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PHD THESIS

Metacognitive Awareness and Technological Pedagogical Content Knowledge in the Context of Virtual Learning Development through Scaffolding

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PART I. ARGUMENT

An increasing research interest has been dedicated to investigating the advantages of 3D virtual worlds usage in education. Virtual reality allows students to create and manipulate virtual objects, explore new environments, otherwise unreachable, have new experiences, and communicate with peers due to 3D avatars (Dalgarno & Lee, 2010). However, more studies are needed to investigate new pedagogical models regarding virtual reality (VR) usage, and also to examine the in-service and pre-service teachers' readiness to effectively put into practice these models by integrating technology, pedagogy and domain-specific content knowledge, given the fact that much of the previous research was carried out from the perspective of developers of information technology solutions.

According to Bailenson et al. (2008), research on the relationship between innovative technologies and education highlights the potential of virtual reality for educational purposes, suggesting that certain characteristics of virtual environments may influence learning performance.

The practical implications of the study are aimed at creating and implementing a teaching-learning program to increase digital competences and metacognitive awareness through virtual learning and metacognitive scaffolding, integrating technological, pedagogical and content knowledge.

1.1. Problem statement, state of the art

Technology plays an exponentially increasing role in our professional and personal day to day life. This is especially the case within the sphere of education, where the COVID-19 pandemic that has challenged and accelerated the need for virtual and remote learning solutions (Wetcho et al., 2022). The shift to virtual learning environments has exposed the gaps in teachers' readiness to use these platforms, both in terms of digital competence and pedagogical strategies (Perifanou et al., 2021). Moreover, we are also compelled to recognize the gap between the advanced level of development reached by the information technology field and the advances in pedagogical and educational psychology research.

Considering the current state of art, the paper aims to fill the gap in knowledge, namely in the following three areas of interest: Technological Pedagogical Content Knowledge (TPACK) framework, metacognitive awareness and scaffolding techniques. The TPACK model is a scientifically proven framework, but its practical application in the context of teacher training for virtual learning environments is a field that remains to be explored.

While the importance of metacognitive awareness in teaching is widely acknowledged, there is limited research on how metacognitive awareness is associated with the digital pedagogy in pre-university education. Moreover, scaffolding is widely valued as an instructional method, yet its specific role in developing both metacognitive abilities and TPACK among educators has not been sufficiently studied. Therefore, we may conclude that it is necessary to investigate how metacognition, metacognitive scaffolding, and TPACK relate to success in virtual learning environments (VLEs).

1.2. Purpose of the research

Creating and testing the effectiveness of a teaching-learning program based on the use of the virtual environment and metacognitive scaffolding for the development of TPACK, digital and metacognitive competences of prospective teachers.

1.3. Research objectives

O1. To investigate the use of the zone of proximal development comprising “prior knowledge activation” and “perceptions of task difficulty” in the practices of Romanian teachers.

O2. To analyze teachers’ digital competence in relationship with their wellbeing level.

O3. To analyze the Romanian pre-university teachers’ experience and perspectives on digital learning and the online educational process during the COVID-19 pandemic.

O4. To analyze the Romanian pre-university teachers’ metacognitive awareness, digital competence, and how are these related to their perceived virtual learning environment success.

O5. To identify the relationship between the level of integration of Technological Pedagogical Content Knowledge (TPACK) and the success in using the virtual learning environment (VLE), with TPACK level as a predictor of teachers’ VLE success.

O6. To evaluate the impact of a formative intervention program based on scaffolding on pre-service teachers’ levels of metacognitive awareness, digital competence and perceived VLE success.

O7. To evaluate the impact of a formative intervention program based on scaffolding on pre-service teachers' levels of metacognitive awareness, digital competence, perceived VLE success, and TPACK integration.

1.4 Research questions

1. What are the practices of Romanian teachers regarding the use of the zone of proximal development comprising "prior knowledge activation" and "perceptions of task difficulty"?

2. What is the relationship between teachers' digital competence and their wellbeing level?

3. What are the Romanian pre-university teachers' experiences and perspectives on digital learning and the online educational process during the COVID-19 pandemic?

4. What are the relationships between the Romanian pre-service and in-service teachers' metacognitive awareness, digital competence, and their perceived virtual learning environment success?

5. What is the relationship between the level of Technological Pedagogical Content Knowledge (TPACK) integration and teachers' success in using Virtual Learning Environments (VLEs)?

6. What is the impact of a formative intervention program based on scaffolding on pre-service teachers' levels of metacognitive awareness, digital competence and perceived VLE success?

7. What is the impact of a formative intervention program based on scaffolding on pre-service teachers' levels of metacognitive awareness, digital competence, perceived VLE success, and TPACK integration?

1.5. Research Design

In order to achieve the present study' s objectives we have adopted a design-based research approach that enabled us to investigate the development of pre-service and in-service teachers' TPACK, digital competence, metacognitive awareness and VLE Success in the context of virtual learning environments usage.

