INDICATORS
Sensations and perceptions	• Raising awareness of teamwork • Increased awareness of one's own skills • Increased perception of the opportunity to learn • Increased enthusiasm and self-esteem • The student change in motivation on the base of the subject • The student enjoys a sense of belonging and connection to school • The student feels included, cared for, and safe and secure
Behaviors and perceptions	• Interactions with class group members • More positive attitudes towards learning • Increase of the student's ability to persist in a task despite failure and difficulty • The student is curious and enjoy intellectual engagement • The student learns and works during the lesson at its own pace

behaviors that occur within the class group. The student should not feel isolated from other classmates, but on the contrary receive the necessary help from them too (peer-to-peer). In this way, those principles are activated that allow the creation of social bonds that lead to autonomy and an increase in self-esteem. Working with another partner or in a group strengthens important skills such as communication, critical thinking and empathy. Students can understand each other better and this facilitates listening: learning to listen to each other and respond constructively.

Monitoring and analysis can be done through the preparation of specific indicators. On the basis of the above considerations, some indicators that the teacher could consider to evaluate the (ongoing) learning process are listed below (see Table 2).

The choice of indicators, which are specific to each context (discipline or topic), depend on the teacher's values. Often the indicators individually provide useful information for monitoring the learning process, but sometimes it is necessary to carry out the analysis through the simultaneous combination of multiple indicators.

At the same time, better indicators could be discovered during the course of the teaching activity, which could replace or supplement those prepared.

5 Discussion

This research aimed to define a series of indicators useful for the teacher to improve the learning process of the dyslexic student.

In schools, students with specific learning disabilities are increasingly encountered. These students need personalized interventions and strategies in order to recover skills and be motivated. The personalization of the intervention must be: capable of responding to the need to construct training and learning paths for students; respectful of individual differences in relation to interests, abilities, rhythm of learning, cognitive styles, attitudes, inclinations, life experiences.

It is therefore necessary for the teacher to activate a virtuous process, which guarantees a systemic intervention and which produces a significant change in the learning process of the dyslexic student. This is achieved through an active participation of the teacher who favors in the student the maturation of specific skills to be constantly supported and integrated (without making the student feel alone towards a situation-stimulus).

The use of new technologies represents a stimulus but also and above all a challenge for the teacher as he must guarantee the student, through their conscious use, compensation for skills that are lacking or to be integrated. To achieve this, the student must develop compensatory competence (see paragraph 3) through the support of the teacher and classmates.

On the one hand, it is necessary to consider the relationship between teacher and student. The teacher helps the student not only for the messages he/she transmits, but above all for the relationship he/she establishes with him/her, aimed at arousing reactions that have a positive influence on learning. The student, in turn, learns and develops knowledge to the extent that, by responding to the messages, he/she provokes reactions that influence the teaching in a positive sense. The teacher and the pupil, therefore, in communication establish a process of mutual self-training between them. This determines the possibility for the teacher to identify new indicators that could replace or supplement those already prepared.

On the other hand, it is necessary to consider the relationship between the student and classmates. A relationship that can have positive outcomes, when the ability to understand the emotions of each individual student develops. Emotion plays an important role in the quality of learning: if in fact it is from these that the behavior of students in class starts, albeit unconsciously, it is on these that the teacher will have to leverage, through the adoption of a empathic approach and a teaching based on affectivity.

These considerations must help the teacher to reflect on the importance of knowing the students who make up a class, before being able to design the learning process. Process that must be based on the concept of inclusion [25]. Tending towards inclusion and empathy therefore means that the teacher must commit to working on their own cognitive schemes in order to be able to look and implement practices that include various diversities.

The use of technologies can only be effective if the dyslexic student achieves a certain autonomy in their use thanks to the help of the teacher and classmates. Autonomy that will allow him to improve his/her approach to social life.

6 Conclusions

This study focused on the importance for the teacher of knowing how to insert technological tools in the learning process to support dyslexic (and not dyslexic) students. The ideal would be to include them in a "compensatory teaching" that includes a teaching activity that can take into account the different individual learning styles and can thus promote an effective and adequate study method.

Epistemological conceptions lead teachers, often unconsciously, to inadequate teaching practices that put the student in difficulty with a very strenuous personal learning that distances him/her from the learning process.

A set of indicators was presented to support the design of the learning process. The training intervention should allow the development of compensatory skills based not only on the knowledge of the use of technological tools but also on the emotional-motivational components: attitudes that ensure that the tools are effectively seen as an opportunity for redemption, a resource on which the student knows he has to invest time and energy to achieve valid goals.

The proposed indicators are intended to be an example, a support for the teacher. Educational technologies are constantly evolving and it is difficult to say how they will develop and what results they will have on learning processes, especially how the overall training system will be transformed.

It is too early to hypothesize standard rules for the teaching/learning context. Firstly, it is necessary to gain experience; secondly, it is necessary to have a realistic representation of the new framework and its tendencies; finally, it will be possible to regulate.

What is necessary for a dyslexic student to learn is not to know the practical utility of technological tools, but the knowledge that the ability to use these tools will unfold a world of wonderful experiences and allow him/her to become the protagonist of his/her learning process.

The challenge that the dyslexic student asks the teacher to overcome is to have the courage to defend those who are different (despite their diversity being invisible) and to make this diversity a wealth for the class through acceptance and sharing.

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Learning Mehtodologies and Pandemic Impact

Online Learning in Higher Education Institution During COVID-19: A Review and the Way Forward

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Abstract. This review paper examines the potential for online learning in COVID-19 and the path forward for establishing Higher Educations Institution (HEI). The critical topics identified included online learning during COVID-19, shifted to online delivery, strategy to enhance the HEI system, post-COVID-19 implication, and the plan forward. The different database searches identified keywords such as online learning during COVID-19; shifted to online delivery, strategy to enhance higher learning educational system; administration strategy; emergency distance/online education; post-COVID-19 implication, pandemic, endemic, and the plan of higher learning institutions on online learning were searched. The various repository identified more than 100 articles, of which 83 full-text articles were assessed covered in this paper. online learning has started in the early '90s, it still needs to be improved and embedded with effective instructional design (ID) to optimize the knowledge transferred. Moreover, the emergency changes during the COVID-19 force everyone to fully utilise technology effectively so learning would not be disrupted. Thus, some issues emerged from the literature: the internet bandwidth connection, the ineffective ID; inexperience of lecturers to adopt online learning; information disparity; and the complicated situation at home. The way forward suggests actions like online teaching arrangement; inexperience of lecturers to develop effective instructional design; the information disparity and the home complexity should be dispatched to ensure the online learning in HEI can benefit all. Hence knowledge can reach everyone effectively, even during the post-pandemic. The findings of this paper allow to assume that post-COVID-19 it might be worth reconsidering the format of online learning mechanisms and shift from conventional face-to-face learning to blended or even distance learning. Additionally, suggestions for further research of online education in tertiary institutions are also addressed.

Keywords: COVID-19 · Higher education institution · Online learning

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1 Introduction

COVID-19 has been declared by The World Health Organization (WHO) as a pandemic that has posed a recent menace to civilization. By August 2021, there were more than 200 million confirmed cases globally and more than 4 million recorded deaths, and the numbers are increasing [1]. Since the COVID-19 pandemic struck in 2020, it has caused the closure of global education sectors. This has resulted in students proceeding with online class learning, and millions have yet to return to the physical classroom. Until this paper was written, 117 countries were now opening their gate involving 539 million students from pre-primary to secondary levels. By September 2021, the percentage of schools open increased from 16% in September 2020 to 35% in 2021, involving 94 countries involving all levels of education, e.g., kindergarten, schools, and higher education institutions [2].

However, those numbers now no longer incorporate schoolteachers, educators, trainers, and school members. Though students and educators were not happy concerning the closure of their institutions, they didn't have any option but to support the choice to safeguard themselves and members of the families. Therefore, tertiary institutions need to work quickly to address the issues and respond promptly to some critical questions, particularly around how teaching and learning could be delivered efficiently without compromising the quality.

This situation has forced conventional physical teaching and learning instructions to turn into fully online learning, allowing educators, teachers, and learners to deliver their education. Almost all institutions chose to neglect physical classes, together with labs, fieldwork research, and other learning activities, and moved their courses to online learning to stop the COVID-19 from spreading [3–5]. Consequently, COVID-19 brings hazards to everyone but somehow has forced institutions to empower online learning [6–10]. A survey done by QS (2020) revealed that COVID-19 had impacted almost 57% of potential students to study abroad. The list of tertiary institutions creating this call has been expanding by days. Institutions of all sizes and types are moving their classes online [3, 11–13]. China, where the virus started, has initiated online learning flexibility at home for every college student to overcome the critical situation entitled Disrupted Classes, Undisrupted Learning [14].

The COVID-19 virus has shown growing flaws in educational institutions worldwide. Today, society desires flexible and resilient teaching and learning structures as the future is unpredictable [4]. Moreover, practically all academics have access to technology that allows for synchronous communication [15]. The adoption of these technologies for online teaching and learning has dramatically accelerated due to the current pandemic. Lectures and educators have no choice but to adopt digital technology in almost every activity and abandon physical classes ([4, 6, 16–18]. Thanks to these learning methods and environments, students have more learning flexibility and can connect with their teachers whenever they wish [19]. The threats and opportunities of online in higher education institutions and continuing education during the COVID-19 pandemic should be addressed so that the trait of tertiary education can be preserved. Therefore the objective of this study is to learn how higher education institution should arrange online learning effectively on the post-covid situation?

2 Online Learning During the COVID-19 Era

Back in its early day, higher learning institutions have only used the internet for research and development. Still, since then, it has expanded into teaching and learning activities [15]. Twenty years ago, the only function of an online platform was for administration, yet somehow teaching resources have slowly roamed through online. Learning materials and stuff that once were given out physically in classes can now get quickly online. The phrase 'blended learning is used in situations where learning occurs both online and, in the classroom, [15]. However, since the COVID-19 outbreak, the situation completely changed where almost every teaching and learning activity in higher learning institutions was done online [19, 20]. There are four evolution phases of online learning in higher education, i.e., i. 20th Century – traditional knowledge); ii. 21st Century - internet usage started and increased; iii. Present-day, when the COVID-19 struck – fully online learning; iv. Blended learning. The present-day and the post Pandemic can be intertwined used as a swapped by necessity between online education and blended learning [15]. Many innovative technologies and learning management systems were developed that could help lecturers, educators, and policymakers optimize the use of information technology even after the COVID-19 era [21]. Higher Education Institutions (HEIs) are among these organizations that forced its society, e.g., students, lecturers, educators, and administrators, to adopt multiple network mediums to maximize schooling activities. Nevertheless, the challenges caused by the COVID-19 pandemic pushed the higher education community to consider many other things related to technologies [22].

Policymakers' decision to close the higher education institutions for a while, which response to the COVID-19 crisis is a wise step to be taken at that time. Universities were compelled to switch physical teaching, learning, and research activities to distance learning (i.e., online), utilizing digital tools, known as e-learning, online, virtual, or e-education as the replacement. Confer to Hodges et al. [6], the structure of distance learning differs from when someone moved to online learning over a night in response to a crisis. This rapid change could cause tremendous shock to faculty members and learners. Therefore, some countries have declared an emergency distance learning where it can be explained as educational activities provided to assist scholars socially, emotionally, cognitively, and physically when they cannot attend school due to unforeseen circumstances [23, 24]. To prevent the spread of COVID- 19, 173 countries or regions, including Hong Kong, temporarily closed many preschools, schools, and universities, affecting 85% of students worldwide [25].

Up to now, higher education institutions have been pushed to think about how to deliver a course in distance, including communicating with learners and regulating assessments sufficiently. As a result, COVID-19 has evolved institutions to invest in online learning, even though it threatens civilization [7]. A quick review has been done on the situation of education and learning institutions in some other countries. It reveals a need to shift physical learning to online learning that will help reduce the viruses from spreading uncontrollably.

China: The Chinese Ministry of Education has released an initiative entitled Disrupted Classes, Undisrupted Learning to offer dynamic distance learning for students [26]. They added that students have a close link with Information and Communication Technologies (ICT) during the pandemic. These evident perceptions and the massive

lockdown during the pandemic forced the intrinsic motivation for this study [27]. **India:** Since the COVID-19 outbreak in February 2020, many universities in India were closed temporarily and hung entirely on digital platforms for teaching and learning activities to contain the spread of the virus. As a result, there has been a movement from a physical teaching paradigm to distance learning for the first time in the history of the Indian education system. Extensive use of digital media is in place [28]. Since all educational sectors, e.g., schools, government universities, private universities, etc., were dangling till the beginning of January 2021, the system was forced to use technology in their teaching and learning activity to allow students to pursue their education. These efforts, backed by the Indian government and collaboration with other non-governmental organizations, were established to ensure the continuity of the teaching and learning process across the country [8]. Greece – The Greek educational system was suddenly accosted with distance education, and many teachers lacked the necessary abilities to keep up. This haste was driven by the uncertainty of how the pandemic would unfold and the desire to avoid having to repeat a full academic year on the other [29, 30].

The USA: Students studying abroad in China, Italy, and South Korea have been encouraged to return home to finish their studies. US institutions have switched classes to online learning, cancelled spring break trips, and encouraged students studying abroad in China, Italy, and South Korea to return home to finish their studies [31]. Study done by Barry and Kanematsu [32] where they are integrated Zoom, MTeam and Gamification element in their class during the pandemic. Zoom was used for audio / video conference meetings, the teaching of classes, office hours, and student presentations. Microsoft Teams was used for a variety of tasks by using posts for the attachment of power point presentations, interactive websites, videos, e-books, etc. Other application such as electronic virtual whiteboards and video calls are available too. One Note, is a powerful features where it is built into Teams for a variety of lessons and activities. Last but not least the gamification element is used of game design elements outside of a game environment. This technology makes learning fun through exciting problem-solving activities that offer awards. **Latin America**: COVID-19 has impacted exceeding 98% of the region's higher education students and teachers, affecting around 23.4 million university students and 1.4 million educators in these regions [27]. **Canada**: In Canada, many faculty members in a particular institution helps students to be ready for remote teaching resulting in the burden of extra hours. Furthermore, they are dealing with a stress and anxiety issue that has a substantial detrimental impact on their research operations. This research which was conducted by members of the Canadian Association of University Teachers [33], and an institutional survey by the Dalhousie Faculty Association [33] reveals these shocking outputs affect their life drastically caused by the shift to online learning entirely [34]. **Europe**: The running of schools across Europe is expected to return to normal until January 2021. However, ministries and regional governments are still grappling with crucial concerns, namely, efficiently organizing school attendance. On the plus side, shifting toward alternate teaching and learning approaches has resulted in excellent prospects [28].

Pakistan: In Pakistan, the institutions employ Microsoft Teams, Google meets, Edmodo and Moodle as learning management systems, as well as their video conferencing apps [35]; others use Zoom, Skype for business, WebEx, and Adobe connect,

among others [7]. Two studies were undertaken at Pakistan's higher education institutions, e.g., Dow University of Health Sciences, Karachi, and Lahore Medical and Dental College, Lahore, revealed students are satisfied with online learning modalities. In addition, the practicality of online learning among students, trainees, and faculty members was investigated in a study from Khyber Pakhtunkhwa. Participants across the medical education continuum indicated vital technology access, online competence, and readiness for online interactions [7]. **Turkey:** Distance education activities have begun at the elementary and secondary level in Turkey as of March 23, 2020, to prevent the COVID-19 virus from spreading frantically by assuring that the younger community remains at home during the process. Educational Information Network (EBA) prepared infrastructure studies where the medium for learning and teaching was finished. Students were unified education using internet technologies and television broadcasts for all grade levels during the process [36]. **Egypt:** Egypt has the most extensive education system in the Middle East and North Africa, with 52,000 schools serving 20 million school students and 44 universities serving 3 million higher education students [37]. In early 2020, the Egyptian government has made the most crucial step to prevent the COVID-19 virus's from spreading fast by closing all schools, universities, and higher education institutions. The Egyptian Ministry of Higher Education and Scientific Research summoned higher education institutions to apply distance education as a modality during the lockdown to ensure the education system survived [38]. **South Africa:** the South African president announced a national state of disaster under the Disaster Management Act of 2002 on the 15 March 2020 Following that week, national lockdown executed, which included measures stipulated in guidelines for education in emergencies, was implemented in South Africa. Somehow study done by Landa et al. (2021) [39], some of university in South Africa already had online presence that could be fully utilise during pandemic. With online learning medium, lectures and teacher can share learning materials alongside physical instructions. Their universities also were attempted to utilise the internet to promote collaborative knowledge acquisition using several well-known apps i.e., WhatsApp, Blackboard, and YouTube. The online learning method keep continued after the post-lockdown where they shared communication through online platform.

Australia: The COVID-19 pandemic has forced Australia's education system to shift its way of transforming knowledge. Almost all education programs need to be done via e-learning and e-practice regardless of local or international students. As an emergency measure to mitigate the impact of COVID-19, Australian universities have been offering distance and virtual learning courses since April 2020 [40]. **Germany**: Two weeks after re-opening, some schools were closed again over COVID-19 infections [41]. **Norway**: Hjelsvold et al. [42] conducted a survey on university students, lecturers, and administrators on the effect of the COVID-19 lockdown on distance learning. It reveals that short time and lack of ready resources were vital obstacles in a rapid change to distant learning. Learners and educators report a lack of practice in online education, but somehow, both students and lecturers actively improved, showing a positive attitude towards the change. They identified significant aspects that influenced the online experience during the first weeks of distance learning, such as feedback to instructors, involvement in discussion forums, utilization of online tutorials, and group work are some significant aspects identified from this survey. In addition, from educators opinion, features such as

timely communication and clear instructions about assessments, communications with learners for aid, providing support using synchronous and asynchronous tools, secure virtual environment for students-to-students and students-to-instructor online interaction, and counsel students on how to set their study place and schedule for an effective study-at-home experience identified were very helpful. Meanwhile, timely communication with students, notably regarding exam regulations and petitions, supporting learners in preparing new pedagogical approaches to teaching as well as learning new tools, and providing a more collective approach to the coordination of activities and collaboration between educators are identified aspects from the ruler and trustee point of view.

Indonesia: Indonesia has also moved the education sectors to teach and learn online platforms due to the COVID-19 crisis. The class that was earlier carried out traditionally via the blended learning method has now totally into a distance-based program [43, 44]. Learning from home these days is jargon to attempt the Pandemic spread rapidly in Indonesia [44]. Study by Amir et al. [43] found that learning model like blended learning where distance learning hooked with combined learning can be best implemented. **Bhutan:** in Buthan, the complete lockdown was enforced on the 1st of August 2020 [45], resulting from the closed of all schools and learning institutions to stop the virus from spreading rapidly [46]. **Israel:** educators should be creative enough to used variety of teaching mechanisms, i.e., integrating active and passive learning, blending direct and indirect experience of nature, by applying nature for observation, investigation and in-depth personal, social and also environmental learning will are few models that done in Israel to address the COVID-19 issues [47]. **Malaysia:** Malaysia's government has also ordered its citizens to do quarantine. In addition, it must adhere to the different phases of movement control order (MCO), which has created uneasiness. The virus spread rapidly, affecting many businesses and organization systems, including the education sector. The Malaysian Higher Education Ministry later proclaimed on the 27th of May 2020 that all teaching and learning activities in all universities and other higher education institutions must be conducted using online platforms until the 15th of October 2021 [48]. Up until now, only a few teachings, learning, and other research activities could be physically or performed face-to-face with stricter rules and a high standard of procedure (SOP) [49].

These are some of the many countries that forced education and learning institutions, including higher learning institutions, to be physically closed temporarily and empower their online learning. This ensures their education business runs usually and supports students' needs throughout the Pandemic. However, until this paper was written, there was a very slim situation for the learning institution to reopen fully. Moreover, the future of physical classes is still questionable since we face another variant, e.g., omicron [50]. Hence, the way forward on should the online learning continue as the primary mode of delivery to higher learning institutions is still questionable. If the answer is yes, how is the best practice to execute it?

3 Review Methods

Until now, less published literature has existed that specifically examined the way forward of post-COVID-19 in the field of higher learning institutions and what is the plan? What is the master plan/s? What if the COVID-19 still developing a new variant that will

force the distance of society unchanged? How does society accept this as a challenge? What is the effective solution of higher learning institutions? And the questions keep on the list.