- Design-based research has been described as having several defining features, namely: Pragmatism, as the methodology focuses on investigating practical issues while also drawing on theory. Both theory and practice are integral parts of the design-based approach and mutually influence each other.

- Theoretically grounded within existing theories and designs, and it is embedded in ecological contexts.
- Characterized by interactive, cyclical, and adaptable processes, researchers actively participate to the design process, working closely with the participants to the study using iterative cycles of analysis, design, implementation, and redesign.

  Integrative, since researchers use mixed methods across different phases as new needs and issues emerge throughout the study.
- Contextual: The research process and outcomes evolve dynamically throughout the study, which are correspondingly documented. Furthermore, the findings are contextualized to the specific process and environments, reflecting variations in what concerns the content and depth of the design principles (Wang & Hannafin, 2005).

PART II THEORETICAL BACKGROUND

2. LEARNING IN VIRTUAL ENVIRONMENTS

2.1. The concept of virtual environment

“Learning Management Systems” (LMS) and “Virtual Learning Environments” (VLE) are interchangeable names for the same concept (Ceobanu, 2016). Milgram et al. (1994) proposed a definition of a “Reality-Virtuality Continuum” where "Reality" and "Virtual Reality" are represented in this model at opposite ends of a continuum, having Mixed Reality (MR) positioned between them as a category of VR technologies that blend the real physical environment and the one that is digitally generated. Mixed Reality is further divided into Augmented Reality (AR) and Augmented Virtuality (AV), the key distinction lying in their level of immersion as AR keeps users mainly engaged with the real world and in the same time integrates interactive virtual elements. The AV places users predominantly in a virtual environment that incorporates elements of reality, the boundary between these two remaining fluid and dependent on the specific application and context in which they are used.

The definitions regarding the virtual learning environment represent an open and versatile chapter. For instance, Holtham & Courtney (2005, p. 4) define VLE as "a space mediated by information and communication technology (ICT) that provides access to organized information and resources that students, individually or in groups, can use to improve their understanding of a given subject". Another definition given to the virtual learning environment is that of Ceobanu, (2016) who states that this concept includes both an IT infrastructure, whose main functions are to ensure the transmission of courses, collaboration with and between learners, and their assessment, as well as a learning environment generated through technology equipped with tools capable of facilitating the learning process.

2.2. The Concept of Virtual Reality

Virtual reality (VR) is a technology that allows the immersion of users in a computer-generated, three-dimensional environment, enabling interaction through devices like head-mounted displays and motion sensors (Encyclopaedia Britannica, n.d.). This setup enables individuals to experience and manipulate virtual settings as though they were real, providing a convincing sense of presence within a simulated world.

Because VR offers the ability to view, explore, manipulate, and interact with objects, it lends itself as an excellent educational tool to aid classroom instruction. Also, due to the interactive nature of VR environments, this technology can be useful in allowing students to apply concepts discussed in class in simulated environments to enhance learning/understanding of critical concepts and principles. Students can use this technology to generate, evaluate, modify, and validate design solutions. Furthermore, students can use this technology to estimate user acceptance, usability, and satisfaction parameters of their product designs (Crumpton & Harden, 1997).

Augmented Reality (AR), though not universally defined (Normand, Servières & Moreau, 2012), is distinct from VR in that it integrates digital elements with the physical world. Users maintain awareness of their physical environment while interacting with overlaid digital data (Sheehy et al., 2014). Unlike VR, which replaces reality, AR blends it with virtual elements, creating hybrid perceptions that enhance or simplify the physical world (Schueffel, 2017).

AR applications rely on three key components: tools for tracking real-world objects, hardware and software for processing data, and devices to display integrated digital content (Azuma et al., 2001; Carmigniani et al., 2011). Examples include flashcards, mind maps, blogs, and mobile educational applications (Huang et al., 2019). Educational research highlights AR's potential to boost student motivation, foster collaboration, and develop spatial and practical skills (Radu, 2014). However, its cognitive demands and usability challenges require careful design to ensure effective learning outcomes.

Emerging technologies like VR and AR have the potential to revolutionize traditional learning scenarios when they are supported by robust pedagogical frameworks (Gales & Gallon, 2020). While VR replaces physical environments entirely, AR enriches or simplifies real-world experiences, offering educators powerful tools to improve knowledge retention, creativity, and problem-solving skills.

2.3 The Characteristics of Digital Learning

Due to the technological advances digital learning has developed significantly and also this allowed educational resources to become more accessible. Therefore, we conclude that this form of learning offers a wide range of advantages that include the possibility of overcoming physical, temporal or material limitations, being particularly useful in areas such as vocational training or medical simulations (Hafezy, 2023; Makransky, et al., 2016). Additionally, digital learning environments provide the opportunity for more personalized learning, allowing students to progress at their own pace and receive tailored feedback and support (Guillén-Gámez et al., 2022).