Between the beginnings of the transition to the submission of this paper, the topic of COVID-19 in educational sectors, specifically in the higher learning institutions, has been explored in several databases, i.e., PDFLinks, PubReader, ePub Link, PubMed, PMC, Article, or manually searched in Google, websites and web pages. A various number of journal posts, editorials, short communication, analysis studies, brief reports emerged, many online research articles printed, newspaper stories, conference papers, working papers, and books, highlighting the challenges and problems featured by students, faculty members, administration members and institutions as they made decisions about whether and how to provide continuity of education as COVID-19 cases continued to.

Keywords such as online learning during COVID-19; shifted to online delivery, strategy to enhance higher learning educational system; administration strategy; emergency distance/online education; post-COVID-19 implication, and the plan of higher learning institutions on online learning were searched. The various repository identified more than 100 articles, of which 83 full-text articles were assessed and covered in this paper. The authors excluded studies published on other viruses and in other languages. The chosen analysis papers were from entirely different parts of the countries like China, India, the United States, the United Kingdom, Australia, Europe, Africa and some Asian Countries to gain an international view. As the authors describe the papers already written and published, there was no need to get formal ethical clearance from the authority.

4 Findings and Discussion

4.1 The Internet Bandwidth Connection

As the COVID-19 virus is still spreading, many people face intensifying pressures to close education institution doors. Worst, because the situation is happening extremely fast, the exact number of closures is a moving target [51]. Transitioning physical learning to online learning in such a short period is a big issue. Many educational practitioners and experts agree that this will be a big challenge and won't be easy, especially for those who are living without essential internet services and lack of necessary electronic devices [52–55]. Internet bandwidth connection is still a big issue in many other developing countries, let alone the gadgets and technology learning aid that could deliver course content. The new normal where most educational institutions rely on online learning to provide knowledge effectively is overwhelmed. Significantly number of students absence access to the internet and technology gadgets required for online learning [56–58]. Variation in connectivity and internet bandwidth connection may affect the effectiveness of courses delivery or constraint student engagement with online content [59]. Research by Cullinan et al. [59] shows that students from lower socioeconomic backgrounds are'at risk' and always do not have good internet connectivity, affecting their learning process. Therefore, they suggest that some Higher Education Institutions need to prioritize these less fortunate students to access campus facilities and services. Research also was done by Roslan and Halim [60] amongst medical students in Malaysia, where they revealed

that 22% of students did not have Wi-Fi access, and 11.2% did not receive mobile broadband coverage at home. This contributes to the student's effectiveness in promoting their learning at home. They also discovered that high-immediacy, low-bandwidth applications like WhatsApp, Telegram, and YouTube are the most accessible and user-friendly mediums for online learning. McKie [61] did a survey where almost half of English students said that since they moved to online learning, it is hard to access course materials, resulting in many students being left behind by their "digital poverty." Matsuda's [62] work revealed that from 1.5 billion students affected by the virus, at least almost 75% of students have no internet connection at home, which brings a crucial issue: not everyone has the same opportunity to join online classes. Additionally, she adds the gap between those who have an internet connection at home and having meaningful learning connectivity is another challenge in delivering knowledge. Back in 2006, a work done by Yan Wu and Turner in connection of bandwidth, liaison, and performance in adults' online courses reveals that different access of learning, e.g., dial-up and a broadband connection, will lead to inconsistency of students' performance with varying tasks of education. In 2021 though, the need for speed dial-up was not that relevant where almost everyone is using WiFi somehow; the vary of internet connection bandwidth needs to be addressed carefully when assessing students with different learning tasks. Yan Wu and Turner [63] suggest that different courses need another way of delivering their course content, and heavily learner-to-learner-oriented students need high internet access. Variation to internet access amongst students intensifies the issue of online learning practices in education and training. Some countries also provided internet data quota for less fortunate people, including those living in remote areas [64]. Pokhrel and Chhetri [65], in their work, reveal another sad story on the less fortunate people who live in Bhutan. Due to the closure of business and workplace, almost all its populations are jobless, resulting in no income. Talking about the internet is another perplexing thing for those with economic disadvantages. Nearly all students do not have access to any technology devices, let alone poor internet connectivity. The data package is too expensive, and not all can afford it. Although synchronized online, face-to-face classes are preferable, less fortunate students have expressed that they could not afford more data packages. There are suggestions to record class through video, yet it will only prolong the worst scenario with fewer interactions between teachers and students. Having a good internet bandwidth connection is essential to have an effective online learning delivery, specifically when it comes to higher learning institutions. The various assessment and learning methods for adult learning in higher learning institutions need to be supported so the teaching and learning can be done effectively. In addition, diverse courses and age groups demand varied online learning methods for various subjects with varying needs [66]. Therefore, establishing an internet bandwidth connection is a significant challenge that needs to be addressed globally.

4.2 The Effective Instructional Design to Delivery Course Content Efficiently

Effective instructional design to deliver course content efficiently is another crucial factor of implementing online learning successfully. Online courses are defined as delivering content and instruction over the internet [67]. Technology was used to engage students with simulations, video conferences, animations, audio recording, documents, and other

interactive content [26, 68]. Students receive direct comments on their assessments where course content can be flexible and customized [69, 70]. Online courses may assist students with specific content, and some require students to reveal their competency along the course and master it phase by phase towards the end of the materials [68]. Again, lecturers and educators need to have a properly structured and well-planned online course for effective course content delivery. Teaching tactics, communication rules, tools, solutions, and insurance policies that support online or combined mastery in the school community are only a few examples [71]. Make your ideas as straightforward as possible but set clear expectations for students, instructors, and careers to learn and train online. Thus, an effective instructional design to meet various learners need and vary of assessment tools need to be addressed wisely so it can be used efficiently for different courses [65].

Higher education institutions may transition away from traditional pedagogy, gradually implementing online long-distance teaching to reach a wider global audience. This finding is particularly significant for some developing countries, such as Egypt, which has decided to incorporate face-to-face and distance online learning into all future higher education plans to reduce costs, reduce student density, and gradually transform students into lifelong learners [38]. In addition, more inclusive authoring tools, such as those that work with diverse functional diversities, should be developed, according to Huang, 2020 [27], so that educators can use them to build accessible digital learning resources.

According to Simamora [72], it is an excellent opportunity for lectures to re-evaluate their learning course content when the rapid movement to online learning happens, like during the Pandemic. Many experts believe online learning is completely different once the lecturer and students are within the room [53]. Lecturers and educators must be obliged to think creatively and critically concerning what learning content should be enclosed once moving to online learning. Learning material production, equipment maintenance, and educator training are among the challenges identified by Bhuasiri [73] in online learning for impoverished countries. Restructuring the course to fit the online learning platform allows lecturers and educators to assess the results of their online learning and ensure that all content is aligned with the learning objectives. With the help of online learning, lecturers and educators can arrange many students in a class at any time and in any part of the world. Educational institutions must creatively use and structure many online pedagogical approaches and use technology more appropriately. Many universities worldwide have fully digitalized their operations, understanding the severe necessity caused by COVID-19 [74].

4.3 The Inexperience of Lecturers and Educators to Adapt Online Learning

One of the major obstacles to online learning adoption is the lack of information technology (IT) skills amongst instructors [75, 76]. Faculty members and students claimed that online learning teaches and assesses knowledge components, not practical or clinical work, according to Mukhtar et al. [7]. This is because previously, these assessments were done physically and not online. The impact? lecturers and educators could not assess students' understanding wholistically; additionally, other issues such as students cheating during an online assessment, limited attention span, and the resources-intensive nature of online learning. In Spain, Nuere and de Miguel [77] reveal that universities

that conducted online classes before the pandemic have fewer issues working in the new normal conditions. After all, when implementing online courses, problems come for more laboratory-oriented, e.g., drawing classes, chemistry labs, or electronics workshops. The quality of online teaching tools strongly reflects the experience of lectures and educators' quality of the process.

Lecturers and educators who do online classes via synchronous and asynchronous methods to deliver courses may misinterpret the shift to online learning without comprehensively studying the course plan. In many cases, traditional classroom strategies were often "transferred" to the virtual environment [6, 78]. Lecturers and educators who are not updated with online learning and left behind digital skills also contribute to these challenges. Other than that issue like plenty of unstructured online resources, learners' lack of communication, interactivity, and motivation, and teacher's lack of social and cognitive presence, which is the ability to construct meaningful learning knowledge through sustained communication within a community of inquiry [53]. The difficulty of delivering traditional work-based learning to the online delivery struggle of teachers used to classroom instruction [64]. Despite facing resource reduction, many experts, researchers, and educators in higher education institutions are now interested in strengthening and fully optimizing their online learning virtual outcomes of students [79]. Somehow online learning is different from a physical classroom setting, where being a good educator in a face-to-face environment does not spontaneously promise effective online learning [80].

Many people anticipate that online learning will become more popular even beyond the pandemic [38]. The current situation, in which everyone must quickly transition from physical class to online learning, has increased the pressures and work overload faced by lecturers and educators, who have struggled to juggle their responsibilities, i.e., teaching, administrating, and other responsibilities, since their inception [80]. In addition, the need to adopt online learning during a rapid time worsens the scenario; students claim that difficulties in interpreting teaching objectives resulting from unstructured learning content from lecturers and educators are one of the biggest challenges to online learning [81]. Therefore, it is a need for lecturers and educators to enhance their skills and adapt to online learning to ensure adequate knowledge content delivery. According to El Said [38], universities should go for extra funding for instructors to create interactive online materials and provide students and professors with needed digital information technology skills.

4.4 Information Disparity

During the pandemic, fast and accurate information must reach students effectively to avoid students being left behind. Hjelsvold et al. [41] reveal a short period, and a scarcity of available resources were crucial obstacles to an emergency transition to distance education. Therefore, they need to effectively narrow the information disparity to deliver course content through online learning. According to the study, despite their lack of online and technological education proficiency, learners and educators adapted quickly, demonstrating a positive attitude toward change. Key factors that affect the online experience during the beginning of distance learning categorize into three aspects, i. students' feedback, ii. educators' feedback, and iii. administrators' feedback. Feedback to teachers,

involvement in discussion forums, utilization of online tutorials, and group work were all mentioned by students. From the perspective of educators, this includes timely communication and clear instructions about formative and summative assessments, exams, quizzes, and assignments, informing learners of how to get help, providing support using synchronous and asynchronous tools, ensuring a virtual space for students-to-students and students-to-instructor online interaction, and advising students on how to set up their study place and schedule. Additionally, on the administrative side: timely communication with students, particularly regarding exam regulations and petitions, assisting learners in developing new pedagogical approaches to teaching and learning new tools, and providing a more collective approach to activity coordination and collaboration between educators are all critical.

Online training and skills upgrading courses should be prioritized to avoid disrupting on-campus activities. Students should access effective and responsive IT technical assistance and troubleshooting services, especially during quizzes and exams [38]. Phone calls, e-mail, online live chat, and video tutorials can be used to provide support 24 h a day, seven days a week. To keep all stockholders informed and aware of the following steps, it is critical to develop and maintain strong communication channels between higher education management, students, and teaching staff [38]. Multiple online informational and introduction sessions should be kept up to date. Developing and sustaining effective communication tactics with staff, faculty, and students is critical for keeping everyone informed about the transition, training, and ongoing assistance.

A dynamic, engaging, and interactive online learning should attract more students' attention. Lecturers and educators should frequently communicate with students, e.g., setting a deadline and reminders to ensure they are alert and focused on their learning process. To the greatest extent possible, efforts should be made to humanize the learning process Students should be given individual attention to readily adapt to this new learning environment. To communicate with students, use social media such as Facebook, Twitter, Instagram, and numerous group forums. When it becomes tough to reach out to students via texts, various messaging apps, video chats, and other means, communication is critical content that should be designed to allow students to practice and improve their digital abilities [74].

4.5 Home Complexity

Home complexity also contributes to the challenges of online learning. This complexity may evolve from having own learning space at home, stress disorder, anxiety, economically unstable, family ties, and the list go on. In their study, Van Leeuwen et al. [34] reveal that at the very beginning of the pandemic, faculty members had trouble managing their individual multifaceted normal living activities since everything needed to be done at home. They added that those who live with children at home typically spoke of difficulties they faced in home-based work environments as they juggled parenting and work commitments. It's quite challenging to juggle work life and family life with children in a single work/home space.

The terminology of "stay at home" changes people's pattern behavior. A home or a house becomes the last place to fight for and avoid the COVID-19 transmission. However, in the case of a pandemic, it is unalike from the before pandemic situation. A house

becomes a center of everything, e.g., work, study, business, etc. Almost all activities that usually take place outside the house must be done inside the house. Somehow not everyone comes from fortunate people having their bedroom and space to work and study [44]. In a study by Roslan and Halim [60], amongst pre-clinical students, learning space at home contributes to their good grades and higher self-regulation. Therefore, this reflects that a good home space may contribute to students' performance academically.

Stress is also related to the hostile environment at home during the pandemic, for those who do not have adequate space but somehow desperately to do everything, e.g., academic and work from home, often associated with stress [3]. These complex environments at home, especially for those living with many family members under one roof, have a risk of getting stress-related disorders. If not addressed wisely, this worsened will lead to anxiety and depression [82]. Background disadvantages economically play a vital part as well, stability of household income is another critical element of where many students withdraw from their course during the pandemic because of retrenchment from industrial sectors [83]. These may lead to economic and social stress [84]. Yazid and Lie [85] reveal that those with financial background issues were anxious about future employment during the pandemic. Previous research discovered that students are upset concerning their guardian and parent cut-cost income on family ties matters. Students coming from a family with average-below income economic environments are at risk. They need to sustain their internet data to follow the online learning course along the semester thus need more funding to maintain. As a result, they are concerned since they cannot afford access based on the education program's final grade [45].

5 Conclusion

As a result, the critical situation catalyst is a robust test of online learning's potential. The crisis provides a powerful test of the potential of online learning, particularly in higher learning institutions. It concludes that although various studies have been carried out, for the way forward, some issues need to be addressed realistically, i.e., the internet bandwidth connection; online teaching infrastructure; inexperience of lecturers and educators to develop effective instructional design; the information chasm; and the home's complicate environment. These ensure that online learning in higher education institutions can benefit all beyond the country's boundary; therefore, these need to be explored further. Concentrating and improving on the implication of the issue could contribute to expanding online learning provision in the post-crisis period and making it more inclusive.

For an instant, comparing the internet bandwidth connectivity between developed and developing countries resulting inequality when it comes to online learning. Whilst more developed countries struggle with what is effective instructional design to be used, developing countries are facing issues like less of data package where most of its population's background is come from less fortunate financial disadvantages, thus making accessibility and affordability are insufficient. Therefore, it is suggested that tools developers could focus on customization to fit various students' needs, and policy-level intervention is necessary to strengthen this type of circumstances. Further exploration and investigation on effective instructional design for online learning in higher learning institutions is also

a promising area to be discovered. One other area that should explore more is developing tools for authentic assessments and timely feedback. Higher education institutions must invest more in the professional development of lecturers and educators, particularly in Information Technology (IT) and effective instructional design (ID), at the policy level. Making online classes more innovative, interactive, creative, yet effective through user-friendly tools is another area of research and development. Therefore, will make higher learning institutions standstill if uncertainties keep on happening. Another research area that could be addressed is the social environment at home where online learning occurs. Social support on students' psychology is essential in motivating students to pursue their studies. COVID-19 taught us a valuable lesson in which everyone should be educated on how to utilize various online learning tools. Therefore, it is hoped when the pandemic is over, and the normal physical classes resume, these priceless experiences on online learning in higher learning institutions should not be abandoned and must be continued as one of the powerful methods in delivering knowledge around the world.

6 Recommendations

From the literature review, many articles are written on the impact of COVID-19 through the technical issues around higher education institutions. However, less is about how the educators, lecturers, or students should respond to a crisis like what we are dealing with at present. For example, from the neuroscience perspective, when students face ineffective online learning material, what should they do? or what action needs to be done to fully utilize the online teaching and learning activity when disruptions happen. On the other hand, lecturers and educators should look more into how the teaching and learning activities should be varied to address the lack of technical issues, especially when it comes to triggering the students' neuroscience activity that will lead to the development of the 21st skill competency in students, i.e., problem-solving, critical thinking, creativity, independent learning, and leadership.

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Delivering an Online Course on 'COVID-19 Vaccination Campaign: Administration in Safety of the Anti SARS-COV 2/COVID-19 VACCINE' for Nursing Students at Italian Universities

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Abstract. Many Italian universities had numerous nursing students attending hospital wards for administrating anti SARS-COV 2/COVID-19 vaccines. The training of nursing students was necessary to facilitate good practices, disseminate knowledge about anti SARS-COV 2/COVID-19 vaccines. On 22 December 2021, the Italian National Institute of Health (NIH) created a course that aimed to promote the anti-SARS-CoV-2/COVID-19 vaccination strategy in the country, providing the basic skills, tools and technical-scientific contents necessary to guarantee all phases of the vaccination campaign, including the safe administration of vaccines and counteract vaccination hesitation through the involvement and informed participation of health and social health personnel towards the population. The purpose of this paper was to describe the method used by the Sapienza University of Rome in delivering the Italian NIH course nursing students at Italian universities. The research group in charge of delivering the course decided to use the Google Classroom platform. From the 03/02/2022 to 25/03/2022, 3154 students from 46 Italian universities attended the course. This paper represents a clear advantage in the field of e-learning, not only because it describes an effective method for delivering a course to many students but also because it demonstrates how health professions students can be protected while allowing them to continue or restart internships in health facilities more safely and with more awareness.

Keywords: COVID-19 · e-learninng · Health professions students · Prevention · Vaccines

1 Introduction

The COVID-19 pandemic represents a health emergency for the world population. Italy, through the Ministry of Health, has followed from the very beginning the phases that

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led to the development of vaccines that can contribute to the protection of individuals and communities, in order to reduce the impact of the pandemic. Vaccines must be considered assets of global interest and a real advantage in terms of public health can only be obtained through a widespread and widespread vaccination campaign. The Ministry of Health, the Higher Institute of Health and AIFA have drawn up the interim document "Vaccination against SARS-CoV-2/COVID 19 - Strategic plan. Elements of preparation and implementation of the vaccination strategy". The purpose of the course is to provide the useful elements for the training of nursing students who will operate in the field in the safe administration of anti SARS-CoV2/COVID-19 vaccines.

Since 2004, the e-learning working group of the Italian National Institute of Health (NIH) [1–3] has been delivering e-learning courses on the EduISS platform (https://www.eduiss.it), assessing the quality of e-learning programs and paying attention to several key factors, such as navigability, a multimedia approach, and the degree of interactivity. Specific e-learning methodologies developed and mainly adopted by EduISS, which were originally developed for classroom learning, are innovative ways to reproduce problem-based learning (PBL) in the e-learning context using the best available web tools.

On 22 December 2021, the Italian NIH created a course that aimed to promote the anti-SARS-CoV-2/COVID-19 vaccination strategy in the country, providing the basic skills, tools and technical-scientific contents necessary to guarantee all phases of the vaccination campaign, including the safe administration of vaccines and counteract vaccination hesitation through the involvement and informed participation of health and social health personnel towards the population. Experts with different backgrounds developed the course, namely, experts who provided the scientific content (Italian NIH) and experts on e-learning methods and technological aspects (Training Office of the Italian NIH). The learning method selected to develop the e-learning course was based on the integration of PBL, an active learning methodology.

The course was developed within the continuing medical education Italian regulation and delivered through the e-learning platform of the Italian NIH, EduISS (https://www.eduiss.it).

The purpose of this paper was to describe the method used by Sapienza University of Rome for delivering the Italian NIH "COVID-19 vaccination campaign: administration in safety of the anti SARS-COV 2/COVID-19 vaccine" course for nursing students at Italian universities.[4,5]

2 Materials and Methods

On February 2022, the Italian NIH entrusted the Sapienza University of Rome with delivering the 'COVID-19 vaccination campaign: administration in safety of the anti SARS-COV 2/COVID-19 vaccine' course, which was already available for Italian healthcare professionals, to nursing students enrolled in Italian universities.

2.1 Teaching Methodology and Delivery Methods

The research group in charge of delivering the course, who was already experienced in managing online courses [3–11] decided to use the Google Classroom platform. This

platform has been chosen because compared to other platforms it is free and recognized by many universities, moreover it is already integrated with Google Drive and other tools and it comes with Google's security. Active teaching method inspired by the principles of problem-based learning (PBL), in which individual participants are activated by defining their own learning objectives and solving a problem, inspired by their professional context. The problem is aimed at stimulating the participants to compare their professional experiences and previous knowledge and to identify personal training needs in relation to the proposed problem. Through the study of the didactic material selected by the experts and the search for further scientific material to achieve their learning objectives, the participant acquires new elements of knowledge and new skills for solving the problem itself. The course contains: an introduction to the course explaining its relevance, general aims and structure; general objectives of the course and one learning unit (Fig. 1).

Fig. 1. Example of a course

The learning unit contains:

- A realistic problem/scenario in relation to the topics of the course, useful for defining the learning objectives and activating the learning process;

- Supporting material (bibliographic references and web addresses specific to the topic discussed) and reading (documents selected or prepared ad hoc by the experts) for the acquisition of basic knowledge on the topics covered in the course;
- The tutorials, which represent the synthesis of the main elements of discussion and study of the course;
- The definition of a solution hypothesis of the problem
- Pre and post self-assessment test
- Final certification test

2.2 Guidelines for Students

To register for the course on the Google Classroom platform, students need an internet connection and a browser on their personal computer (PC) (e.g. Chrome, Firefox, Internet Explorer, or Safari). In general, the platform is supported by the main versions of browsers on an ongoing basis. To use the tool, students need to access their Gmail e-mail inbox, and then they must access the Google menu and click on Classroom (Fig. 1). Alternatively, after logging in with their email credentials, they can access the Classroom application directly from the following link: https://classroom.google.com/.
Once the subscribe to the course item has been selected, simply enter the course code from the guidelines. Codes are constantly updated at https://www.associazioneroma.org/covid19-corso-studenti/. All the course material is immediately visible in the Stream section of the course (Fig. 2).

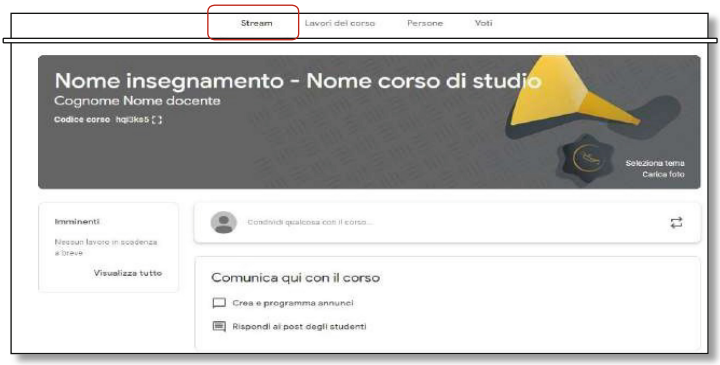

Fig. 2. STREAM section

All students are required to complete the entrance test and the final test, which are found at the beginning and end of the course materials in the Stream section. To obtain the certificate of participation, it is mandatory to complete the two evaluation tests. At the end of the test, simply click on delivery, and the certificate of participation in the course will be sent to the participants at the email with which they enrolled. Only upon

successfully completing all the course activities is an attendance certificate provided for each participant. The tutors are available by email to resolve any doubts regarding the course content, methodological aspects, and technological issues.

2.3 Duration of the Course and Assessment Methods

Participants were expected to spend 16 h to complete the course. They could access the course at any time; however, they were required to complete the course within four weeks. Participation in the course was voluntary for universities, courses, and students, and at the time of recruitment, the participants were informed about the modalities and objectives of the project. The certification test consists of questions with multiple choice answers (4 options), of which only one is correct and will be passed with the achievement of 75% of correct answers. The participant will have five attempts to pass the final evaluation test, subject to the repetition of the use of the contents for each single failed attempt.

Participants must also have completed the training tests provided for in the course, which are:

- the entrance test (pre-test) to be completed at the beginning of the course which allows the participant to evaluate their previous knowledge on the topics covered in the course. It is mandatory, but does not constitute a barrage test.
- the self-assessment test (post-test) of the level of acquired knowledge, inserted at the end of each learning unit. It is mandatory, but it carries out a training function because it allows you to independently assess whether or not you need to deepen the study of the topics covered, by displaying a feedback in which the questions that have not been answered correctly are indicated, with the reference to the learning objective to be reviewed.

The course also includes a course satisfaction questionnaire of perceived quality, to be filled in. The results of the tests were communicated individually to the participating students and did not affect the evaluation in progress or the final evaluation, while the aggregated data were transmitted to the coordinators of the courses involved and to the university referents.

3 Results

Since 03 February 2022, 3154 students enrolled at the bachelor's degree in nursing from 46 Italian universities have been trained. The 81% percent of participants are female, and the mean age 23.35 (standard deviation 4.93). At the end of the course the 92.7% of the students answered that the objective of the course were clear, the 93.8% affirmed that the content was consistent with the course objectives, the 85% said that the teaching methodology was effective, finally, the 90.9 declared to have learned new concept. The most interesting results are reported in Figs. 3 and 4, respectively with the percentage of students affirming that the they have learnt new skills, and that they can play that skills in the training.

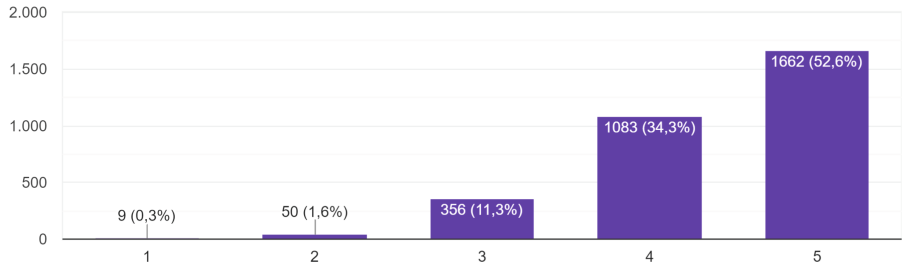

Fig. 3. Percentage of students affirming to have leant new skills

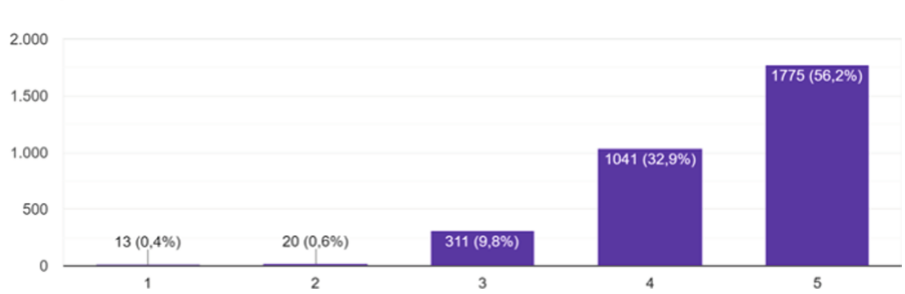

Fig. 4. Percentage of students claim to be able to apply what they have learned in this course during the internship

4 Discussion

COVID-19 has significantly affected all of our lives. It is challenging our ability to adapt and be resilient, and people are facing major challenges worldwide. The education sector is responding to quarantines with a sudden shift to online learning (Electronic Platform for Adult Learning in Europe, 2020). The present study represents an important element to provide the useful elements for the training of nursing students who will operate in the field in the safe administration of anti SARS-CoV2/COVID-19 vaccines. Unfortunately it was not possible to analyse how the platform used demonstrated to be effective, efficient, better or similar to other platforms.

Experts in the academic world must be encouraged to spread and share strategies used to face difficulties. The advantage of international communication lies in the sharing that allows ever-higher standards in education. This paper illustrates clear advantages of e-learning, not only as an effective method to deliver a course to many students but also because as a method by which health professions students can be protected while allowing them to continue or restart internships in health facilities more safely and with more awareness.

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The Lockdown Impact on Students' Successfulness

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Abstract. COVID-19 presented traditional higher education institutions with challenges that most did not meet. Unpredicted lockdown forced them to move all pedagogical processes online overnight. Institutions and academics with some online teaching experiences transited more smoothly than others. Many researchers mainly reported the negative impact of the lockdown on students' well-being and achievements. In the paper, we present a case of how lockdown could be an excellent opportunity to improve students' success and reach goals that were unreachable before. Business Informatics was a hard nut for business students for years, and teachers did not know how to deal with it. Adapting course learning design to lockdown situations, wise use of existing digital (and non-digital) technologies, interactive and supportive learning environments significantly improve course accomplishment rates.

Keywords: Higher education · COVID-19 · Students' successfulness · Course learning design · Online learning

1 Introduction

The SARS-CoV-2 virus, which caused COVID-19, exploded in Wuhan (China) at the end of 2019 [10]. Globalisation caused the virus to spread quickly worldwide and caused lockdowns in different countries [1, 4]. As of the end of January 2020, the virus has been found in EU countries (France, Finland, Italy, Spain, etc.) [13]. Northern Italy, especially Bergamo, has been severely affected [9]. University of Primorska (UP) is only 20 km away from Italy, 400 km from Bergamo; for this reason, the university transferred all teaching activity online on March 9th, 2020. Lockdowns were reported all around the world [1, 2, 5, 11, 12, 14, 15], and traditional universities were forced to adapt themselves to new circumstances and to move all their pedagogical activities online and start working from home. The transition is evident from Eurostat data [3]. The proportion of regular internet users[1] between 20 and 24 (student population) in EU28, who took an online course, increased from 14% in 2019 to 27% in 2020, and 37% in 2021. Further, the proportion of users (20–24 years) who communicate with instructors or other students' using educational websites increased from 29% in 2019 to 41% in 2020.

[1] Used internet in the last 3 months.

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Online education in some environments is still a negative notion, primarily because of correspondence education a hundred or more years ago. Some classical universities still have not accepted the idea that learning outside of school walls could be performed successfully. The obligatory transition to online environments was a real shock for online-sceptical universities' management. Our university was one of them, so they determined that all contact hours must be substituted with one of the existing videoconference systems (Jitsi,[2] ZOOM[3] or MS Teams[4]). The university and faculty leadership were severely concerned about reducing and abandoning contact hours.

We had previous experiences with online teaching, so we organised several online workshops for colleagues to help them transition to online learning environments. We were almost grateful to the epidemic because it seemed to accelerate the digitalisation process at our and other traditional universities more than all the initiatives before.

Authors [1] analysed 47 scientific papers published in high impact journals about education during COVID-19. The study explored disadvantages and limitations, advantages and opportunities, and students' and teachers' feedback. Besides technology issues, they showed that students' engagement and participation were frequently low, mostly because of pre-recorded lectures. Low interaction, lack of personal contact, and digital fatigue caused by prolonged usage of computer screens decreased students' motivation and impacted their mental well-being. The research (ibid.) also exposed assessment issues that opened questions about evaluations modalities. Teachers must think about redesigning the whole evaluation process.

The same study showed that, on the other hand, online environments offer many opportunities for communication and discussion, sometimes even more appropriate for students who have difficulties or feel discomfort in face-to-face discussions (ibid.). Interestingly, only 6% of analysed papers reported improvement in students' performance.

The authors recommended rethinking pedagogical strategies and adapting them to online environments (ibid.). Implementing information and communication technology (ICT) in education, as with implementation of ICT in businesses [6], needs a concrete renovation of main processes; in education, this is the pedagogical process. Teaching strategies and course learning design must be changed and adapted to a new learning environment.

We were actively involved in remote teaching during the epidemic as a teacher who taught a course and as academic support at the university. We followed different discussions and research about students' success/dropout rates during the COVID-19 era. Comparing our experience and course outcomes to these discussions opens a research question: what caused positive impacts is presented below.

2 Business Informatics

Business Informatics is an obligatory course for undergraduate business students. It is taught in the academic and professional study programme of Management. Before 2013,

[2] https://jitsi.org/.

[3] https://zoom.us/.

[4] https://www.microsoft.com/en-us/microsoft-teams/group-chat-software.

the course was a part of the second-year courses, while from 2013 to 2019, the course was moved to the first year. In 2019, both study programmes were renovated, and the course of Business Informatics has been moved back into the 2nd study year. Skills topics resided in the 1st year (a new 3 ECTS course named "Study and ICT practicum" has been created) while the theoretical part of the course is now an obligatory course of the second year. Even though the students are surrounded by different ICT, Business Informatics has been one of the courses students struggled with the most. We tried to make this course more student-friendly and easier to understand and pass during these years, but we failed (Table 1). In the presentation, we include only courses taught by the same teacher so that the course learning design and teaching methods are the same and the teacher characteristics are excluded.

Table 1. Business Informatics statistics by years

Academic year	Professional study programme			Academic study programme		
	N students	Finished (N)	%	N students	Finished (N)	%
2018/2019	78	21	26.9	33	13	39.4
2017/2018	Taught by others			36	17	47.2
2016/2017	78	29	37.2	26	15	57.7
2015/2016	74	23	31.1	30	14	46.7

All courses at the faculty are taught quarterly – seven weeks of lectures, seminars, and tutorials; the eighth week is used for the examination. The final grade of the Business Informatics course is composed of graded weekly assignments (30%), an ICT skills test[5] (20%) and two mid-term exams (50%). Students presented in Table 1 finished the course with ongoing quarter work (column "Finished"). Students who failed at the end of the quarter could pass the exam during the regular examination periods (winter, summer, and autumn).

2.1 Course Design for 2020/2021

The remodelled course of Business Informatics was first taught in 2020/2021. As mentioned, the core of the theoretical part of the course stayed the same; thus, the topics on using ICT have been moved to another, 3 ECTS, course. An additional five hours of lectures and tutorials have been added to the new course. The first performance of the course faced another challenge: due to the epidemic of COVID-19, all pedagogical activities were moved online. The university, having no previous experience with teaching online, demanded that all contact hours needed to be undertaken synchronically via the ZOOM videoconference system. Teaching 70 h per course (35 h of lectures and 35 h of tutorials) online in 7 weeks is not something that we preferred to do, especially because we had previous experience with teaching courses online. We decided to use

[5] From 2019/2020 a part of the course Study and ICT practicum.

a combination of synchronous and asynchronous e-learning approaches (Fig. 1) and to combine different learning activities [8].

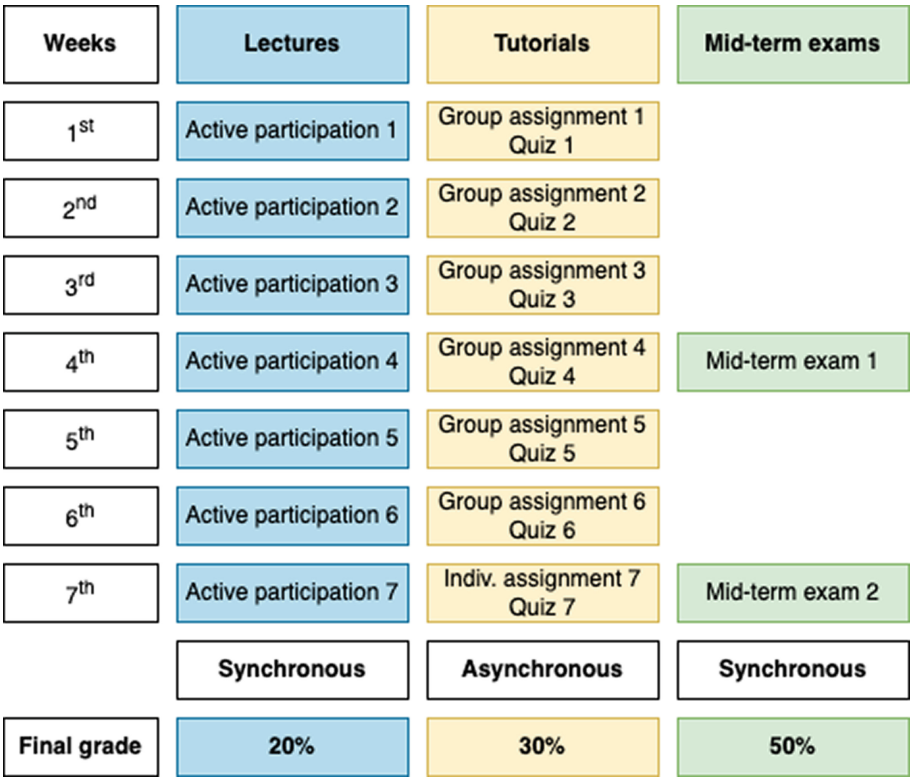

Fig. 1. Course learning design

Synchronous Implementation of Contact Hours (Lectures)

The week began with a lecture in ZOOM. Other personal and reported experiences of using video conferencing – students mostly passive participating or pursuing other activities during online lectures, the physical absence of the student, etc. – guided us to the introduction of so-called active participation activity. It was not enough that students only enrolled themselves in ZOOM meetings; they had to take notes from the lecture. The notes, with exceptions, had to be handwritten, as research prioritises such notes over computer-taken notes [7]. Students were organised into groups formed at the beginning of the course in Moodle during the lecture. The group list and students' distribution among groups were uploaded into ZOOM. Students were automatically assigned to their working groups each time a teacher started ZOOM breakout rooms. In separate groups, students performed different tasks related to the presented topic. In this way, we tried to link the presented theoretical concepts as much as possible to the practice and, above all, to enable students at a distance to communicate more with each other.

Communication can be achieved more smoothly in a smaller than in a larger group. The group work was supported by Google documents, where they answered different questions and resolved assigned problems. At the first meeting, a teacher moved from one breakout room to another, but later the teacher monitored their work only by following ongoing work in the group's Google documents. If the teacher noticed that the group was not active, she entered the group's breakout room and checked what was going on. Students were also able to call a teacher for help when they needed it. The breakout rooms are undoubtedly the most useful ZOOM feature when working synchronously at a distance. The feature impressed teachers and students. Lectures were recorded, and the recording link was shared with the students via Moodle. The recording was available until the end of the week so the students could view it again later. To accomplish the activity of "active participation", the students had to submit a photo of handwritten notes and a copy of the group Google document that they were working on. Students who, for various reasons, were unable to attend the morning lecture were able to view the recording later, write notes and submit the photo of the notes as other students did. For this, they received a portion of the points for active participation. In this way, we tried to eliminate technical difficulties (connection stability, access to the ICT etc.) as reported in many papers explored by Abu Talib [1].

Asynchronous Implementation of Contact Hours (Tutorials)
Tutorial hours were undertaken asynchronously. During the week, students had to accomplish two type of activities – a weekly group assignment (in the last week, the assignment was individual) and a knowledge quiz that was taken individually. Group assignments were done using Google Docs where each student's participation was easily identified; all students were obliged to participate. All weekly quizzes were time-limited, but students were free to start a quiz when it suited them the best – between Friday, 8:00 and Saturday, 15:00.

2.2 Student Successfulness

Both courses, in the professional and academic study programme, were taught online due to COVID-19. Students actively attended ZOOM lectures and ongoing weekly activities (group/individual assignments and weekly tests). The final grade of the course was composed of points received on ongoing activities (30%), active participation (20%) and two mid-term exams (50%) where they presented their knowledge of the theoretical part of the course (Fig. 1).

Table 2. Course completion statistics (2020/2021)

Study programme	Number of students	Number of passed	%
Academic	32	27	84.4%
Professional	33	27	81.8%

Comparing data in Table 1 with data in Table 2 shows that students' dropouts in 2020/2021 decrease and successfulness increases significantly. All students of the academic programme who had collected at least 50% of points on ongoing activities, the preconditions to accessing the second mid-term exam, succeeded. In the professional study programme, the portion was 90%. Some students dropped out at the beginning or during the course.

2.3 Course Evaluation

Each year, we ask students about the course's activities, learning design implemented, and learning outcomes achieved at the end of the course. The student's response is presented in Table 3.

Table 3. Student response

Study programme	Number of students	N of replies	Response
Academic	32	23	71.9%
Professional	33	26	78.8%

The Business Informatics course was performed online for the first time. As presented above, the videoconference system ZOOM was used to deliver lectures. Students were asked to express their opinion on the reasons for joining ZOOM meetings (Fig. 2). All opinions were expressed on the 4-degree scale (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree). Averages 3 and up present agreements, while those below 3 present disagreements (Fig. 2).