A central aspect of digital learning is the enhancement of immersive and interactive experiences that allow users to explore and engage with complex concepts through practical applications. For example, virtual simulations have been used to explore microscopic structures or astronomical phenomena (Mikropoulos et al., 2003; Barnett et al., 2005), as well as to experience visits to different cultural or historic sites (Mikropoulos & Strouboulis, 2004). These applications contribute to student's experiential learning by simulating relevant scenarios that are difficult to reproduce in the real world.

Another key characteristic of digital learning is the transfer of knowledge from the virtual environment to real life. For example, Bailenson and colleagues (2007, 2008) have demonstrated that by simulating social interactions task engagement and learning outcomes are enhanced. They used virtual reality (VR) to replicate and enhance real-world learning conditions, showing that by personalizing the educational experience through avatars attention and retention are optimized.

A crucial aspect that is central to the design of digital environments is the concept of immersion (Dede, 2009). Although, when it comes to this matter there is disagreement in the specialty literature regarding its impact on learning, VR technologies have been acknowledged the merit of their ability to provide easier mental integration of the educational content. Studies have shown that although the immersion does not always directly influence the retention of information, it can facilitate more in-depth understanding regarding spatial-related subjects and the overall context of the studied content (Mania & Chalmers, 2001; Fassbender et al., 2012).

In conclusion, the specificity of digital learning lies in the unlimited possibilities it provides for personalized learning (Wang et al., 2012) and exploration of knowledge, as well as in the use of advanced technologies to create relevant and engaging educational environments. The ever continuous and exponential development of these technologies has the potential to redefine the traditional pedagogical practices and facilitate access to high-quality education.

2.4 Digital Competence and the TPACK framework

The European Framework of Digital Competence for Citizens - DigComp 2.1 developed by the Joint Research Centre (JRC) and the European Commission stipulates 5 main areas of digital competence that can be used in education and training planning: (1) the ability to read, understand, generate and communicate data as information; (2) communication and collaboration through digital technologies; (3) digital content creation; (4) safety for people, equipment, personal data and the environment; (5) problem solving: technical, identifying technology needs and solutions, creative use of different technologies, identifying skill gaps (Carretero et. al, 2017).

According to Krumsvik (2011) digital competence is the teacher's competence to use ICT in a professional context, with good pedagogical-didactic reasoning and awareness of the implications for learning strategies. This integrative approach to ICT is the practical precursor of what is today called the TPACK Framework.

Øgrim, L. (2010) argues that digital skills are foundational for teachers to achieve TPCK, which is the initial form of the TPACK model. In this presents findings from a study of teachers from Norway that are newly qualified, highlighting the importance of systematic and continuous integration of technology into teacher education. Øgrim, L. (2010) also settles on a definition: “the skills of using digital equipment and the understanding of the technology necessary for democratic participation in society.” This definition encompasses digital skills (use skills), technological knowledge, and an understanding of the relationship between technology and society.

The Technological Pedagogical and Content Knowledge (TPACK) model established by Koehler and Mishra (2009) identifies teacher digital competence as the intersection of three primary forms of knowledge: content, pedagogy and technology. As stated by Koehler and Mishra (2009), the TPACK framework is a way to understand and describe the knowledge teachers need to effectively integrate technology into their teaching practices. What makes this framework interesting is the fact it highlights the differences in teachers' digital competencies that may exist depending on the subject matter being taught. Content Knowledge (CK), namely the teacher's knowledge about the subject matter to be learned or taught – concepts, theories, ideas, organizational frameworks, evidence, and established practices, is the key component that emphasizes the differs between fields.

Other key components that are conceptualized by the TPACK are Pedagogical Knowledge (PK) and Technology Knowledge (TK). The PK refers to the teacher's deep knowledge about the processes and methods of teaching and learning process. This component includes knowledge about educational purposes, values, how students learn, classroom management, lesson planning, and student assessment. TK addresses the teacher's knowledge of both digital and analog technologies. Koehler and Mishra (2009) highlight the fact that TK is always changing, and it represents more than basic computer literacy, involving a deeper understanding of how technology may be used for information processing, communication, and problem solving.

The TPACK framework of Koehler and Mishra (2009) goes beyond these three key components and focuses on the interactions between them. These interactions are:

- Pedagogical Content Knowledge (PCK): this is the knowledge of pedagogy that is applicable to the teaching of specific content. PCK involves transforming the subject matter for teaching by interpreting it, finding multiple ways of representing it, and adapting materials to students' prior knowledge.
- Technological Content Knowledge (TCK): represents an understanding of the way that technology and content influence and constrain one another, involving understanding of how technology changes the subject matter and how the content influences the choice of technologies.
- Technological Pedagogical Knowledge (TPK) encompasses the understanding of how teaching and learning can change when certain technologies are used in particular ways. TPK includes knowing the pedagogical affordances and constraints regarding a range of technological tools and the way they relate to learning.
- Technological Pedagogical Content Knowledge (TPACK) represents the emergent form of knowledge that goes beyond all three core components. TPACK is the basis of effective teaching with technology and requires an understanding of how to represent concepts using technology, pedagogical techniques that use technology to teach content, and the knowledge of how technology can address learning difficulties (Koehler & Mishra, 2009).