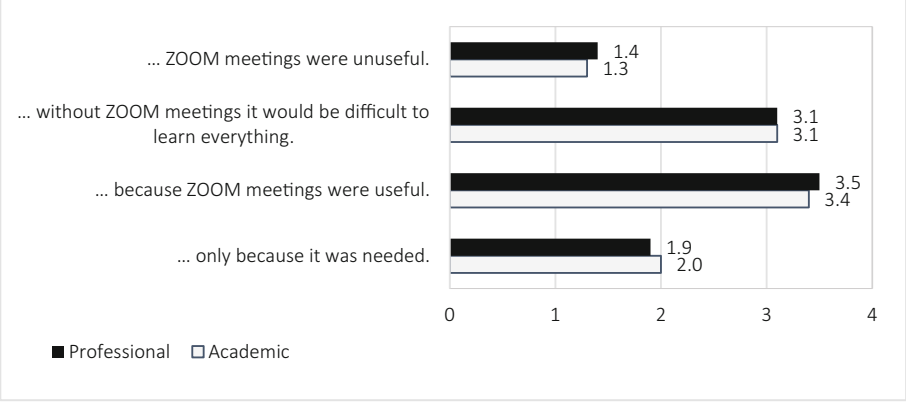

Fig. 2. Students' opinions about attending ZOOM meetings

The students' opinions do not differ significantly. Students attended ZOOM classes because the lectures were useful ($M_{Acad.} = 3.4$, $M_{Prof.} = 3.5$) and because without ZOOM meetings (lectures), the whole learning process would be more difficult ($M = 3.1$ for both groups of students). The lectures were recorded on the ZOOM cloud, and the recordings were accessible to students for the working week. Students of both programmes rated the usability of the recordings on the same 4-step scale with an average of 3.7, confirming our decision to record and share links to recordings for later view. The recordings allowed anyone who could not attend the ZOOM meeting to see the lecture later and obtain a large part of the points for active participation in the lecture (1.5 of 2.0 points).

A major part of the obligatory study material (a textbook) was updated and made available to students in PDF format, divided into chapters and accessible in Moodle. Students found the textbook chapters understandable, illustrative, and clear ($M > 3.0$ on the 4-degree scale) (Fig. 3).

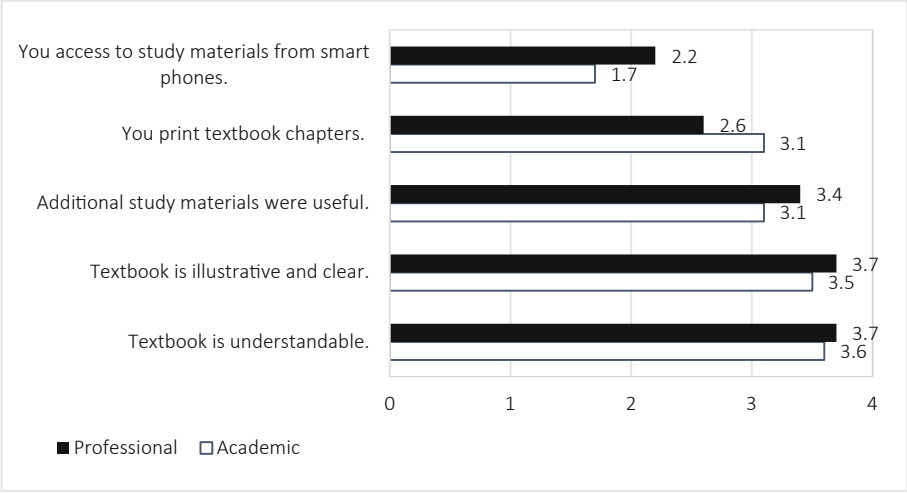

Fig. 3. Comparison of opinions on materials

Students who studied in academic study programmes printed more textbook chapters ($M = 3.1$) than students in professional study programmes ($M = 2.6$).

The difference between the two groups was found in how they used study materials. A third of students (34.6%) in professional study programmes read the textbook on smartphones. There were only two students in academic study programmes who used smartphones for reading the textbook (Fig. 3).

As mentioned, students had different ongoing weekly activities. Appropriateness was checked with the evaluation survey at the end of the course. Students expressed their opinion on the 4-step scale presented above (Fig. 4).

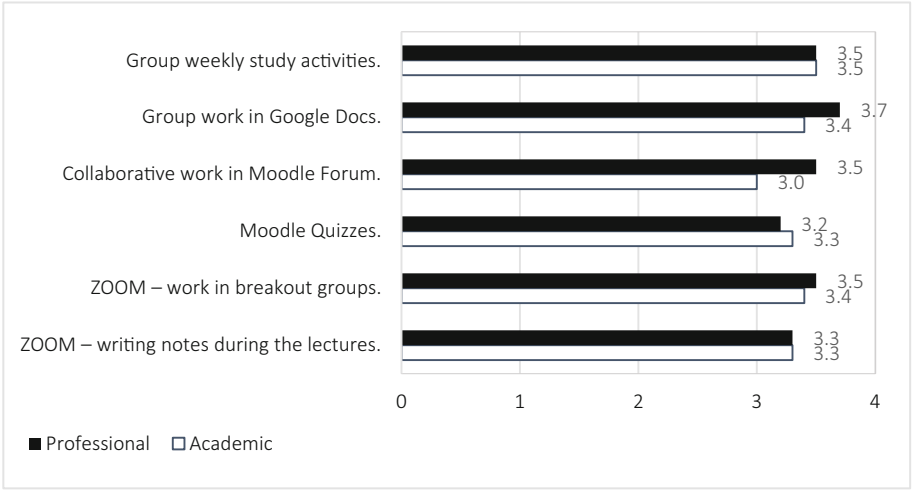

Fig. 4. Appropriateness of study activities

All weekly activities were very well accepted by all students ($M \geq 3.0$) (Fig. 4).

Although the study obligations were demanding ($M = 3.0$) and extensive ($M_{Acad.} = 3.2$ and $M_{Prof.} = 3.4$), the students performed them easily ($M_{Acad.} = 3.3$ and $M_{Prof.} = 3.4$). This was undoubtedly contributed to by comprehensible guidance ($M_{Acad.} = 3.4$ and $M_{Prof.} = 3.5$) and a clear presentation of study obligations ($M_{Acad.} = 3.7$ and $M_{Prof.} = 3.8$) (Fig. 5).

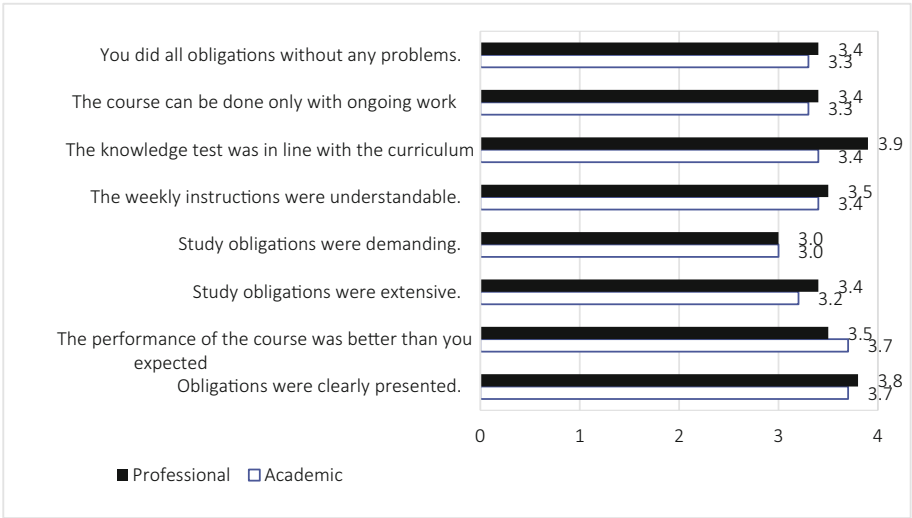

Fig. 5. The complexity of study obligations

Improving ICT use and developing awareness of the challenges associated with ICT use is one of the course objectives. We wondered if the objectives were met (Fig. 6).

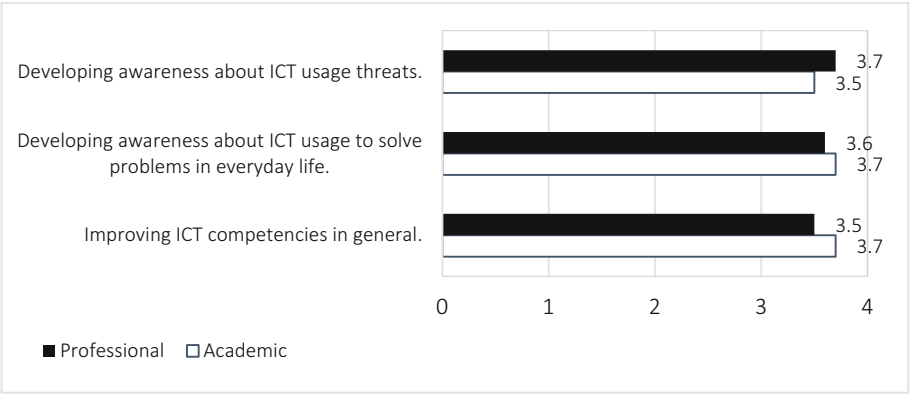

Fig. 6. Using ICT and awareness of the challenges of ICT use

Students in the academic study programme improved their ICT competencies in general ($M_{Acad} = 3.7$, $M_{ProfS} = 3.5$) and awareness of the possibilities of ICT use in daily life and work ($M_{Acad} = 3.7$, $M_{Prof} = 3.6$) more than their colleagues in the professional study programme. The increase in ICT skills is in line with what we already see in practice – students coming from grammar schools (except the economic grammar school) come with a gap in ICT competencies compared to peers from professional programmes, especially in economic directions. This gap is successfully filled during their study in business school.

During the course, the students' workload is monitored. Every week students reported the number of hours they spent studying Business Informatics (Fig. 7). There were no significant differences between both groups of students. An average student enrolled in an academic study programme invested 15.04 h in the course, and an average student in a professional study programme 14.95 h. The course lasts seven weeks, which means that the average student spent 105 h on the course. According to the ECTS system criteria, the average student should have to invest more (between 150 and 180 h for six ECTS courses). We must increase the burden on students, even if students consider that the study obligations were extensive (Fig. 5). The weekly load of students in the course should be at least 20 h per week, which is even more than students investing in performing all the obligations at the faculty.

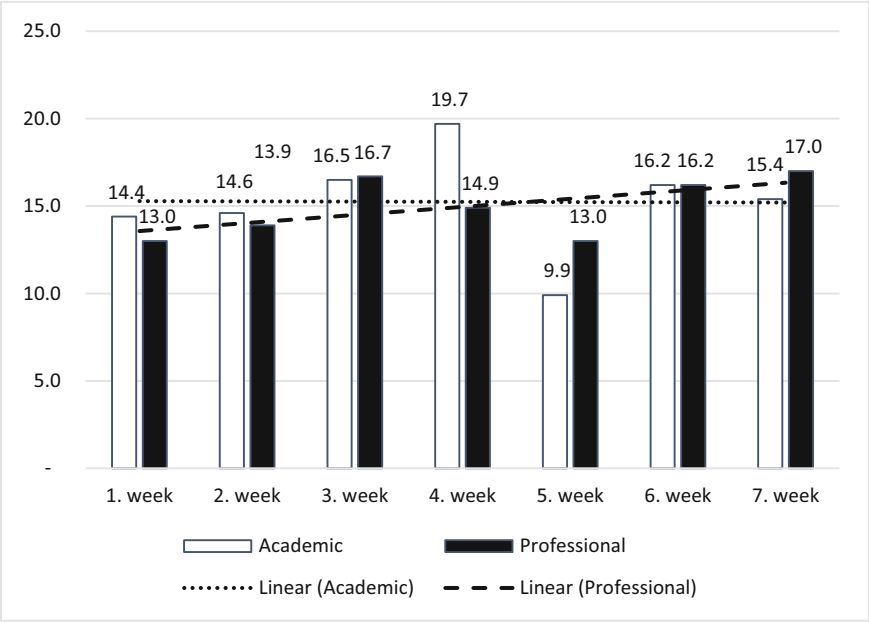

Fig. 7. Comparison of the weekly burden on students

3 Discussion

The COVID-19 pandemic forced all schools to move online. The university governance demanded substituting all contact hours planned in the curriculum and usually carried out in classical classrooms by one of the videoconferencing applications. Even if we had experience with online education, we had to follow the university guidelines and adapt the course design to new circumstances. All lecturer hours were undertaken synchronously using ZOOM. Four-hour lectures were divided by group activities taken in breakout rooms. Students had to take handwritten notes during the lectures, which helped them be active during the ZOOM lectures.

Every week students worked in groups asynchronously. They could meet each other via ZOOM if they wished; for these purposes, they had student ZOOM licences. And at the end of each week, students were invited to test their knowledge via Moodle Quiz. All of these contributed to increasing students' success at the end of the quarter (Table 2). It was the first time that most students successfully finished the course as early as the end of the quarter, even if the course had been performed online.

Moving the study process online due to the COVID-19 pandemic was criticised a lot because of missed physical student contact and opened questions about the appropriateness of online study. If we could organise the course asynchronously, we would omit long ZOOM lecture hours and substitute them with several asynchronous student activities. Due to the university e-learning requirements, we changed and adapted the course learning design, and surprisingly, we succeeded. However, the course in 2020/2021 had been moved back to the second study year; what is required is to see if the students'

success is related to the study year (students are a year older and already have some business knowledge) or is a result of course design.

We collected data about students enrolled in Business Informatics courses from 2005/2006 to 2019/2020. From 2005/2016 to 2012/2013, the course was taught in the second study year, from 2013/2014 to 2018/2019 in the first year and, as mentioned before, from 2019/2020 in the second year once more. The students enrolled in our faculty attended the course in 2020/2021. Students' data were collected from the student information system. The raw data offer us the possibility to compare students who passed the exams, to ascertain if the exam has been passed in the academic year, they had been enrolled in. We found that the academic year in which a course has been performed does not relate to the student's success. Based on data, it could be seen that students from 2013/2014 to 2018/2019, when the course was taught in the first year, were more successful than the previous generation. The success could be related to new study materials that were prepared. Still, data from 2020/2021 may indicate that the achievements are probably connected to the new learning design introduced during the epidemic. In 2021/2022, a similar learning design is being used, except that all lectures are performed in the classical classroom, not via ZOOM.

Students must be active during the lecture; they must take notes and collaborate in Google documents. At the time of finishing the article, students of the academic study programme have just finished the course. The success rate is lower than it was in the previous COVID-19 academic year. One-quarter of the students failed. It seems that the online course is more efficient than face-to-face learning. Students reported that attending lectures via ZOOM in-home in a safe and calm environment helps them be more focused, and recorded lectures enable them to watch the lesson again if they missed something or were unable to attend it live. We will check these assumptions with another group in the summer semester.

4 Future Research

The results are impressive and ought to be tested and compared to course performance in the future, in a post-Covid era, and to see if there are elements to contradict the well-known "The No Significant Differences" results of Russell's study.[6] These elements need to be identified and explained. It would also be interesting to use a similar approach to the courses from other non-IT study fields and compare the results.

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Learning Technologies Performance

Test of Competencies (TECO) in the Bachelor's Degree Course in Psycho and Neurodevelopmental Therapy at the "Sapienza" University of Rome: Cross Sectional Study Internal Consistency and Discriminant Validity

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Abstract. The aim of the study was to evaluate the psychometric properties of the Disciplinary section of the TEst of COmpetencies (TECO-D) in students of the Bachelor's degree in Psycho and Neurodevelopmental Therapy in Italy. The sample was recruited between October and December 2019. To be included in the study, the participants had to be enrolled in the bachelor's degree course of Psycho and Neurodevelopmental Therapy at the "Sapienza" University of Rome and had not to be outside the prescribed time for completion of exams. The test was administered digitally, during 2019, the students from different year levels completed the survey. The internal consistency for the TECO-D score was excellent ($\alpha = 0.71$). The cut-off point for the TECO-D was 0.90 (95% CI 0.85–0.95) for the first year of the course, 0.95 (95% CI 0.92–0.98) for the second year of the course and 0.86 (95% CI 0.80–0.82) for the third year of the course. The scores showed that the TECO-D is able to assess the students' skills for the three years of the course. This study had a great impact for students, researchers and academics, giving important information to improve quality of education.

Keywords: Test of competences · Progress test · Psycho and neurodevelopmental therapy · Bachelor degree · Students

1 Introduction

Progress testing is a longitudinal testing approach, [1–3] it represent a periodic assessment of the entire body of knowledge needed to graduate from medical school. Rather

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https://doi.org/10.1007/978-3-031-08890-2_16

than assessing mastery of a small amount of knowledge, progress exams look for incremental improvement in a student's performance over time. Progress testing is a form of assessment in which groups of learners of different seniority (i.e., different classes in a curriculum) are given the same written test. The test is comprehensive by sampling all relevant disciplines in a curriculum, usually determined by a fixed blueprint [4–7]. Because of the need for wide sampling, questions are typically of the multiple-choice type. The test is repeated at regular intervals [8] Used correctly, this approach has a number of advantages, including reduction of student stress [9] early identification of struggling students [10], and provision of ongoing data to help students and faculty identify and address learning needs [11]. Progress testing has been increasingly used in medical programs across the globe [12, 13].

On this principle, in Italy in 2012, the National Agency for the Evaluation of Universities and Research Institutes (ANVUR) started a project with the aim of testing and monitoring the learning outcomes of Italian undergraduate students through the TEst of COmpetencies (TECO) [14]. This instrument monitors the quality of the educational process in fact TECO results are part of the Italian quality assurance system in the quality process of education. From 2017 TECO test has been adopted in "Sapienza" University of Rome for bachelor's degree courses in nursing, physiotherapy and radiology technicians, from 2019 the test was adopted also for Psycho and Neurodevelopmental Therapy, Occupational Therapy, Speech Therapy and obstetric. Since then it showed interesting results and a great potential for improving the educational system in these courses [4–7, 15]. The comparison that the test allows, between different Universities, also allows to correct, with a view to improving, the study paths through the adaptation of Didactic Plans and Regulations, where the results in specific disciplinary sectors and/or in qualifying training areas, are not compliant with the levels of competence required by the core competence of the Psycho and Neurodevelopmental Therapy. TECO project proposes both Transversal section (TECO-T) and Disciplinary section (TECO-D). TECO-D analyses specific training contents of the course and students are examined with digital platform managed by Consorzio INteruniversitario pEr il Calcolo Automatico dell'Italia (CINECA) in classrooms on the university campus. The time testing is established by the ANVUR in collaboration with the CINECA (usually September – December).

The aim of our study was to evaluate the psychometric properties of the Disciplinary section of the TECO (TECO-D) in students of the Bachelor's degree in Psycho and Neurodevelopmental Therapy in "Sapienza" University of Rome.

2 Materials and Methods

This study was conducted by a research group from the "Sapienza" University of Rome and from "Rehabilitation & Outcome Measure Assessment" (R.O.M.A.) association. R.O.M.A. association in the last few years has dealt with several systematic reviews and the validation of many outcome measures in Italy [16–24].

2.1 Population and Procedures

The sample was recruited between October and December 2019. To be included in the study, the participants had to be enrolled in the bachelor's degree course in Psycho and Neurodevelopmental Therapy at the "Sapienza" University of Rome. They were also required to have completed university exams within set tie period. Participation in the TEst of COmpetencies (TECO) project was voluntary for universities, courses, and students, and, at the time of recruitment, the participants were informed about the modalities and objectives of the project. The test was administered digitally in university computer rooms during 170-min sessions [10]. The results of the tests were communicated individually to the participating students and did not affect the evaluation in progress or the final evaluation, while the aggregated data were transmitted to the coordinators of the study courses involved and to the university referents. During 2019, the students from different year levels completed the survey.

2.2 Instruments

Disciplinary section of the TECO (TECO-D) for the Psycho and Neurodevelopmental Therapy bachelor's degree course used in this study was a single file consisting of 100 closed questions with five alternative answers each. It was divided into ten macro areas, as shown in Table 1. The number of applications for each sector is directly proportional to the University Credits (CFU) reserved in the regulations for the respective scientific disciplinary sectors; this ensures that students have the potential to respond to topics treated equally in all universities.

Each question has been formulated in such a way that it can be read and pondered by a student over a period of approximately 1–1.5 min. Each question has 5 answers, of which only one is correct.

With regard to the method of defining the pool of questions for each Scientific Disciplinary Sector (SSD), the working group established an imperative general principle according to which each request for an SSD had to be shared and accepted by all the teachers of that specific sector., in the various locations involved. It was therefore possible to create questions on fundamental and essential topics in the knowledge of a Psycho and Neurodevelopmental Therapy professional; questions on more specific and in-depth aspects of a topic are avoided, which are instead the subject of a normal examination of that teaching. Number of questions for each area was chosen on the basis of the credits of that area during the course. For example "Professional training responsibilities, health management and organization" is less represented during the didactic paths compared with other subjects.

2.3 Data Collection and Data Analyses

For each year of study, data was collected for each of the main areas of the TECO-D, and, through SPSS-23 software, the data were registered in terms of mean and standard deviation of the score distributions. The internal consistency of the TECO-D was evaluated by Cronbach's alpha, which was considered statistically significant at a cut-off of > 0.70. According to the COnsensus-based Standards for the selection of health Measurement

Table 1. Macro areas.

Number macro areas	Learning	Number questions
1	Physiological development in pediatric	21
2	Semeiotics, study of pathologies, therapy and rehabilitation	62
3	Professional training responsibilities, health management and organization	3
4	Applied knowledge	20

Instruments (COSMIN), discriminant validity was evaluated through receiver–operator curve (ROC) [25, 26] A ROC was plotted and the mean (95% confidence interval [CI]) area under the curve (AUC) was used to estimate a cut-off score for distinguishing the years of course. When the tangent line slope of the ROC (computed using SPSS) is statistically equal to 1 (i.e., AUC = 0.5), then the ROC curve is considered inaccurate for prediction purposes. The predictive ability of a variable was classified with reference to the AUC (excellent = 0.9–1.0, good = 0.8–0.9, fair = 0.7–0.8, poor = 0.6–0.7, or non-discriminative = 0.5–0.6.

3 Results

The sample for the study was composed of 221 students of the Psycho and Neurodevelopmental Therapy bachelor's degree course. Of these, 41 (18.5%) were excluded because the students had not completed university exams within set time period. Demographic characteristics of the population are reported in Table 2.

Table 2. Demographic characteristics of the population

	SAMPLE = 180
Age Mean (SD)	21.7 (3.8)
Gender male n (%)	171 (95)
Year of course N (%)	
First year	53 (29)
Second year	44 (25)
Third year	42 (24)
Fourth year	41 (22)

3.1 Internal Consistency

The internal consistency for the TECO-D score was excellent (Cronbach's alpha = 0.71). The item-total analysis is present in Table 3.

Table 3. Cronbach's alpha if item deleted

Area	Alpha di cronbach
Physiological development in pediatric	0.713
Semeiotics, study of pathologies, therapy and rehabilitation	0.918
Professional training responsibilities, health management and organization	0.684
Applied knowledge	0.954

3.2 Discriminant Validity

Regarding the discriminant validity, the AUC showed a value of 0.90 (95% CI 0.85–0.95) for the first year of the course (Fig. 1), 0.95 (95% CI 0.92–0.98) for the second year of the course (Fig. 2) and 0.86 (95% CI 0.80–0.82) for the third year of the course (Fig. 3) indicating a moderate capability to discriminate the score of year. The score with the best sensibility and specificity for every year of the course is reported in Table 4.

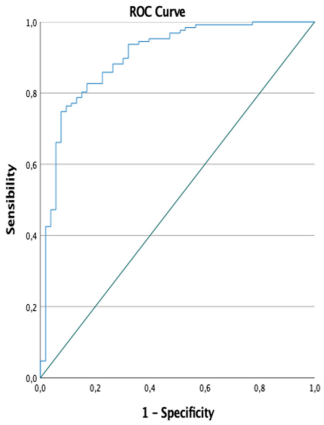

Fig. 1. ROC curve for the first year of the course

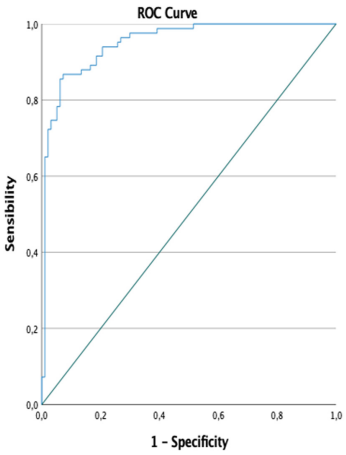

Fig. 2. ROC curve for the second year of the course

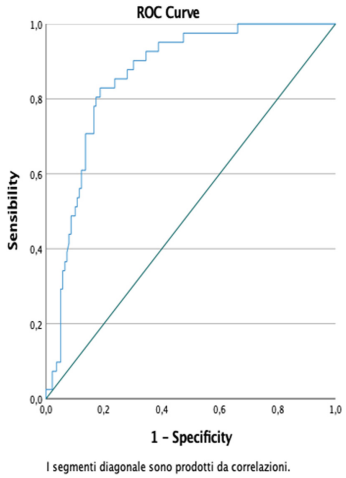

Fig. 3. ROC curve for the third year of the course

Table 4. Cut-off point of TECO-D for Physiotherapy course

Year of course	Cut-off	Sensibility	Specificity
1	185	85%	78%
2	200	89%	82%
3	214	83%	79%

4 Discussion

The aim of our study was to evaluate the psychometric properties of the TECO-D in students of the Bachelor's degree in Physiotherapy at "Sapienza" University of Rome. The progress of individual students can be modelled, giving a sequence of test results, and the effects of rules for progression and remediation can also be modelled.

The results of this study, in line with international guidelines, suggesting that the TECO-D is a reliable and valid tool for assessing the skills of students of Bachelor's degree in Physiotherapy. Internal Consistency of the tool was found to have a good degree of Cronbach's alpha (0.86) which means that the questions of the TECO-D are correlated between each other and produce similar scores.

The cut-off points based on Youden's index were provided for practitioners and researchers to use these tests as screening tools. The cut-off point for the TECO-D resulted to be 186 for the first year of course with a 90% of sensibility and specificity, 204 for the second year of course with a 80% of sensibility and 70% of specificity and 219 the third year of course with a 83% of sensibility and 75% of specificity. The scores show that the TECO-D is able to assess the students' skills for the three years of the course. This study has certain limitation; the current study does not compare the TECO-D with other tools that evaluate the skills of the students in Physiotherapy, this did not allow to evaluate the construct validity. It was not possible to test-retest to evaluate the reliability of the instrument.

This work proposes to evaluate the TECO (TECO-D) instrument in undergraduate physiotherapy students at a university. It has great potential for the future of secondary education. It represents the starting point to provide all students with an equal quality of education and to provide academics with information on teaching areas that need improvement or deepening. This study provides useful information for the recommendation of the TECO-D tool for the academic and scientific world to create degree courses with comparable and reliable teachings. Finally, this study provides useful information in research to investigate, compare and improve specific study courses.

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Means Ends Analysis Learning Model on Students' Problem-Solving Ability and Creative Thinking Ability

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Abstract. This research specifically aimed at; 1) Testing the difference in student's mathematical problem-solving ability through Means Ends Analysis learning model and through direct learning model; 2) Testing the difference in student's mathematical creative thinking ability through Means Ends Analysis model and through direct learning model; 3) Testing the difference in improvement of student's mathematical problem solving and creative thinking abilities through Means Ends Analysis model. This research employed a Quasi Experimental Design with research design of Nonequivalent Control Group Design. The research population was grade VII Junior High School consisting of two classes with 33 students. The samples were taken using a simple random sampling, consisting of two classes with class VIIA as the control class and class VIIB as the experiment class. The data analysis used was t test of independent sample, N-Gain test and t test of paired sample. Based on the research results, it is concluded that; 1) there is difference in student's mathematical problem-solving ability between the experiment and control classes; 2) there is difference in student's creative thinking ability between the experiment and control classes; 3) there is difference in improvement of student's mathematical problem-solving ability and student's mathematical creative thinking ability through Means Ends Analysis model.

Keywords: Means end analysis model · Problem solving ability · Creative thinking ability

1 Introduction

One science a student must master during learning is mathematics. Mathematics education in each stage intends to help student understand the concept learned and apply it in various situations. Mathematics learning is expected to give student the logical, analytical, critical and creative thinking ability and to grow other mathematical ability (Depdiknas 2006). Creative thinking ability is one of the mathematical abilities which may be developed through mathematics learning process (Rahmazatullaili 2017). In mathematical problem solving, student needs to have flexible thinking ability, which is

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one of the aspects of creative thinking ability. Creative thinking ability can be measured based on fluency, flexibility, originality, and elaboration indicators (Siswono 2008).

Besides creative thinking ability, the other ability which may be developed through mathematics learning process is problem solving ability. According to NCTM (2000) in the Principles and Standards for School Mathematics, problem solving ability is one of the five abilities a student needs to have besides reasoning, communication, connection and representation abilities. Problem solving is a process to solve difficulties found to achieve a desired objective. Problem solving ability is one of the important components to develop student's thinking ability, since mathematics learning process is basically problem solving and needs to associate the currently studied material with the existing problems in daily life and create ideas in various ways (Rahmazatullaili 2017). Answering questions on problem solving, besides motivating student to think, can also make student more creative and improve their mathematics ability and aware of the use of mathematics, thus mathematics learning process is expected to be significant (Sumarmo 2000). Furthermore, Turmudi (2009) confirms by using student's problem solving in getting to know how to think, habit of persevering, high curiosity, and self-confidence in uncommon situation, that will serve them (students) well out of mathematics class. Problem solving ability can be measured with the following indicators; 1) Understanding problem; 2) Devising solving plan; 3) Implementing solving plan; and 4) Reexamining (Polya (Winarti 2017).

The correlation of problem-solving ability with creative thinking ability is disclosed by Kiesswetter (in Pehkonen 1997), that in his experience, flexible thinking that is one component in creative thinking is one of the most important abilities, even the main ability, a good problem-solver should have. Choosing and developing various alternative problem-solving strategies certainly requires creativity. It is apparent that creative thinking ability and problem-solving ability are really needed in solving various problems. Mathematics learning is expected to give students the two abilities. Problem solving ability can be measured based on the indicators of understanding problem, including, devising plan, implementing solving plan and reexamining.

In fact, however, problem solving and creative thinking abilities still lack attention in mathematics learning. This is apparent from learning by teachers at junior high school level that mathematics learning is still felt rigid, non-creative and the problems presented are less challenging, only requiring sole answer. This is in line with the finding of Wawan and Hamdi (2018) that mathematics learning is commonly not completely developing high level thinking ability like creative thinking ability. Amalia et al. (2015) also discloses that students lack of practice of doing questions related to problem solving. Moreover, Saefuddin (2012) states that creative thinking lacks of attention in mathematics learning.

All this time, learning is still centered on teacher, and student only serves to receive subject materials (Burais et al. 2016: 78). After teacher has discussed example of question, followed with student doing practice questions with solving steps as the teacher given in the example, student is never challenged to try other ways or student's own logical ways. Problem solving in mathematics is deemed sole and lacking giving space for different answers or different ways in solving a problem. Permana and Sumarmo (2007) states that in learning mathematics, student should be given with big opportunity to explore knowledge on their own, so that they can solve problems.

To solve the matters above, efforts are needed to improve the quality of learning, especially in student's mathematical reasoning. One of the appropriate learning models were used by the author to improve student's mathematical problem solving and creative thinking abilities, namely Means Ends Analysis learning model. MEA can be defined as one way to investigate a problem to achieve desired objective. MEA is a process to solve problems into two or more sub-objectives that are worked on consecutively or systematically (Nurhadi 2017). Huda (2017) states in his book that MEA has become variation of learning for problem solving and creative thinking, especially in mathematical learning (Huda 2017). MEA learning model can have student accustomed to student's mathematical problem solving and creative thinking, and had much experience to find something in answering questions (Pratiwi 2016).

Based on the explanation of problems described above, the research's points of focus are:

a. Is there difference in student's mathematical problem-solving ability through means ends analysis learning model and through direct learning model on main set material?
b. Is there difference in student's mathematical creative thinking ability through means ends analysis learning model and through direct learning model on main set material?
c. Is there difference in improvement of student's mathematical problem solving and creative thinking abilities through means ends analysis learning model and through direct learning model on main set material?

2 Research Method

This research used quantitative method and research design Nonequivalent Pretest-Posttest Control Group Design aiming at improving student's mathematical reasoning and communication abilities through Mean Ends Analysis learning model. This research involved two classes (groups of students): experiment class that received learning treatment using Mean Ends Analysis learning model, and control class received direct learning from teacher. The research design can be observed in Table 1 below.

Table 1. Research design

Class	Pre-test	Treatment	Post-test
Experimental class	O1	X1	O2
Control class	O1	X2	O2

The research population was all students of grade VII Junior High School. The samples were obtained using simple random sampling. The chosen samples were class VII A (Control Class) with 17 students and class VII B (Experiment Class) with 16 students. The research instrument was mathematical reasoning ability test that had been tested and met the criteria for test of validity, reliability, difficulty level and distinguishing characteristics and sheet of learning enforceability. Statistical test Independent Sample T-test

was used to examine the difference in student's mathematical reasoning ability between experiment class and control class (Liang 2019; Gerald 2018, Woodrow 2014). Similarly, t-test would be carried out for two dependent samples (paired samples) to examine the difference in improvement of student's mathematical reasoning ability through Mean Ends Analysis learning model on set material. Whether the application of Mean Ends Analysis learning model was performed well could be examined by calculating the percentage of enforceability of the whole indicators of each observer and calculating the percentage of entire enforceability of the two observers.

3 Result and Discussion

3.1 Difference in Student's Mathematical Problem-Solving Ability Through Mean Ends Analysis Learning Model and Through Direct Learning Model

The data presented in this research were the data obtained from the answers of Post-Test questions given to the experiment and control classes. The Post-Test questions were given to examine the difference in student's mathematical problem-solving ability through Mean Ends Analysis learning model and direct learning model. Meanwhile, the post-test questions given were in the form of mathematical problem-solving ability test containing indicators of problem-solving ability, namely: (1) Understanding problem (2) Devising solving plan (3) Solving problem as planned, (4) Reexamining.

Student's mathematical problem-solving ability in the experiment class and control class was reviewed per indicator of student's mathematical reasoning ability with indicator of mathematical problem-solving ability, that for understanding problem, the average score of indicators in experiment class was 78.00 and in control class with average score of indicators of 64.03. For the indicator of mathematical problem-solving ability of devising solving plan, the average score of indicators in experiment class was 76.56 and in control class the average score of indicators was 65.63. For the indicator of solving problem as planned the average score of indicators in experiment class was 73.83 and in control class the average score of indicators was 68.75. For the indicator of reexamining, the average score of indicators in experiment class was 72.56 and in control class the average score of indicators was 63.05. The average score per indicator of student's mathematical problem-solving ability in experiment class and control class above is presented in the bar chart in Fig. 1 below.

A difference test was then performed on the posttest average scores of experiment class and control class, but before calculating the posttest average scores of experiment class and control class, data normality and homogeneity tests were performed first, and the results are presented in Tables 2 and 3 below.

Tables 2 and 3 show that the posttest average scores of experiment class and control class were normally distributed and homogenous, and a statistical test analysis was then performed on the difference in the two averages of samples with student's mathematical problem-solving ability test on the experiment class with Mean Ends Analysis learning model and on the control class with direct learning model. The test criteria H_a was accepted if $t_{count} > t_{table}$. The recapitulation of count result of two averages of students from experiment class and control class can be observed in Table 4 below.

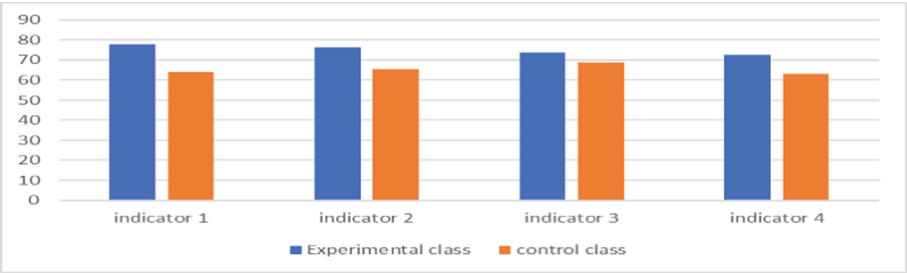

Fig. 1. Bar chart of average score per indicator of mathematical problem-solving ability

Table 2. Recapitulation of normality test results on problem solving post-test data

Description	Experimental class		Control class
L_{count}	0.1750		0.1878
L_{table}		0.2130	

Table 3. Recapitulation of post-test results on problem solving variants in both experimental and control class

Description	Experimental class		Control class
Variants	92.92		132.92
F_{count}		1.43	
F_{table}		2.40	

Table 4. Recapitulation of calculation of two differences on reasoning averages in both experimental and control class

Description	$\sum X_1$	$\sum X_2$	$\overline{X}_1$	$\overline{X}_2$	S_1^2	S_2^2
Score	1190	1030	74.37	64.37	92.92	132.92
T_{count}	2.66					
t_{table}	2.40					

Based on Table 4 above, t_{table} is 2.66 and t_{table} is 2.40. Since $2.66 > 2.40$, then H_a is acceptable. This means there is difference in student's mathematical problem-solving ability between the experiment class and control class. Based on the test of difference in two averages, we may conclude that there is difference in student's mathematical problem-solving ability through Mean Ends Analysis learning model.

This means that learning using Mean Ends Analysis learning model facilitates student's mathematical problem-solving ability to grow and develop, since in this learning

model students are driven to cooperate in producing ideas, suggestions and opinions and required to make logical conclusion and to predict the answer and solution process in making valid argument in solving the problem together. This is in line with the research conducted by Syahrul and Edwin (2019) that student's mathematical problem-solving ability through MEA learning model is better than that through conventional learning model.

3.2 Difference in Student's Mathematical Creative Thinking Ability Through Mean Ends Analysis Learning Model and Through Direct Learning Model

The data presented in this research were obtained from answers for posttest questions given to the experiment and control classes. The posttest questions were given to examine the difference in student's mathematical problem-solving ability through Mean Ends Analysis learning model and direct learning model. The posttest questions given were in the form of mathematical creative thinking ability test containing indicators of creative thinking ability, namely: (1) Fluency (2) Flexibility (3) Elaboration.

Student's mathematical creative thinking ability in experiment class and control class was reviewed per indicator of student's mathematical creative thinking ability, Fluency, with average score of indicators in experiment class of 83.33 and in control class of 54.17. For the Flexibility indicator of mathematical creative thinking ability, the average score of indicators in the experiment class was 66.67 and in the control class of 64.58. For the Elaboration indicator of creative thinking ability, the average score of indicators in experiment class was 67.19 and that in the control class was 64.06. The average score per indicator of student's mathematical communication ability in the experiment class and control class above can be presented in bar chart in Fig. 2 below.

Fig. 2. Bar chart of average score of indicators of creative thinking ability

A difference test was then carried out on posttest average score of experiment class and control class; however, data normality and homogeneity tests were conducted first before calculating the posttest average score of experiment class and control class, of which results are presented in Tables 5 and 6 below.

Table 5. Recapitulation of normality test results on creative thinking post-test data

Description	Experimental class		Control class
L_{count}	0.1989		0.1925
L_{table}		0.2130	
Conclusion	Normal		Normal

Table 6. Recapitulation of post-test results on creative thinking variants in both experimental and control class

Description	Experimental class		Control class
Variants	162.92		91.66
F_{count}		1.77	
F_{table}		2.40	
Conclusion	Homogenous		Homogenous

The test criteria mention that H_o was accepted if $F_{count} < F_{table}$. Based on Table 22, it is apparent that the variance of experiment class was 162.92 and variance of control class was 91.66, resulting in F_{count} 1.77 and F_{table} 2.40. It is found that $1.77 < 2.40$, thus we may conclude that the variance of posttest data of the two classes was homogenous.

A statistical analysis was then carried out on the difference test on the two averages of samples with student's mathematical creative thinking ability test on the experiment class with Mean Ends Analysis learning model and on the control class with direct learning model. The test criteria mention that H_a was accepted if $t_{count} > t_{table}$. The recapitulation of calculation result of two averages of students from experiment class and control class can be observed in Table 7 below.