As we may see from the conceptualization of this framework, Koehler and Mishra (2009) emphasize that TPACK is not simply the sum of content, pedagogy, and technology knowledge, but rather it is an understanding that emerges from the interactions between them, describing this relationship as a "dynamic equilibrium" where a change in one area must be "compensated" by changes in the others.

3. METACOGNITIVE SCAFFOLDING

3.1. Metacognition

Metacognitions are classically defined as "a person's cognitions about his or her own cognitions" (Flavell, 1979) or the ability to actively control a variety of cognitive processes (Pintrich, 2000; Tobias & Everson, 2009; Moss, 2007). They are not qualitatively different from other cognitions but are different only from a relational point of view because they have as their object the individual's own cognitions (Bromme et al., 2009).

Flavell, one of the first researchers to focus his attention on metacognition, argues that the ability to control the cognitive processes involved in learning is related to the knowledge, experiences, and metacognitive abilities that students possess. These three dimensions are essential for managing different cognitive processes. Metacognitive knowledge can be defined as beliefs about tasks, strategies and goals, metacognitive experiences comprising affective experiences related to cognitive processes and metacognitive skills constituting the strategies used to control cognitive processes (Flavell, 1979; Desoete & Ozsoy, 2009).

In addition to the perspective developed by Flavell (1979), another perspective of metacognition is the one developed by Brown (1987). According to Brown's (1987) perspective, metacognition consists of two dimensions: metacognitive cognition and metacognitive regulation. Metacognitive cognition is defined as how students understand their declarative, procedural, and conditional knowledge, while metacognitive regulation involves strategies such as planning, evaluation, and monitoring (Brown, 1987; Jacobs & Paris, 1987; Schraw & Moshman, 1995; Lee, Teo & Bergin, 2009; Spada, Georgiou & Wells, 2010). A student who knows that learning is easier when there is interest in the subject studied, who becomes aware when he understands something, and who uses different learning strategies depending on the situation, could be described as a student who understands his or her own declarative, procedural, and conditional knowledge. Moreover, a student who thinks of several ways to solve a problem and who verifies his work can be described as a student who regulates his knowledge.

3.2. Theories of scaffolding

The scaffolding technique is a technique dedicated to the learning process through which help is gradually provided to students, and then the aid is gradually reduced to increase the level of knowledge and competence of students. This technique presents clues, questions, and commands addressed to students to improve their cognitive abilities. As each student has different metacognitive abilities, the teacher/facilitator will help according to his/her abilities (Sumadyo et al., 2018). The concept of scaffolding comes from the Zone of Proximal Development (ZPD), a theory developed by the psychologist Lev Vygotsky (1978). It refers to the social support provided to the student during the completion of a learning task when he or she has solved a problem or to achieve a goal that was initially beyond the student's ability to achieve it. In this sense, scaffolding is seen as a pedagogical support in the teaching process with the aim of improving learning outcomes (Wood, Bruner, & Ross, 1976). In developing this theory, researchers explore the potential of incorporating different types of scaffolding during information and communication technology (ICT)-mediated learning to address the difficulties students face when managing and regulating their knowledge during the learning process (Alexander, Bresciani, & Eppler, 2015; Moos & Azevedo, 2008).

Salmon (2004) has developed a teaching/learning model that has as its main objective the creation of situations that make online learners more confident and more capable of successfully developing their learning. This model is organized into 5 sequential levels, each of which requires a certain type of technical skills from the students. The five-step model can be used not only to provide information about what is happening in online discussion groups, but also to scaffold individual development. These five levels are: (1) access and motivation; (2) online socializing; (3) exchange of information; (4) knowledge construction; (5) development.

3.3. Forms of scaffolding

Forms of scaffolding include one-on-one scaffolding, peer group scaffolding, and computer-aided scaffolding.

3.3.1 One-to-one scaffolding

One-to-one scaffolding or individual scaffolding is defined as the situation where a teacher works one-on-one with a single student to dynamically assess the student's current level, providing only the right amount of support so that the student can develop their skills and perform the target task, with the support being personalized as needed until the scaffolding can be removed entirely and the student can independently perform their tasks (van de Pol et al., 2010). In individual scaffolding, it is useful to think about the intentions of the scaffolding – that is, what the teacher seeks to accomplish through scaffolding; and to the scaffolding means – the specific strategies used (Belland, 2012). The means of individual scaffolding include modeling, interrogation, explanation, giving clues and feedback (van de Pol et al., 2010).

3.3.2 Peer group scaffolding

Peer group scaffolding refers to the provision of peer scaffolding support (Davin & Donato, 2013). But it can also refer to the situation in which older students provide scaffolding support to younger students. For example, students with good English-speaking skills can use questions and clues to help beginner-level students improve their English speaking skills (Angelova, Gunawardena, & Volk, 2006). In another example, third-grade students provided scaffolding support to preschool students to help them create projects from crafts (Fair et al., 2005). Empirical studies indicate that peer-to-peer scaffolding positively influences cognitive outcomes (Fair et al., 2005; Pifarre & Cobos, 2010) and help students who have a low level of self-regulation to successfully address the central problem (Helle et al., 2007), but apparently, there is no comprehensive meta-analysis that addresses this form of scaffolding.

3.3.3 Computer-aided scaffolding

Computer-aided scaffolding can be defined as a computerized support that helps students engage and develop skills in tasks that are beyond their abilities (Belland, 2014). This type of scaffolding assists students as they generate solutions to complex, unstructured problems and is provided entirely by a computerized tool. This means that the tool helps to expand students' capacities so that they can perform at a higher level than usual. For example, Belvedere software asks students to argue important concepts that correlate between problem and diagram and characterizes the connections between these concepts by mapping concepts (Cho & Jonassen, 2002).

3.4 Metacognitive scaffolding

Structuring any type of problem-solving activity can be done by providing specific or general domain support. Domain-specific support refers to support for learning the content of the material, while general support refers to supporting the use of adaptive behaviors related to reasoning, which will probably allow the student to discover the content. As for field-specific support in scientific problem-solving tasks, it has been shown to lead to better knowledge of the content, with the overall scaffolding supporting the development of scientific reasoning skills such as planning, monitoring and evaluation (Bulu & Pendersen, 2010). It has also been shown that in invention activities domain-independent metacognitive scaffolding leads to better student inventions and higher-quality reasoning that focuses on the key features of the problem (Roll et al., 2012). For example, intervention activities in science classes may include metacognitive scaffolding with minimal support, implicit or explicit.

3.4.1. Explicit scaffolding

A number of metacognitive prompts, such as domain-independent questions and self-explanation, demonstrate the use of explicit scaffolding. Self-explanation, in which students form written statements to explain their reasoning and strategies, has been shown to improve learning outcomes, performance in transfer tasks, and integration of new information (Aleven & Koedinger, 2002; Chi et al., 1994). In tasks that involve inventiveness, it has been found that students spontaneously explain their invented solutions, and those who receive scaffolding during invention tasks produce higher-quality self-explanations in the design phase (Roll et al., 2012). Behavioral cues (prompts), although specific, are kept independent of the domain and can be recycled for use in other tasks with a similar structure. Scaffolding was developed to engage students in reasoning behaviors that were considered useful by experts for inventions. The scaffolding framework involves five stages: defining the task; analyzing; planning and design; implementation and interpretation; and evaluation (Roll et al., 2012).

3.4.2. Default scaffolding

An initial attempt to carry out an invention should start with the definition and analysis of tasks, which is the first level of the default scaffolding consists in the fact that all subsequent steps are iterative and cyclical. This feature should be supported and encouraged by default throughout the invention so that students understand the cyclical nature of scientific reasoning, for example, by facilitating free movement back and forth between sections of the task.

Interaction within the peer group is another example of implicit scaffolding, for example by putting students in tasks in small groups or pairs. The use of peer-to-peer interaction during activities generates feedback between students and allows them to get assistance in identifying gaps in reasoning (Roll et al., 2012).

Another example of default scaffolding is the way in which the data on the activity of the invention is presented. To highlight the characteristics of the domain, the data can be presented as a series of contrasting cases, in which pairs of data that differ only by a single characteristic of the domain can be found. This allows students to observe what is relevant to the data for solving the task (Schwartz & Bransford, 1998). In addition, students use contrasts to discern what effect the varied feature has on the result.

PART III

CHAPTER 4. The Zone of Proximal Development in Romanian Pre-University Teachers' Practice

4.1 Theoretical background

The overall purpose of the current study is to analyse if there are differences in the classroom use of the Zone of Proximal Development (ZPD) in terms of the pre-university teachers' training and experience or seniority in the education system – expressed through the didactic degree held by the teacher. The present study provides valuable evidence for developing effective intervention programs for teachers and indicates that the ZPD is an essential variable that should be considered when developing and providing teacher training intervention programs.

4.2 The present study

The *aim* of the present study is to investigate the use of the zone of proximal development comprising "prior knowledge activation" and "perceptions of task difficulty" in the classroom context managed by Romanian pre-university teachers having different levels of training and experience or seniority in the education system, and different educational backgrounds. Table 4.1 presents how variables introduced in this study are conceptualized.

Table 4.1

Concepts / variables operationalization

Category	Operationalization
Zone of Proximal Development	➢ Prior Knowledge Activation ➢ Perceived Task Difficulty
Teaching expertise	➢ Academic background ➢ Didactic degree

4.3 Research questions

- Does the teachers' academic background influence the use of the Zone of Proximal Development (ZDP) as a teaching practice?
- Does the teaching degree influence the use of the Zone of Proximal Development (ZDP) as a teaching practice?