Table 7. Recapitulation of calculation of two differences on creative thinking averages in both experimental and control class

Description	$\sum X_1$	$\sum X_2$	$\overline{X}_1$	$\overline{X}_2$	S_1^2	S_2^2
Score	1150	980	71.87	61.25	162.92	91.66
t_{count}	2.66					
t_{table}	2.40					

Based on Table 7 above, it is apparent that t_{table} is 2.66 and t_{table} is 2.40. Since 2.66 > 2.40, then H_a is accepted. This means that there is difference in student's mathematical creative thinking ability from experiment class and control class. Based on the difference test on the two averages, we may conclude that there is difference in student's mathematical creative thinking ability through Mean Ends Analysis learning model. This is in line with the research conducted by Selfi and Sofia (2021) that Mean Ends Analysis learning model is one of the strategies to facilitate student's mathematical creative thinking ability development since the MEA model has students used to analyze problems with various ways to achieve the desired final objective.

3.3 Difference in Improvement of student's Mathematical Problem Solving and Creative Thinking Abilities Through Means Ends Analysis Model

Two independent samples-T test was carried out to examine the difference in Improvement of Student's Problem Solving and Creative Thinking Abilities in the Experiment Class with the Mean Ends Analysis learning model by processing the test data, that was to have pretest and posttest on their mathematical problem solving and creative thinking abilities. Before testing the difference in improvement, it was necessary to note the extent of improvement of mathematical problem solving and creative thinking abilities before and after performing Mean Ends Analysis learning model by first calculating the N-Gain on problem solving and creative thinking abilities. The recapitulation of N-Gain data test calculation results is presented in Table 8 below.

Table 8. Average N-gain value of problem-solving ability and mathematical creative thinking of experimental class students

Problem solving skill	Average value			
	Pre-test	Post-test	N-Gain	Category
	4.5	7.4	0.52	Moderate
Creative thinking ability	Average value			
	Pre-test	Post-test	N-Gain	Category
	4.8	7.2	0.46	Moderate

Table 8 shows that student's mathematical problem-solving ability is of medium category and there is improvement in student's ability before and after performing Mean Ends Analysis learning model. Having the improvement in mathematical problem solving and creative thinking abilities identified, it was then to identify the difference in improvement in mathematical problem solving and creative thinking abilities using two independent samples-T test. Before using the two independent samples-T test, data normality test was conducted first, followed with homogeneity test.

Normality test was carried out using chi-square. The normality test criteria mention that Ho was accepted if $x^2_{\text{count}} \leq x^2_{\text{table}}$ and Hα was rejected if $x^2_{\text{count}} > x^2_{\text{table}}$. Having

Ho accepted means that the data were from normally distributed population, while having Hα rejected means the data were from non-normally distributed population.

The homogeneity test would use f-test. The decision-making criteria were if $f_{count} \leq f_{table}$ using $\alpha = 5\%$, the N-gain data of experiment class's problem solving and creative thinking abilities had homogenous variance. Based on the results of analysis on homogeneity test calculation on N-gain of student's problem solving and creative thinking abilities, the of N-gain of homogeneity test on experiment class and control class, the $f_{count} \leq f_{table}$ was $1.7533 \leq 2.4034$, then we may conclude that the N-gain of experiment class's problem solving and creative thinking abilities was homogenous. Because of normally distributed analyzed data and homogenous variance, the next step was to identify the difference in improvement in student's mathematical problem solving and creative thinking abilities of experiment class using Mean Ends Analysis learning model. The researcher used two independent samples-T Test, and the calculation resulted in $t_{count} = 0.62$ at significance level $\alpha = 0.05$ resulting in t_{table} $(5\%.\ 28) = 2.40$. That the calculation resulted in $t_{count} < t_{table}$, or, $0.62 \leq 2.40$, then Ho was accepted and Ha was rejected. We can then conclude that there was significant difference in improvement between student's problem solving and creative thinking abilities by using Mean Ends Analysis learning model.

The difference in improvement in student's mathematical reasoning ability was due to the difference arising from each treatment in learning. The higher improvement in student's mathematical reasoning ability of the experiment class that used the Mean Ends Analysis model was based on the correlation of abilities with the model. Problem solving and creative thinking abilities are more closely related to the Mean Ends Analysis model since Mean Ends Analysis in its steps uses heuristic-based problem-solving approach more, that is to solve a problem into two or more sub-objectives, making it easier for student to solve the problems and make conclusion. In learning with MEA model, students are also trained and used to solve problems and to participate more actively and express their ideas in various situation they face (Shoimin 2014).

This is in line with the research conducted by Nurhadi (2017) that the group of students learning using Mean Ends Analysis (MEA) learning model shows better outcome than the group of students learning using conventional learning model. Moreover, as revealed by Juanda et al. (2014), the use of MEA learning model may improve problem solving and creative thinking ability, and accuracy in facing mathematical problems.

4 Conclusion

Based on the research data processing, we may generally conclude as follows.

1. There is difference in student's mathematical problem-solving ability through Mean Ends Analysis learning model and through direct learning model on set subject material for grade VII
2. There is difference in student's mathematical creative thinking ability through Mean Ends Analysis learning model and through direct learning model on set subject material for grade VII

3. There is difference in improvement in student's mathematical problem solving and creative thinking abilities through Mean Ends Analysis learning model on set subject material for grade VII.

The researcher desires to follow up this research by measuring other mathematics abilities, not only on the mathematical problem solving and creative thinking abilities, in mathematics learning using the Mean Ends Analysis learning model.

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Development and Validation of a Progress Test in Occupational Therapy Degree Courses: A Cross-Sectional Study

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Abstract. The aim of this study was the development and validation of a progress test (PT) useful to evaluate the learning progress of occupational therapy students in order to allow the improvement of skill acquisition and the qualitative analysis of teaching and degree course organization. The PT was developed on the basis of didactic plans, teaching modules, and/or scientific-disciplinary sectors (SDS) common to all 12 degree courses in Italy. The reliability of the PT was assessed using Cronbach's alpha (α) and the intraclass correlation coefficient (ICC). The efficacy and discrimination of the items were analysed using the facility index and point-biserial correlation (P-Bis), respectively. The PT was composed of 11 areas with a total of 190 items with 5 multiple-choice responses, one of which was correct. Six universities confirmed their participation in the study, and 734 students enrolled in one of the four course years were included in the study. The PT showed excellent internal consistency, with Cronbach's α values of 0.95. However, areas 2 and 4 of the PT showed poor intercorrelation with the other areas, with Cronbach's α values of 0.24 and 0.56. The results highlighted that the PT was quite difficult for occupational therapy students, who achieved a maximum score of 126 out of 190. Test-retest reliability showed ICC values between 0.90 and 1. The PT is a useful tool for the assessment of the learning progress of occupational therapy students, the qualitative analysis of teaching and degree course organization, and the acquisition and time-dependent maintenance of essential knowledge and skills to be evaluated.

Keywords: Test of competences · Progress test · Occupational therapy · Bachelor's degree · Students

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1 Introduction

Verification of student acquisition of the appropriate cognitive, professional, and emotional skills is critical. In Italy, the current evaluation system of three-year degree courses in the health area is based on a subjective standard that is often provided by university professors, hence it is not uniform and standardized for all universities. Therefore, valid and reliable tools are lacking that measure and provide a graphically observable [1] description of student learning and the evolution of professional skills.

The progress test (PT) is a longitudinal assessment tool given over the degree course that is aimed at assessing whether and in what way the student is acquiring the skills necessary to carry out the specific profession. Moreover, it provides an analysis of the teaching quality and organization of the degree course [2]. The PT was initially developed to evaluate medicine and surgery courses, and is therefore based on the International Classification of Diseases and Related Health Problems (ICD) in order to include all medical-health disciplines [3]. The development of a similar tool applicable to degree courses in the health professions is supported by studies on the psychometric properties of the PT itself, which is largely considered a reliable and valid tool, particularly in regard to its predictive validity [4, 5]. Moreover, the usefulness of the PT is its longitudinal value: it does not consider what a student knows at the time of a specific exam, but rather the way in which students manage to use their knowledge later, in terms of skills and problem solving [3].

In Italy, the structure of the PT is based on the core competences specific to each profession, which allow the general objectives of degree courses to be identified and a competence-oriented training curriculum developed [6]. Adopting core competences as the final goal of a study course represents a key revolutionary element that requires planning aimed at acquiring skills and not just knowledge. Furthermore, structuring a PT based on the training areas defined by the core competences allows all professional areas to be covered [7–11].

Since occupational therapy degree courses never had core competences and, consequently, a specific PT could not be administered to students, the aim of this study was to develop and validate a tool useful to evaluate the learning progress of occupational therapy students in order to improve skill acquisition as well as the qualitative analysis of teaching and degree course organization.

2 Materials and Methods

This study was conducted by a research group from Sapienza University of Rome and the Rehabilitation & Outcome Measure Assessment (ROMA) association. Over the last few years, the ROMA association has performed several systematic reviews and the validation of many outcome measures in Italy.

2.1 Tool Construction

Since occupational therapy degree courses have never had core competences, we used the physiotherapist profession as a reference since we considered it to be the health profession most similar to that of the occupational therapist in terms of skills and competences and it is also included in the same degree class [12, 13]. In addition, development of the PT was also based on didactic plans, teachings, and/or scientific-disciplinary sectors (SDS) common to and present in all degree courses in Italy. A group of experts then screened all these elements and established a specific series of questions for each SDS based on the European Credit Transfer and Accumulation System (ECTS) number assigned. From this analysis, 190 items were obtained and then divided into 11 areas (Table 1).

Once the number and types of questions were established, the working group decided on the following: 1) the development of two multiple-choice questions for each ECTS with five possible responses, one of which was correct. Each professor belonging to the teaching staff of the occupational therapy degree course of Sapienza University of Rome was asked to develop a question concerning their own teaching; 2) the maximum time allocated to answer each question (about 1 min and a half); 3) the scores to give to the items (1 point for each correct answer); and 4) the randomization and administration methods. Randomization was considered necessary in order to standardize attention levels to all questions. The resulting PT was composed of 11 areas with a total of 190 items with 5 multiple-choice responses, one of which was correct.

Table 1. The 11 areas of the progress test and the number of ECTS and questions

Area	Teaching modules	ECTS	Number of questions
AREA 1	Anatomy, physiology, and biology basic Knowledge	18	36
AREA 2	Socio-psycho-pedagogical Sciences	6	12
AREA 3	General bases of occupational therapy	13	26
AREA 4	Knowledge of the English language	3	6
AREA 5	Occupational therapy in neurology and psychiatry	13	26
AREA 6	Occupational therapy in orthopedics	6	12
AREA 7	Occupational therapy in pediatrics	6	12
AREA 8	Occupational therapy in geriatrics	6	12
AREA 9	Health management, bioethics, and deontology	12	24
AREA 10	Advanced bases of occupational therapy	7	14
AREA 11	Evidence-based rehabilitation	5	10

2.2 Participants and Data Analysis

In order to proceed with the study, all 12 occupational therapy degree courses active in Italy were involved. A paper-based test was administered and data were collected in Excel. All statistical analyses were conducted with Statistical Package for Social Sciences (SPSS) 23.00.

Reliability and validity of the PT were assessed following the Consensus-Based Standards for the Selection of Health Status Measurement Instruments (COSMIN) checklist. Internal consistency was examined using Cronbach's alpha ($\propto$) to assess the interrelatedness of the items in each area and the homogeneity of the test. An $\propto$ coefficient of at least 0.70 indicated satisfactory homogeneity of all items within a tool. Efficacy of the items was analyzed using the facility index, which evaluates the level of ease of the single item and of the entire tool by relating the students who correctly answered the question to the whole group. Items with a score between 0.25 and 0.75 are considered generally acceptable, and the higher the number of students who correctly answered the question, the easier the item [14, 15]. In the specific case of the PT, a high facility index value is expected at the end of the degree course, while lower values would be more plausible at the beginning of the degree course.

Furthermore, the discriminatory ability of the items was calculated through the point-biserial correlation (P-Bis), which evaluates whether the item is able to distinguish the most prepared students from those who are least prepared [16, 17]. P-Bis varies from -1, when the most competent students answer the question incorrectly and least prepared answer correctly, to $+1$, when the most competent students answer the question correctly and the least prepared answer incorrectly. If the P-Bis approaches 0, it means that the item is unable to properly discriminate the two groups of students.

In order to evaluate test–retest reliability, the intraclass correlation coefficient (ICC) was obtained by administering the PT twice to a randomized subsample of the population enrolled at Sapienza University of Rome, Montefiascone, and Policlinico Umberto I.

3 Results

Of the 12 occupational therapy degree courses present in Italy, 6 courses participated in the project (Chieti-Pescara, Milan, Padova, Sapienza University of Rome (Montefiascone and Policlinico Umberto I), and the Catholic University of the Sacred Heart (Moncrivello)). The remaining universities declined to participate in the project. Each university enrolled first-, second-, third-, and fourth-year students of occupational therapy courses, with a total study population of 734.

3.1 Reliability

The PT showed excellent internal consistency, with Cronbach's α values of 0.95. Table 2 shows the α value for each subpopulation, as well as facility index and P-Bis values. Despite the test-retest being administered to a randomized subsample of the population, the PT showed variable and reliable ICCs, with values between 0.90 and 1. Results are shown in Table 2.

Table 2. Cronbach's alpha, facility index, and point-biserial correlation for each year of the course

	Year of course			
	1	2	3	4
Cronbach's αlpha	0.90	0.90	0.93	0.95
Facility Index	0.18	0.28	0.37	0.43
P-Bis	0.22	0.22	0.25	0.29

Table 3. Test-retest analysis: range of ICC parameters for each item of the PT

Areas	Items	Baseline median	Re-test median	ICC (95% CI)
Area 1	Biochemistry	1.33 (0–3)	1.56 (0–3)	0.73 (0.56–0.84)
	Medical Genetics	1.12 (0–3)	1.25 (0–3)	0.75 (0.59–0.86)
	Physics	1.15 (0–4)	1.03 (0–3)	0.78 (0.64–0.86)
	Human Physiology	1.45 (0–4)	1.8 (0–5)	0.75 (0.58–0.85)
	Human Anatomy	0.97 (0–5)	1.03 (0–5)	0.80 (0.67–0.88)
	Histology	0.45 (0–2)	0.56 (0–2)	0.69 (0.46–0.79)
	Microbiology	1.44 (0–4)	1.97 (0–4)	0.45 (0.10–0.66)
	General Pathology	0.74 (0–2)	1.04 (0–4)	0.58 (0.31–0.74)
	Clinical Pathology	0.56 (0–2)	0.62 (0–2)	0.76 (0.61–0.85)
Area 2	General Sociology	0.56 (0–1)	0.51 (0–2)	0.77 (0.63–0.86)
	Philosophy of Medicine	0.39 (0–2)	0.68 (0–2)	0.88 (0.68–0.88)
	General Pedagogy	0.34 (0–3)	0.46 (0–3)	0.58 (0.32–0.74)
	General Psychology	1.43 (0–4)	1.5 (0–3)	0.65 (0.43–0.79)
Area 3	Occupational Therapy – I	5.21 (0–6)	5.39 (0–6)	0.64 (0.41–0.78)
	Cutaneous and Venereal Diseases	1.27 (0–3)	1.3 (0–3)	0.79 (0.65–0.87)
	Physical and Rehabilitation Medicine	0.6 (0–2)	0.86 (0–3)	0.55 (0.26–0.72)
	Infectious Diseases	1.77 (0–4)	1.78 (1–4)	0.78 (0.65–0.87)
	Diagnostic Imaging	1.03 (0–4)	1.15 (0–4)	0.72 (0.54–0.83)
	Occupational Therapy – II	2.62 (0–4)	2.62 (0–4)	0.69 (0.50–0.81)

(*continued*)

Table 3. (*continued*)

Areas	Items	Baseline median	Re-test median	ICC (95% CI)
Area 4	English	2.68 (0–6)	3.18 (0–5)	0.73 (0.56–0.83)
Area 5	Occupational Therapy – III	1.1 (0–4)	1.3 (0–4)	0.82 (0.71–0.89)
	Physical and Rehabilitation Medicine – II	1.3 (0–3)	1.4 (0–3)	0.82 (0.70–0.89)
	Neurology	1 (0–4)	1.4 (0–4)	0.55 (0.26–0.72)
	Occupational Therapy in Neurology	2.3 (0–4)	2.5 (0–4)	0.77 (0.63–0.86)
	Clinical Psychology	1.5 (0–4)	1.5 (0–4)	0.82 (0.71–0.89)
	Psychiatry	1.2 (0–4)	1.2 (0–4)	0.87 (0.78–0.92)
Area 6	Musculoskeletal System Diseases	0.8 (0–3)	1.1 (0–3)	0.68 (0.48–0.80)
	Rheumatology	1.1 (0–4)	1.2 (0–4)	0.87 (0.78–0.92)
	Occupational Therapy in Orthopedics	1.8 (0–4)	1.9 (0–4)	0.76 (0.61–0.85)
Area 7	General and Specialist Pediatrics	1 (0–3)	1.2 (0–3)	0.76 (0.61–0.85)
	Child Neuropsychiatry	0.8 (0–3)	0.9 (0–3)	0.86 (0.78–0.92)
	Occupational Therapy in Pediatrics	1.8 (0–5)	2 (0–6)	0.90 (0.83–0.94)
Area 8	Cardiovascular Diseases	0.4 (0–3)	0.4 (0–3)	0.82 (0.71–0.89)
	Internal Medicine	0.5 (0–2)	0.5 (0–2)	0.57 (0.30–0.74)
	Occupational Therapy in Geriatrics	0.5 (0–2)	0.6 (0–2)	0.72 (0.55–0.83)
	Occupational Therapy – IV	1.7 (0–4)	1.9 (0–4)	0.75 (0.59–0.85)
Area 9	Business Economics	0.7 (0–3)	0.8 (0–4)	0.68 (0.48–0.81)
	History of Medicine	0.35 (0–2)	0.5 (0–2)	0.64 (0.52–0.78)
	Forensic Medicine	0.8 (0–2)	0.8 (0–2)	0.87 (0.78–0.92)

(*continued*)

Table 3. (*continued*)

Areas	Items	Baseline median	Re-test median	ICC (95% CI)
Area 10	Electronic and Informatics Bioengineering - I	0.4 (0–4)	0.9 (0–4)	0.78 (0.64–0.86)
	Physical and Rehabilitation Medicine – III	1 (0–4)	1 (0–3)	0.75 (0,60–0.85)
	Advanced Bases of Occupational Therapy	1 (0–4)	1.3 (0–4)	0.68 (0.48–0.80)
	Electronic and Informatics Bioengineering – II	1.2 (0–4)	1.2 (0–4)	0.79 (0.66–0.87)
	Occupational Therapy – V	1.3 (0–3)	1.3 (0–3)	0.49 (0.178–0.69)
	Plastic Surgery	0.7 (0–4)	0.8 (0–4)	0.74 (0.57–0.84)
	Occupational Therapy – VI	0.2 (0–2)	0.1 (0–1)	0.53 (0.23–0.71)
Area 11	Medical Statistics	0.01 (0–1)	0.01 (0–1)	1
	Informatics	0.3 (0–2)	0.3 (0–2)	0.71 (0.52–0.82)
	General and Applied Hygiene	0.4 (0–1)	0.6 (0–2)	0.66 (0.48–0.79)

4 Discussion

As evident from the scientific literature [18–21], the PT is universally considered to be a useful tool, particularly for the medical and health sectors. Since occupational therapy degree courses currently have no evaluation tools, the aim of this study was to develop and validate a PT useful to evaluate the learning progress of occupational therapy students in order to allow the improvement of skill acquisition as well as the qualitative analysis of teaching and degree course organization.

To evaluate the consistency of the scale, Cronbach's coefficient was used and a high rate of internal consistency (0.95) was found. However, specific values of Cronbach's alpha relative to the 11 areas of the instrument, as shown in Table 3, highlight the presence of items with poor intercorrelation and at the limit of reliability. This is the case with area 2 (socio-psycho-pedagogical sciences), with an α of 0.24, and area 4 (English), with an α of 0.56. These results can be useful for future studies in order to make some changes to the number, type, and formulation of PT items.