4.4 Participants

The sample of the study was composed of one hundred and twenty pre-university teachers from randomly selected educational institutions from the school network of educational institutions posted on the website of the Ministry of National Education. The institutions were selected in order that all the different regions of the country to be represented. A great amount of the respondents carry out their didactic activity in urban areas (73.3%), while the rest of them (26.7%) teach in rural areas. Their ages range from 22 years to 61 years old. The participants are kindergarten or pre-school teachers (32.5%), primary school teachers (30.8%), gymnasium or middle school teachers (19.2%) and high school teachers (17.5%). The seniority of participants in the education system ranged from 1 year to 40 years, 65.0% holding the definitive teaching degree, 6.7% the second didactic degree, and 28.3% the first didactic degree. The majority of the sample is represented by female respondents (over 90%). Regarding the participants' academic background, the highest level of education completed was high school for 1.7% of the participants, while 40.0% hold a Bachelor's degree, 53.3% hold a Master's degree, and 5.0% hold a Doctoral degree.

4.5 Measures

The teachers were asked to answer online, and they were assured their answer will remain anonymous. The questionnaire consisted of two sections. The first section asked the respondents to provide demographic information, and data on their educational background and their didactic certification and degrees. In the second section, the teacher version the "Self-Regulated Learning Opportunities Questionnaire" (SRLOQ) (Annex 1) was used to measure self-regulated learning. The supra-ordinate subscale of the zone of proximal development assessed both perceptions about concepts like "prior knowledge activation" and "perceptions of task difficulty", participants were asked to rate each item on a five-point Likert scale (from 1= Strongly Disagree to 5= Strongly Agree). The Zone of proximal development subscale has an estimated Cronbach's Alpha coefficient of 0.77 (Vrieling et al., 2013). The SRLOQ scale has good psychometric properties reported in the literature: $\chi 2/df = 3.31$, RMSEA = 0.070, TLI = 0.95, CFI = 0.95 and SRMR = 0.072 (Vrieling et al., 2012). The Prior Knowledge Activation subscale used in this study has 10 items and the second one, the Perception of Task Difficulty, has 2 items. The first subscale has an Alpha Cronbach coefficient of 0.857 and for the second subscale we found an Alpha Cronbach value of 0.738. Both subscales used in the study (12 items) have an Alpha Cronbach value of 0.888.

Although the scale is not validated on the Romanian population, we used the standard procedures for translating and adapting the scale. This means that in the first phase we translated the scale from English into Romanian (two professionals). In the second phase we offered the Romanian version to two colleagues and asked them to translate it back into English. Then we checked the English translated versions with the original one. Because no inconvenience was found, we used all the items from the original version. The third phase involved piloting the scale in a group of PhD studens and M.A. students and B.A students (40 students in total, most of them teachers at pre-university levels). This procedure was used for all the scales included in this thesis.

4.6 Procedure

The data were collected by applying the instrument of this study online. This method of assessing the respondents was chosen because it has an optimal cost-effectiveness ratio, obtaining detailed information about the didactic activity of the teachers in a much shorter time. Moreover, by offering access to research participants, who are otherwise inaccessible, the method can be used rapidly and economically and can collect data of elevated quality when judiciously managed. Although the method has several challenges, many of them have proved to be easy to overcome, presenting to researchers a new modus operandi for efficient quantitative research. Another benefit of online communication is the exclusion of the bias that may be produced when entering the data into the statistical analysis program. The estimated period of filling in the questionnaire was 20 to 30 minutes. A brief presentation about the research, its purpose and the voluntary character of the participation was provided in the email.

4.7 Results

4.7.1 Descriptive statistics

The demographic characteristics of teachers are illustrated in Table 4.2.

Table 4.2

Demographic characteristics of participants

Variables	Categories	Percent
Gender	Male	6.7
	Female	93.3
Age	25-29	15.0

	30-39	19.2
	40-49	43.3
	50-59	18.3
	over 60	4.2
Teaching institution level	Preschool	32.5
	Primary school	30.8
	Middle school	19.2
	High school	17.5
Teaching years	1-4	13.3
	5-9	10.8
	10-14	10.8
	15-20	17.5
	over 20	47.5
Environment	Urban	73.3
	Rural	26.7
Didactic degree	Definitive teaching degree	65.0
	teaching degree II	6.7
	teaching I	28.3
Academic background	High-school	1.7
	Bachelor's Degree	40.0
	Master's Degree	53.3
	Doctoral Degree	5.0

The highest percentage of teachers are females (93%), with the largest age group being 40–49 years old (43.3%), who teach in urban institutions (73.3%) at preschool and primary school levels (63.3%), hold a definitive teaching degree (65%) and a Master’s degree (53.3%), and have over 20 years of teaching experience (47.5%).

4.7.2 Inferential statistics

Teachers’ academic background and the use of ZPD

To check whether there are differences between teachers’ use of scaffolding according to their academic background, an ANOVA analysis was conducted. Results are presented in Table 4.5.

Table 4.5

ANOVA test for academic background and ZPD

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.002	3	.667	1.417	.241
Within Groups	54.623	116	.471		

Total	56.625	119

The academic background of the teachers does not influence the use of the Zone of Proximal Development in classroom settings. With F= 1.417 and p= .241, ZPD scores do not differ significantly among teachers with different academic backgrounds.

The didactic degree and the use of ZPD

To analyze the influence of the didactic degree on the use of the ZPD as a teaching practice an One-Way ANOVA was run in SPSS. Results are presented in Table 4.6 below.

Table 4.6

ANOVA test for didactic degree and ZPD

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.674	2	.337	.705	.496
Within Groups	55.951	117	.478		
Total	56.625	119			

The didactic degree held by the teachers does not influence the use of the zone of proximal development in classroom settings. The value of F is 0.705 but the significance level p is 0.496.

The test to identify the differences in the ZPD scores according to academic background and didactic degree was run for each dimension of ZPD. The results are reported in Table 4.7.

Table 4.7

Differences in ZPD subdimensions according to didactic degree and academic background.

ANOVA – Didactic degree						
		Sum of Squares	df	Mean Square	F	Sig.
Prior knowledge activation	Between Groups	.864	2	.432	.843	.433
	Within Groups	59.969	117	.513		
Perceived difficulty of task	Between Groups	2.359	2	1.180	1.572	.212
	Within Groups	87.807	117	.750		
ANOVA – Academic background						

	Between Groups	2.514	3	.838	1.667	.178
Prior knowledge activation	Within Groups	58.319	116	.503		
Perceived task difficulty	Between Groups	2.337	3	.779	1.029	.383
	Within Groups	87.829	116	.757		

All the statistical tests presented above aimed to examine whether there were differences in ZPD practices according to teachers' didactic degree and academic background for each dimension of the ZPD. However, the results were consistent: there were no significant differences in teachers' use of prior knowledge activation and perceived task difficulty practices according to their didactic degree and academic background.

Differences in the implementation of ZPD according to teachers age, experience, institutional level and teaching environment were also investigated. The results of this analysis are presented in Table 4.8.

Table 4.8

ZPD differences according to teachers age, experience, institutional level and teaching environment.

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Age	Between Groups	39.867	33	1.208	1.141	.308
	Within Groups	91.058	86	1.059		
Teaching Institution Level	Between Groups	39.237	33	1.189	1.011	.468
	Within Groups	101.129	86	1.176		
Teaching Years	Between Groups	70.518	33	2.137	.978	.514
	Within Groups	187.982	86	2.186		
Teaching environment					t	Sig.
					.984	.327

No significant differences were found in teachers' ZPD practices according to age, teaching institution level, teaching years and teaching environment.

4.9 Discussions and conclusions

The goal of this study was to investigate if there are any significant differences between the use of ZPD (prior knowledge activation and perceived task difficulty) between teachers who have different academic background and didactic degrees. The result of this exploratory study indicates no significant difference in teachers use of ZPD in their teaching according to their academic background and didactic degree.

Teachers report medium to high levels of ZPD use in their teaching, offering students assignments that are well connected to students' prior knowledge and that require students to use their prior knowledge. Moreover, teachers create lessons whose content connects well to students' prior knowledge. We offered a description of two groups of ZPD users: average users and high users. Although both groups have similar characteristics regarding their demographics, minor differences seem to exist between them. As an example, a higher percentage of teachers from the average ZPD hold a PhD degree, compared to the ones in the high ZPD group.

Even though the demographic criteria included in the study seem to be equally distributed among the ZPD users, the results of the study are valuable for both future research and practice. Researchers, teachers and policymakers should consider the results of this study when developing and implementing formative programs that aim to develop teachers' competencies of using ZPD in teaching students. The lack of any significant differences allows researchers and practitioners to develop and implement formative programs that are suitable for the large population of teachers, regardless of their age, experience, teaching environment, didactic degree and academic background. This would facilitate the implementation of such formative programs.

Based on the result of this study, we encourage researchers to further investigate the relationship between scaffolding and teachers' demographics since this study reveals some interesting results. Although no significant difference was found between teachers' demographics and scaffolding, we identified some tendencies. For instance, this study shows that as teachers' age increases over 50 years, ZPD seems to decrease, since a slight percentage of teachers over 50 years have a high ZPD level. Moreover, higher academic background should be related to deeper pedagogical knowledge and skills and a higher ZPD level. Further research is needed to identify the factors that prevent teachers with higher academic backgrounds performing better on scaffolding.

CHAPTER 5: Pre-University Teachers' Digital Competence and Wellbeing in the Context of Virtual Learning

5.1 INTRODUCTION

This study aims to investigate the experiences of Romanian teachers with educational technology. Digital competence is an essential asset in everyone's life, regardless of personal or professional life. The digitalization of many services has brought important changes about the most important skills needed to be a successful professional. On education, digital competences are becoming increasingly important, not only for students, but also for teachers. Teachers need to use technology in their daily classroom teaching. Since using technology could be a challenge for many teachers, it is important to know whether teachers' wellbeing is related to their digital competence.

5.1.1 Variable operationalization

Both wellbeing and digital competence have been intensively studied in the literature. Although there are several theories and perspectives for both wellbeing and digital competence, there is agreement on how they can be operationalized.

Table 5.1 illustrates the operationalization of these concepts.