Regarding the scores obtained from the different years of the degree course, the results obtained from the statistical analysis were different than what was expected. For example, regarding area 1 (anatomy, physiology, and biology basic knowledge),

students in the first year of the course correctly answered 18 out of 36 questions, which could be justified by the knowledge acquired for the university admissions test. This number should increase significantly in the following years of the course, particularly in the second year when university lessons are offered to strengthen anatomy, physiology, and biology knowledge. Area 2 is also problematic since 3 out of 4 cohorts obtained low scores, particularly those in the first year of the course, while those in the third year achieved the maximum score. This result was different than expected since socio-psycho-pedagogical sciences is a teaching module of the first year of the course. The same occurs in area 5 (occupational therapy in neurology and psychiatry), in which the total score for those in the third year of the course was 19 out of 26, a score lower than what was expected considering the neurology and neuroanatomy knowledge that is required to pass from the second to the third year.

However, as expected, those in the third and fourth years of the course achieved the highest scores in the so-called professionalizing areas that are specifically related to occupational therapy professions. This is presumably due to attending lessons and exams where they had the opportunity to deepen their knowledge of occupational therapy interventions in the different areas considered.

In conclusion, test-retest reliability showed variable and reliable ICCs, with values between 0.90 and 1, when the test was administered to a randomized subsample of the population.

It is therefore possible to affirm that the developed PT is generally quite difficult for occupational therapy students, who achieved a maximum total score of 126 points out of 190.

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Shaping Learning Within the Digital Transformation the Hagen Manifesto on #NewLearning

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Abstract. The way people learn has changed within the digital transformation – where and when learning takes place, what digital tools are used, how learning fits to the personal contexts of the learners. Still, education institutions are not quite prepared for this change. In September 2020, the Hagen Manifesto on 'New Learning' was launched at the FernUniversität in Hagen. In twelve theses, it describes how learning within the digital transformation must be structured and designed in order to bring about a cultural change.

Keywords: NewLearning · Digital transformation · Higher education

1 Introduction

We have seen that the Corona pandemic especially hit people with pre-existing conditions particularly hard. To a certain extent, this also applies to educational institutions: In the summer semester of 2020, it became clear that universities coped with the pandemic differently. Those who had already invested in the digitalisation of teaching have dealt with the crisis much better than those who had been less well prepared (cf. Bils and Pellert 2021).

In that way, Corona has only made visible the challenges that had existed even before the pandemic in higher education institutions (cf. Beutner 2020). This includes the fact that many universities have had no genuine concepts for online didactics. The necessity caused by Corona not to hold the summer semester 2020 in presence thus represented a hurdle, especially for higher education institutions that were completely unprepared for the changeover to digital teaching. One of the coping strategies was to shape the digitisation of teaching by transferring proven formats from face-to-face teaching to corresponding online formats (cf. Panke and Wagenknecht 2020). Thus, Educational institutions that had already included such considerations into their planning and that had strategies for the further development of teaching were able to expand their range of offerings and increase the toolbox of methodological options for action – and were thus also less restricted by the changes Corona broght (cf. Bils and Pellert 2021). Some universities had also already figured out incentive systems for innovative teaching before

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the pandemic, which have now proven to be conducive to the culture of innovation (cf. Bils et al. 2020, p. 10).

Whatever measures were implemented in the first digital semester, they must now be comprehensively reflected upon. Therefore, university actors can start joint processes of consideration for example in professional associations, university alliances or communities of practice (cf. Bils and Pellert 2021). If the experiences of the past two years are taken seriously, then the universities should develop concepts that are not just a continuation of what has been tried and tested in the face-to-face format, but radically create different approaches. What is needed instead is a cultural change (Bils 2021), not least because the labour markets of the future will require important key qualifications that are not only technical in nature. The so-called future skills also include a different approach to the digital transformation, dealing with a culture of error, with the way people work together (cf. Stifterverband für die Deutsche Wissenschaft/McKinsey & Company 2019). The image of the teacher standing in front of students at a certain place at a certain time and presenting his or her knowledge no longer really fits.

So a fundamental preoccupation with how learning must be designed in the digital transformation is necessary. Furthermore, it would also be short-sighted to regard the ad hoc measures implemented during the pandemic as state of the art for the coming years (Bils and Pellert 2021).

Digitisation should thus be seen less as a technical process and more as a social process that can transform rigid structures in higher education institutions and challenge the traditional understanding of education. It is changing what, where, when, with whom and how we learn and work. With more personal responsibility, more flexible, lifelong. In addition, other skills are needed, besides the technical aspects, especially creativity, critical thinking, communication and collaboration. Of course, this digital transformation also has an impact on culture, on the norms and values of educational institutions.

2 The Hagen Manifesto on New Learning

At the FernUniversität in Hagen, the '*Hagen Manifesto on New Learning*' was published in September 2020. In a cooperative process with experts from the education sector, twelve theses were drawn up that look at learning from a new angle and include various perspectives (cf. FernUniversität in Hagen 2020). Following the concept of *New Work*, *New Learning* expresses that there needs to be an equivalent in learning for the competences required in the working world of the future. If work in the future is characterised by technological and non-technological skills, collaboration and sovereignty in dealing with data, learning must also be able to reflect this and prepare for it. The requirements that the labour market brings with it and that formulate demands on learning have also changed: Competences that will be relevant for learning and working in the future, e.g. agility, networking, but also skills such as comprehensive data competence, do not yet have a high priority in the curricula and are accordingly not yet sufficiently practised in educational institutions (cf. ibid.).

In addition, lifelong learning no longer takes place only in institutionalised educational institutions, but also in everyday life, at work, etc. So, the manifesto argues for a change in the concept of learning. It formulates what constitutes New Learning and at

the same time makes demands on educational institutions and educational policy. The manifesto assumes that digitalisation has created new learning venues, learning formats and learning occasions, which bring with them a new understanding of roles and new demands on institutional learning. Learners are particularly involved in their learning process through the digital transformation – in the content, in the learning times, in the way they acquire content. (cf. ibid.).

2.1 Twelve Theses

Within the Hagen Manifesto learning is regarded as the key to mastering the digital transformation. In the following the twelve theses on how we should, how we can, how we must learn in the future (cf. ibid.) are presented:

1. *New Learning means lifelong education.*
2. *New Learning promotes equal opportunities.*
3. *New Learning puts learners at the center.*
4. *New Learning rethinks the roles of teachers and learners.*
5. *New Learning means networked learning.*
6. *New Learning makes flexible and self-directed learning possible.*
7. *New Learning measures learning success by individual goals.*
8. *New Learning sees technology as an opportunity – without ignoring risks.*
9. *New Learning increases digital (media) competencies and data literacy.*
10. *New Learning guarantees privacy and data protection and prevents digital discrimination.*
11. *New Learning overcomes boundaries between educational institutions.*
12. *New Learning requires new, collaborative educational policy* (ibid.).

New Learning stands for the expansion of didactics and the use of digital formats to complement classroom teaching. It is about finding the right mix of online and face-to-face learning that is tailored to the respective framework conditions. So it is less about viewing face-to-face and online teaching as dichotomous poles, but rather to choose the best fitting condition, be it blended or hybrid learning, face-to-face or purely online seminars. So, digital and networked teaching and learning concepts that make meaningful use of digital and analogue formats are needed. This includes a reflective and participatory process in which teachers and learners negotiate and reflect together on appropriate learning paths and goals. The approach is essential for a learning culture that strengthens collaboration and (self-)responsible learning in education and supports learners in developing individual strengths and interests (cf. Bils and Pellert 2021).

Three theses, which will be discussed in the following, are to be singled out as examples:

These 1. New Learning means lifelong education.

> *"New Learning is an established part of our lives. We understand New Learning as a lifelong educational process: from early childhood education and school, to career training and academic education, to continuing education and professional development. This also includes informal learning that takes place outside of the formal educational system"* (FernUniversität in Hagen 2020).

An important factor of the manifesto is that learning guidance must take place over the entire lifespan. This, for example, requires the development of new skills in order to allow self-directed and self-organized learning – but also educational policies that place the topic of learning in all areas of society (ibid). If digitisation and lifelong learning are thought as one, teaching and learning in the future should be agile, networked, collaborative and supported by virtual communication tools. With problem-based learning and teaching digital competences through collaborative work on concrete problems can be acquired. In addition, learning needs to be individualised and personalised (cf. Pellert 2020).

These 3: New Learning puts learners at the center.

> *"Each person learns in their own way. This is why we consistently center our thinking about New Learning on learners. New Learning supports their individual strengths and uniqueness both through personal guidance and through digitally-supported systems that create adaptive learning environments" (ibid).*

A focus of the Hagen Manifesto is to put learners at the center. As universities, we are used to being supply-based. The Manifesto takes a different approach by starting from the needs of the learners. This includes forms of support and organisation around the learners – e.g. study guidance that supports and motivates individual learners and cohorts throughout their studies. At the same time, intelligent, adaptive systems are needed that enable personalised learning. This means that the curriculum will be more strongly oriented towards the individual interests of the learners and will promote their respective strengths in different ways. AI-based systems can, for example, use learning analytics to suggest personalised learning paths.

These 5 New Learning means networked learning.

> *"For us, New Learning means designing learning in a networked way. Learning settings must connect to the world of learners' everyday, career, and life experiences. Only then can they promote experience-based and motivated learning and create emotional and sensory access to learning on a number of levels. New Learning simultaneously requires and makes possible new methods of networked learning in order to implement digital media in a didactically appropriate way" (ibid).*

That implies that New Learning requires digital and networked teaching and learning concepts in all levels of education. For example, it must be possible to enter into educational processes, to change them and to learn in a non-institutional way guided by interests (cf. Pellert 2020). But this also requires time to invest into these cooperations and networks (cf. FernUniversität in Hagen 2020).

It becomes clear that the manifesto spans a framework that has references to various disciplines such as educational science, but also computer science or educational policy. It has since been widely discussed and already has over 1200 signatures. It has triggered a discourse that extends beyond the FernUniversität in Hagen, for example at non-university educational institutions and with various stakeholders. A number of recommendations for action have been derived from this, which will be presented below.

3 To Dos for Modern Educational Institutions

In the following, some aspects will be mentioned that are considered necessary in the framework of the manifesto in order to anchor New Learning in educational institutions.

Curricula Development
Educational institutions must constantly develop and adapt their curricula. In this context, it is essential to focus on the needs of learners and to provide them with demand-oriented support. Particularly when learners take on more responsibility than before for their own lifelong learning process, it is important to establish counselling services that offer overarching support in the sense of coaching and accompany learners (cf. FernUniversität in Hagen 2020). Especially when campus life cannot take place in the usual way, support and networking structures are needed for students so that they do not feel isolated or disconnected.

To this end, educational institutions must allow experimentation to enable innovation and provide good digital training opportunities for the entire institution. Administrations also need to have digital skills to meet the changing demands of teaching, learning, research and knowledge transfer. To promote cultural change, this should be understood in the context of the application of technology and digital tools, as well as meta-competences such as cooperation skills and agility for the digitally augmented reality (cf. Bils and Pellert 2021).

Teacher Support
Furthermore, it is essential to support teachers with regard to online didactics and the use of digital tools (cf. ibid.). In order to establish ideas and concepts for innovative teaching, educational institutions must allow free space and fields of experimentation for the agile development of innovations. On the one hand, internal support programmes for innovative teaching should be mentioned here. On the other hand, non-monetary recognition mechanisms also offer corresponding incentives. Here, for example, teaching awards or appointments to prestigious committees are worth mentioning (Bils and Pellert 2021).

Essential for the success of New Learning is a learning culture that does not see mistakes as failure but as a productive aspect of learning processes. This attitude must be lived accordingly and concerns not only teaching and learning concepts, but also the interaction between staff.

There should also be an emphasis on the relevance of cooperation. This includes associations of learners who can work together on learning projects, but also participation of teachers and universities in an overarching exchange (cf. ibid.).

Competences in the Area of Administration
In order to be able to adequately accompany the digital transformation at higher education institutions and to meet the changed requirements of teaching, studying, research and transfer, it is necessary to also equip the area of higher education administrations with the corresponding competences (cf. ibid.). This aspect of personnel development is also of cultural significance, as the mindset of a university can also be sharpened through personnel selection, as well as continuing education. This is not only about formats for

the application of technology and digital tools, but also about meta-competences such as cooperation and agility, in order to enable the introduction of a cultural change.

Review Infrastructure and Governance
On a structural level, it can be stated that even if the Hagen Manifesto does not go into technical details, a functioning and secure infrastructure is the basis for digital learning. It is important that technical support and didactic planning are intertwined. To this end, infrastructures must be reviewed, adapted and expanded (cf. Bils 2021).

Here, it is important that technical support and didactic planning are intertwined - infrastructures must support the didactic concept and not the other way around. An infrastructure must be designed in such a way that collaborative work, also across institutions, is made possible (cf. Bils and Pellert 2021).

4 Conclusions

The manifesto proclaims the need for a change in attitude by responding to changing demands, developing an appreciative culture of error, recognising the importance of networks and welcoming experimentation. Ultimately, it is about a shared commitment between learners and educational institutions that says: "This is how we want to learn". So, New Learning is never about the why, but about the how and proposals for the what, which is then ultimately a design task for individual higher education institutions, depending on their own context, resources, etc. The Hagen Manifesto offers a good starting point for a discussion on learning and *New Learning*. It describes the basics for learning in the digital transformation, but calls on educational institutions to become active themselves. It does not make any specifications, but only gives impulses that can be followed up individually.

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Matching Efficiency of Admission Procedures in Online-Education

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Abstract. This paper empirically evaluates the relationship between the university admission process and the study success of online students. We investigate data from fully accredited higher education courses over multiple cohorts, yielding a sample of 502 students from both Bachelor- and Master-studies. We link rankings from 3 test procedures, an interview, a resume analysis, and an aptitude test, with grade achievements and successful course completion. We find that all procedures predict grades, but only resume analysis has a robust relationship with successful course completion. Crucially, the predictive power of the resume analysis depends on controlling for a student's age. Our results thus call for nuance in evaluating and interpreting admission scores when allocating seats in online education.

Keywords: Admission procedure · Online students · Predictive power · Admission interview · Study success

1 Introduction

Unlike most goods in market economies, student placement in higher education is not solely coordinated by prices. Instead, many institutions opt for admission processes that elicit students' fit for the program in question by scoring the applicants and then allocate seats competitively based on these scores. The goal of this matching process is to distribute the limited educational resources efficiently. This, among other concerns such as equity and social transparency, includes allocating placements to students who are more likely to successfully finish their studies on both the extensive margin (obtaining a degree) and on the intensive margin (finish with better grades). How well this goal can be achieved crucially depends on how well the employed admission procedures can predict future student success (Makransky et al. 2017).

Previous research suggests that designing and employing suitable mechanisms for online-courses is particularly challenging. Online courses are plagued with severe retention issues (see Bawa (2016) for a review). Some studies report 20% and 50% of students do not complete their courses (Patterson 2018; Rovai and Downey 2010), others attrition rates above 75% (Simpson 2013), whereas for Massive Open Online Courses (MOOCs) they are even above 90% (Su and Waugh 2018). Difficulties in correctly assessing suitability for online as opposed to present studies may stem from different requirements

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due to the difference in modes of teaching as well as a typically different demographic of the applicants (Delnoij et al. 2020). As it stands, it appears that many societies distribute their online education resources wastefully.

This study investigates which indicators successfully predict study success in online learning. To this end, we use scores from a multi-staged admission procedure from a higher education institution and match them with actual study outcomes. In particular, we discuss 3 types of admission criteria: a personal interview, the applicant's resume, and an aptitude test (please see. Sect 2 for a detailed description of the procedures).

We find that ratings from all of the employed admission procedures robustly predict student success in online learning. This holds true for each factor individually, but importantly also when regressed simultaneously on student outcomes. These relationships remain highly robust in several iterations of the regression model: we control for program and time-fixed effects as well as a host of demographic variables. We further show that changes, if relevant, of the underlying scoring system alter the strength of the effect, while leaving our core findings unchanged. A retention rate of 11.7% may be seen as a further sign of success of the documented procedures (see Sect. 4 for the full results).

We claim that this article contributes to the existing body of literature in the field in several ways. First, our data is of high quality, allowing us to track student success in fully accredited higher education courses over several years and education tiers with complementing demographics to enrich the inquiry. Second, the diverse nature of the admission process allows for a multi-faceted test of the applicants' skill sets, evidencing complex requirements for success in online education. Third, the strength and robustness as well as the recency of the results may serve as guidelines for further online education institutions aiming to more efficiently allocate their resources.

2 Related Literature

Based on social, historical, political, or economic backgrounds, admission systems differ a lot across countries (Haj et al. 2018). However, most of them have some underlying principles in common. First, they assume that individuals differ regarding their skills and personal qualities and that these aspects can be measured and make a difference for succeeding in their studies as well as in a future career. Second, the procedures imply that future behavior is predictable, and partly based on past behavior, such as work experience or grades in previous education (Patterson 2018).

The quality of admission systems may be judged with respect to many criteria. Transparency (Kurysheva et al. 2019), class cohesion (Mountford-Zimdars 2016) and equal accessibility (Bowen 2002; Rosinger et al. 2021) are important objectives in their own right in the design of admission procedures for higher education. In this article, we focus on the validity and reliability of the admission process in predicting student success when evaluating its merit. Finally, the applied methods should be valid and reliable. The validity of admission criteria refers to its predictability of an applicant's performance during his or her studies, whereas the reliability shows the chance of ending up with the same results when repeating a measurement with the same sample (Murshid 2013). Inappropriate selective admission criteria can cause either false-positive or false-negative

cases in the admission process, hence higher education institutions end up with either a student who is admitted to the program but not able to complete it or an applicant who would have been able to complete it but never received the chance to do so. (Kurysheva et al. 2019). In the context of our study, a "better" admission process, therefore, refers to a more efficient matching process between applicants and seats in the sense that it minimizes such false-positives and false-negatives.

In the literature, study success is defined differently depending on the research focus. According to Dahm et al. (2018), successful students are characterized by the fact that they can master the different challenges of their studies. From an output- and process-related perspective, the criteria for success are study grades, study progress, graduation, and dropout rates. As previous research most frequently uses grades to operationalize study success (Trapmann et al. 2007), grades are also used in this paper. In literature, all criteria mentioned above are linked to persistence factors that positively influence the students' success in a program. In an online context, Hart (2012) defines persistent behavior as "successfully finishing all course requirements" (p. 39). Displaying this persistent behavior can be particularly difficult in an online learning setting because the learning environment is mainly self-driven and often based on a constructivist learning approach where learners are given props and aids to learning, but where they must come up with solutions by themselves. This can demotivate and intimidate students if they are not prepared for it (Bawa 2016).

Demographic factors, such as gender, age, and ethnicity can influence academic success. Tartavoulle et al. (2018) report that older students (defined as 22 years and older) were less likely to graduate timely. Conversely, Al-Alawi et al. (2020) find that age is no significant predictor of academic success. Silva et al. (2020) find that male students in economics performed better than their female fellow students. However, similar to age, there are studies that show no significant relationship between gender and academic success (Al-Alawi et al. 2020). Although our study focuses on the admission procedures as predictors of student success, we employ student age and gender as demographic controls in our analysis. When controlling for a host of other covariates, we do not find that gender correlates with student success, but we do find a significant and sizeable correlation between age and both measures of student success.

For admission systems, we can differentiate between biography-oriented and property-oriented procedures. Biography-oriented procedures use information about previous behavior and past performances, like grades, to predict future behavior. Property-oriented approaches are particularly important when future fields of activity change rapidly and therefore are difficult to predict. Here, psychological tests, like personality tests, are frequently used (Päßler et al. 2011). The aspects that need to be considered for a highly predictive admission procedure for the target group of this paper, the nontraditional students in an online setting, are manifold. Not only do they differ from traditional students regarding age, educational biography, or prior educational experiences (Dahm et al. 2018). Also, the main predictors of study success differ. Hence, for the particular target group, GMAT score, undergraduate GPA, and work experience have been identified as highly predictive (Yang and Lu 2001). However, in online contexts, increasing attention has been given to non-cognitive aspects: "Maybe personality traits will become more relevant to academic success in the future when we think of

e-learning situations. If e-learning was the ordinary way to study in the future, students would get less personal support and individual differences would become more and more important" (Trapmann et al. 2007, p. 147). In practice, there are various selection methods available, for example, academic achievement, aptitude tests, personal statements, CVs, references and letters of recommendation, situational judgment tests, personality assessment, work samples, simulations, or interviews (Patterson 2018).

In the following subsections, we review relevant literature on relations between student success. For a better overview, the structure of our discussion is according to the 3 main admission branches of the process examined in this paper, namely, aptitude test, resume analysis, and interview. We further relate findings from previous literature to the procedures investigated in this article in general terms. For a detailed description of content and operationalization of these procedures, please review Sect. 3.

2.1 Aptitude Tests

Aptitude tests in admission processes of higher education institutions can be categorized according to whether they test for cognitive or non-cognitive factors. Tests for cognitive factors are prevalent across institutions and disciplines. To select students for an Executive MBA Program who would perform well during their studies, the Graduate Management Admission Test (GMAT) could be used. At various institutions, the predictive power of the GMAT differs. Gropper (2007) finds that the GMAT exam scores predict more the first-year performance of students than the end-of-program grades. Sobol (1984) confirms that GMAT is an important predictor of the overall first term grade performance. Similarly, nursing schools use standardized entrance exams like the Test of Essential Academic Skills (TEAS), the American College Testing (ACT) exam, and the HESI Admission Assessment (A2) Examination to predict students' future academic achievements. Further studies uncovered correlations between the scores in the aptitude test and the GPA, program completion, and graduation of the program (Al-Alawi et al. 2020).

Tests for non-cognitive skills show similarly inconsistent relations to student success. Strickland and Cheshire (2017) document that a critical thinking standardized entrance exam and the Mayer- Salovey-Caruso Emotional Intelligence Test showed no correlation between these scores and the academic success measured by the GPA. Barrick et al. (2001), on the other hand, report that personality tests, mainly done in the form of a self-assessment, show a high validity in predicting student success.

Aptitude tests, hence appear to have a non-robust relationship with student success but instead are highly context-dependent regarding study form, subject, and student cohort. The aptitude test examined in this article comprises both cognitive as well as non-cognitive factors. Its relationship to student success in higher online education is, therefore, an unsettled empirical question to which this article contributes. In fact, our results show that ranking in aptitude tests has a significant link with study outcomes.

2.2 Resume Analysis

Findings from prior research suggest that the consistency of prior learning contents with the content of a study course is one of the most influential factors on study success

(Kurysheva et al. 2019). Biography-oriented approaches of admission procedures see a high predictive power when there are overlaps between past and future activity requirements. Following this line of argumentation, grades from school have been identified as a highly robust component of admission procedures with respect to predicting study success (Päßler et al. 2011). Seethaler (2018) explains the high predictive power of grades with their ability to show applicants' intellectual potential, their willingness to make an effort as well as the successful application of learning strategies. In an online learning setting, previous positive learning experiences have been identified as particularly useful. The students' learning style could be linked to the likelihood of persistence in an online learning environment (Harrell and Bower 2011). Similarly, Dickson et al. (2000) identified past academic performance as a contribution to study success.

Likewise, also an applicant's work experience should be taken into account. Pratt (2015) describes work experience as the most related aspect to student success. However, not only prior experience but also working alongside studies can have a positive impact on the study success: if work intensity and flexibility are appropriate, work can positively influence non-cognitive aspects, such as students' goal orientation or organizational skills (Scholz Fenech and Raykov 2018).

The resume analysis featured in this article's focuses on background aspects, such as previous education, further training, and professional experience. Our results are partly at odds with previous findings. We find that the relation between the resume ranking and study success highly depends on whether demographic controls, in particular age, is accounted for. In the absence of such controls, we confirm a significant, albeit weak relation with study success and no relation with completion. Adding demographic controls, however, both relations become increase in strength and become significant. These findings suggest that designing systems evaluating an applicant's biography in online studies requires nuance.

2.3 Interviews

Interviews are an integral part of many admission processes and are particularly common in medical contexts but also frequently applied in other fields because they allow the exchange of relevant information for both, the applicant as well as the institution (Päßler et al. 2011). Rippentrop et al. (2003) state that 99% of U.S. medical schools use interviews in their selection process and they identify 4 major purposes that interviews fulfill during medical school admission procedures, namely, "information gathering, decision making, verification of information in the application, and recruitment" (p. 1).

Compared to other selection methods, the acceptance of interviews is high among applicants as well as institutions. Specifically, biographical interviews, which are most useful when participants have work experience and therefore can directly transfer the questions to their field of expertise, are widely accepted. Interviews lead to a higher degree of validity of the candidate can relate the questions to specific work experience during the interview and if the target behavior is similar to the previous behavior at work (Päßler et al. 2011). According to these findings, for students who work full- or part-time alongside their studies – the targeted group of this paper - interviews are more suitable than for younger students.

Despite the high acceptance, their reliability and validity are discussed controversially in the literature. For example, Patterson (2018) indicates that evidence for the predictive validity of interviews is little. McAndrew et al. (2017) argue based on a meta-analysis of academic admission interviews in the healthcare sector, that there is little predictive power of interviews concerning the students' academic as well as their clinical achievement. Besides, other disadvantages are listed, for example, interview situations are prone to coaching which can falsify the results. However, several studies highlight a potential increase in predictive power if interviews are well-structured (Patterson 2018; Edwards et al. 1990; Streyffeler et al. 2005). Certain aspects are characterizing structured interviews, such as the use of the same predefined questions for all applicants in the same order and - following the interviews - an assessment according to a predetermined scheme. Furthermore, the quality of interviews can be improved if a panel is installed, which decreases individual interviewer's biases (Edwards et al. 1990).

The findings referring to structured interviews in higher education settings are comparable to several meta-analyses in the field of professional success, which show the effect of the interview structure on the predictive power (Cortina et al. 2000; Huffcutt and Arthur 1994; Huffcutt et al. 1996; Wright et al. 1989). Due to the positive impact of structured interviews that could be shown in other professional fields, there is a recommendation to rely more strongly on structured interviews in the field of higher education selection processes as well (Streyffeler et al. 2005).

Having discussed structural aspects of predictive interviews, let us now turn to interview content. Previous findings indicate that a focus on non-cognitive skills, such as motivation, self-efficacy, critical thinking, or problem-solving skills could lead to lower dropouts and higher study success (Makransky et al. 2017). There is evidence, that non-cognitive skills can predict short- and long-term educational success (Heckman and Kautz 2012). Similarly, in a meta-analysis in the field of humanities, study motivation and study skills were identified as a valid predictor of first-year GPA (Credé and Kuncel 2008). Besides, the fit of a program and a person's interests and skills, particularly personality-related criteria, such as motivation and attitudes, is highlighted as an important aspect of admission procedures (Kurysheva et al. 2019). This line of argument is comparable to seeing non-academic criteria in higher education admission as a necessity to prepare students of the twenty-first century for the labor market. Therefore, non-academic criteria, such as basic personality factors like conscientiousness or openness, affective competencies, such as creativity or emotional intelligence, attitudinal constructs, like self-efficacy or social beliefs, and learning skills, like time management or organization, should be considered (Hossler et al. 2019; Mahlangu 2020). Nevertheless, also concerning non-cognitive factors, the challenge of reliable and valid assessment has been brought up. Non-cognitive measures have been used more frequently since 2000 (Mahlangu 2020).

3 Data and Methods

We estimate the matching efficiency of a set of higher education admission procedures in terms of how strongly and robustly they predict study achievements. We employ a pooled an ordinary least square model, where each student is a unit of observation. Letting i

index student, j the course of studies and t the year when the respective cohort started their studies, the regression equation can be written as follows:

$$\text{OUTCOMESijt} = \beta 0 + \beta 1 \cdot \text{RANKINGSijt} + \phi j + \tau t + \gamma i + \varepsilon ijt \quad (1)$$

For OUTCOMESijt, we mostly focus on the grade average, but we complement our findings by considering the chance of not finishing the studies successfully. For the latter analysis, our empirical exercise should be interpreted as a linear probability regression. We consider 2 sets of RANKINGSijt as predictors of study outcomes. First, the FINALRANK of the admission procedure under study and second the 3 main sub-categories INTERVIEW, CV and TEST, which are the focus of this article (see section Sect. 2 for a detailed description of these procedures). Finally, we supplement our analysis with a host of controls: φj courses, τt for time, γi for demographics (switched on and off) and β0 is the regression constant. The remainder of this section describes the operationalization in detail.

Our data comprises all students who have applied for and studied in 3 courses in the years 2014–2019 at an Austrian university of applied sciences. This includes a 3-year Bachelor of Arts on business studies taught in German with cohorts starting in all of the years 2014–2019, an English-taught equivalent 2016–2019 and a 2-year Master of Arts in Corporate Governance and Finance 2017–2019.

We mainly focus on the overall grade average at the time of data retrieval (February 2020) as our measure of study success (see Sect. 2 for a critical discussion on the point). Due to the staggered nature of the student cohorts starting over time, this measure comprises the final-grade averages for typical students who started a 3 year program until 2016, the average after 5 semesters for Bachelor students who started in 2017 and so forth. Grades throughout the dataset are coded on a scale from 1 to 5, where 1.0 is the highest obtainable grade and 5 the lowest. Any grade greater than 4.0 constitutes a fail in any given course. These grades, in turn, are generated based on a continuous percent grading system, where percent grades >90–100 correspond to a 1, >80–90 correspond to a 2, and so forth. All point scores of 50 or lower result in a grade of 5.0. Our grade measure thus fulfills the requirements of an interval-scaled variable, facilitating sensible interpretations of proportional linear effects across its range of measurements. Points being capped below at 50 points in the grade representation may introduce a slight skew in the aptness of the scale to represent student skill, but such low points are rare and unlikely to influence our paper's results in a meaningfully. We will complement this expression by information on successful course completion. We operationalize this as a binary variable that takes on the value 1 if a student decides to forfeit the seat in the given program or is expelled; all other cases (e.g. successful completion, currently studying, break from studies) receive the value 0.We will complement this expression by information of successful completion. We operationalize this as a binary variable which takes on the value 1 if a student decides to forfeit the seat in the given program or is expelled; all other cases (e.g. successful completion, currently studying, break from studies…) receive the value 0.

The predictors of student success, yielding the relationships of main interest in this article, stem from 3 admission procedures that every applicant must complete. Here is a detailed description:

Interviews: All applicants are invited to a structured interview with a duration of 20 min in front of a committee. The head of the committee welcomes the applicant, introduces the committee and starts with an opening question referring to the student's career. Afterward, all board members ask predefined questions from a pool regarding different assessment criteria. Up to 2019, these were the applicant's study intentions, personal competence as well as different measures of specialized competence. From 2019, these specialized measures of competence, were transformed into one unifying measure of how well the student fits the respective course's target group. In the end, further information, for example about the start of the program, the online mode, or the next steps in the admission procedure are given. Besides, each applicant is given the possibility to ask questions. Following the interview, all committee members use a rubric for each assessment category. Based on individual assessment, the committee agrees on a total number of points for the respective applicants.

Curriculum vitae: Up to 2017, the application materials were graded on the volume and quality of previous academic experience, professional experience and further education. From 2017 onward, this was complemented with a criterion on the overall impression.

Tests: All tests are computerized digital tests. Up to 2018 in the Bachelor-courses as well as in all Master-courses, the test consisted of questions and exercises on language and mathematical skills as well as adequate knowledge of business studies.

From 2018 onward, the range of questions for the Bachelor-programs was significantly extended to include self-reported personality questions and general intelligence measures such as fluid intelligence and numerical-inductive questions. This latter version is based on the Vienna Test System, which is a standardized and tested procedure with a duration of approximately 2 h, using in particular the test-segments "Intelligence Structure Battery", "English Language Skills Test" and "Big Five Structure Inventory" (see Schuhfried GmbH 2022 for further information).

The completion results in a score for each application criterion, according to which the students are ranked. These ranks are the predictors of student success in our study, subsequently named INTERVIEW, CV and TEST, so that, for example, a measurement of 1 indicates that an applicants has performed best for the criterion within the cohort, a 2 slightly worse and so on. From the scores in the sub-categories, a final ranking is generated by weighting interview, CV and test with 50%, 20% and 30%, respectively. We name this outcome of the application process FINALRANK.

According to the measurement FINALRANK, program places are allocated from the best ranked to the worst until no further open places remain. The number of available places within each program vary slightly over the years due to natural variations in dropouts from existing students, but are by and large stable. Hence, we measure the predictive power of the admission procedures on student success in the variation of outcomes of students who are, in fact, admitted to the program. We finally supplement our empirical investigation with demographic factors such as gender and age (i.e. year of birth) and binary dummies for standard time and study program-fixed effects. Generally speaking, we include this last set of variables in order reduce noise in our estimations and thereby decrease the potential for omitted variable bias. In particular, time entering studies may be an important factors as several articles have noted that grade average

Table 1. Descriptive statistics.

	Mean	Std. dev
	(1)	**(2)**
Panel A: Study outcomes grades	2.17	0.806
Dropout	0.117	0.322
Panel B: Predictors FINALRANK	26.57	17.19
INTERVIEW	24.87	16.90
CV	26.89	17.42
TEST	27.04	17.41
Panel C: Demographics year of birth	1988	6.67
Male-dummy	.533	.499

Notes: This table provides descriptive statistics in the reduced sample (dropping missing data and outliers) for the study's variables.

tend to generally improve over time (Rojstaczer and Healy 2012). Age is also important to consider in our context, as older students tend to have more impressive resumes and thus tend to score higher in this evaluation dimension. Adding the variable allows to disentangle these factors. Table 1 shows descriptive statistics for key variables in our study.

4 Results

We perform an ordinary least squares regression exercise, using our regression model established in Sect. 3. Table 2 shows the regression coefficients for different iterations of the model. For better overview, we drop the constant from the display and only signal the in- and exclusion of controls with checkmarks. As the first impression, Column (1) shows that the admission procedure, as a whole, successfully predicts student achievements, where students with worse ranks (numerically higher) receive worse (numerically higher grades). This relationship is highly robust, with a p-value far below the 1%-level. Column (2) shows that these relationships are qualitatively identical for each sub-category. Each ranking, while the others are simultaneously are accounted for, robustly predicts study success. The overall strength of these effects is rather strong: a student who places 20 ranks worse in each category on average has $20 \cdot 0.0072 + 20\ 0.00595 + 20\ 0.012 = 0.52$, or approximately half a grade, worse grade average. Given that some programs see more than 100 applicants, the potential discrimination in student quality stemming from the admission system is therefore sizeable. For better illustration, Fig. 1 depicts the magnitude of the respective effects and their significance from column (2) of Table 2 using a bar chart with whiskers.

Column (3) shows the same regression as column (2), but with demographic controls (i.e. age and gender) switched on. This leaves direction and robustness of the effects unperturbed. While the strength of the effects of TEST and INTERVIEW remain largely

Table 2. Regression coefficients between admission rankings and study success.

	(1) Grades	(2) Grades	(3) Grades	(4) Dropout	(5) Dropout
FINALRANK	0.0199***			0.00184*	
	(9.24)			(1.95)	
INTERVIEW		0.00791***	0.00720***		0.00134
		(3.51)	(3.55)		(1.35)
TEST		0.0120***	0.0110***		-0.000062
		(5.54)	(5.17)		(-0.07)
CV		0.00595***	0.0145***		0.00306**
		(2.84)	(5.42)		(2.55)
Fixed Effects					
Demographics	✓		✓	✓	✓
Program	✓	✓	✓	✓	✓
Cohort	✓	✓	✓	✓	✓
N	502	502	502	502	502

Notes: This table provides the coefficient estimates of the rankings from the three considered admission procedures on two measures of study success. Constant and fixed effects are suppressed for better overview. t statistics in parentheses. Statistical significance is denoted as follows: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

unchanged, the predictive power of CV triples in size and becomes much more robust. This can be attributed to the age controls: while gender neither correlates with age nor CV, age correlates strongly (0.55) and significantly (below 1%) with CV. Older students on average have worse study outcomes but higher experience. In the absence of agecontrols, the correlation coefficient for CV picks up on these age-effects that dampen its overall magnitude. Controlling for age, however, disentangles these ambivalent effects and uncovers the true predictive power of considering a student's previous experience given that student's age, making the procedure the strongest and most robust in a direct horse-race.

We re-run our regressions with Dropout as an alternative measurement of student success (columns (4) and (5)). As the total number of dropouts, and thus overall variation in the dependant variable, in the dataset is rather low, all significance levels of the considered relations decrease. While most predictors retain the 'right' direction and significance levels of above or close to the 10%-level, the procedure TEST marks the most notable deviation, where the respective t-statistic indicates no predictive power of TEST-scores on successful graduation. Note that despite the cited limitations of the

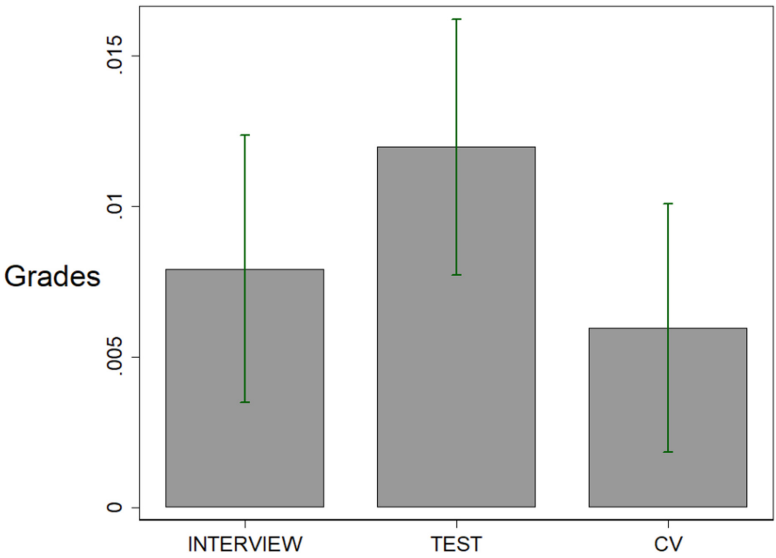

Fig. 1. Regression coefficients of the three predictors of student success, INTERVIEW, TEST and CV, on average grades using robust standard errors. Study program and cohort fixed effects are included as controls but not shown.

exercise, CV emerges as the strongest and most robust predictor again. Moreover, we checked whether adding a dummy-variable to account for the change in the testing regime 2018 of the admission procedure for the variable TEST and found that while the impact changes in magnitude (i.e., it gets larger), our main results remain qualitatively unchanged.

5 Discussion

Accurately and robustly predicting student achievements is crucial for efficient allocation of resources of higher education. Several studies suggest that this is a particular challenging task in the realm of online education. This study uses high-quality administrative data to identify 3 strong and robust procedures, allowing us to characterize students in the admission process. We thus confirm previous findings that aptitude tests can be an indicator for efficiently allocating course seats alongside interviews if they are sufficiently structured (see Sect. 2 for related literature).

Some recent studies have focussed on prior academic (Kurysheva et al. 2019) as well as work experience (Pratt 2015; Scholz Fenech and Raykov 2018) as indicators of student success. Our findings corroborate these notions. This is noteworthy for 2 reasons. First, the measure crystallizes as the most valuable predictor of student success when accounting for all other fixed effects. Second, giving this indicator its just recognition helps leveling the playing field for older students, who are a disadvantaged group in higher education but typically have an advantage in experience over younger students.

This study is subject to some limitations. First, all results are correlations generated from observational data. Although we consider a large set of controls with respect to

circumstantial and personal characteristics, we cannot exclude the possibility that we have omitted important regressors in our estimations. The reported findings may thus underestimate the true strength of the predictive power, with some ambivalence in their relative strength among each other. Moreover, our study only measures the relationship between our cause- and effect-variables on the subset of students who were, in fact, admitted to the considered programs. All projections of the overall discriminatory power of the cited procedures on the entire field of applicants are therefore only linear extrapolations. Also, while the structure and aim of each process has remained stable throughout the observation timeframe, some procedures have undergone some changes for some students (as described in section Sect. 2). The reported predictive strengths should thus be understood as average effects across any potential regime change. Where possible, we have considered these changes and found that they leave the overall findings of this study unchanged.

Despite these limitations, we believe that our study uncovers robust relationships between admission rating and student success in online teaching. While some of these confirm the previously documented evidence, others introduce new predictors to the discussion that have previously received little attention. As a whole, the results may serve as guidance for institutions in higher online education designing or re-modelling their admission processes.

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