Table 5.1

Concept operationalization

Category	Operationalization
Digital Competence	➢ Professional engagement ➢ Digital resources ➢ Teaching and learning ➢ Assessment ➢ Empowering Learners
Wellbeing	➢ hedonic ➢ eudaimonic

5.2 Methodology

5.2.1 Research Questions

The present research study aims to answer the following questions: (1) What is the experience of Romanian teachers in using educational technology? (2) What is Romanian teachers' level of wellbeing? and (3) What is the association between digital competence and wellbeing level?

5.2.2 Participants and sampling methods

The sample of the study was composed of 98 pre-university teachers from rural and urban areas. The sample included 11 male teachers and 87 female teachers. The sampling is a convenience one, participants being recruited from Romanian public-school network. Teachers were asked to voluntary answer an online survey in the last month of the current school year after previously informed consent.

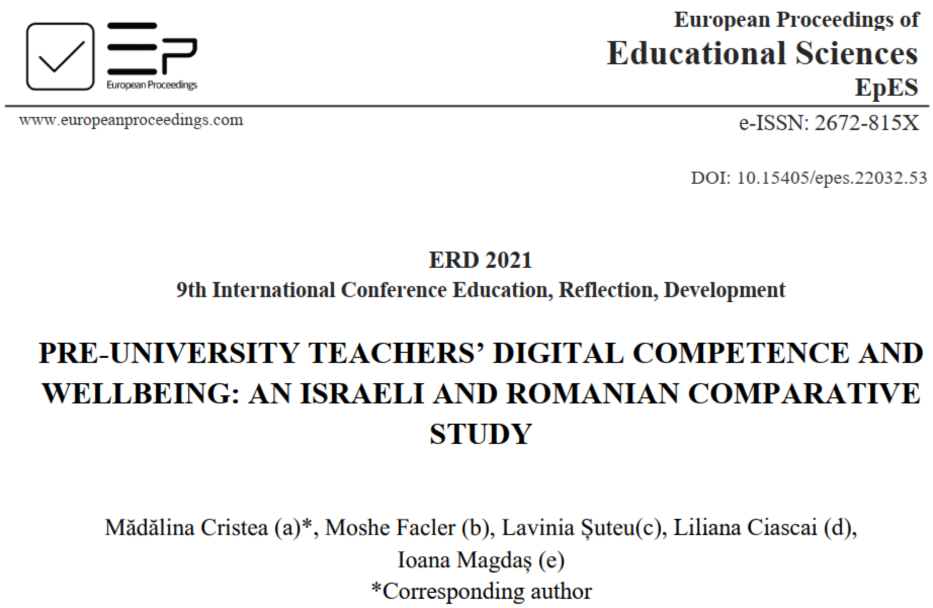
5.2.3 Measures

The scales we have chosen to measure the variables have very good psychometric properties. The first one, "The Warwick-Edinburgh Mental Wellbeing Scale" (WEMWBS) (Anex 2) has been elaborated to measure mental wellbeing in the general population and the evaluation of programmes aimed at improving mental wellbeing. The WEMWBS scale has 14 items and 5 answer categories, summed to give a score, covering the hedonic and the eudaimonic approach. All items are formulated positively and encompass both the emotional and functional aspects of mental wellbeing, thus helping the understanding of this concept (Tennant et al., 2007). This scale has been applied worldwide to monitor and evaluate programmes and to analyse the mental wellbeing indicators, being validated for use in a wide variety of different geographical locations, cultural contexts, and various contexts, including schools (Stewart-Brown et al., 2011). The Alpha Cronbach coefficient for this study was 0.923. High internal consistency of the scale has been repeatedly reported in the literature (with values between 0.87 – 0.91) (Tennant et al., 2007). The test-retest reliability indicator ranges between 0.83 and 0.86 (Maheswaran, 2012). The second survey tool is the DigCompEdu questionnaire (Anex 3) developed according to The European Commission's framework for the Digital Competence of Educators. It includes 22 statements assessing teachers' digital technology practice, which are divided into 6 areas: professional engagement, digital resources, teaching and learning, assessment, empowering learners and facilitating learners' digital competence (Punie & Redecker, 2017). Professional engagement comprises 4 items, digital resources 3 items, the teaching and learning area has 4 items, the assessment domanin has 3 items, the empowering learner's domain has 3 items, and the facilitating learners' digital competence 5 items.

For both WEMWBS scale and DigCompEdu questionnaire we followed the the standard procedures for instruments translation and adaptation described in the 1st study of this paper.

5.2.4 Procedure

Note: The data collection of the study has been developed under a work financially supported through the Operational Programme Human Capital 2014-2020 under the project number POCU 123793 with the title Researcher, future entrepreneur – New Generation, which was published in the Education, Reflection, Development 2021 (ERD) Conference, namely the European Proceedings of Social and Behavioural Sciences (Cristea et al., 2022).



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PRE-UNIVERSITY TEACHERS' DIGITAL COMPETENCE AND WELLBEING: AN ISRAELI AND ROMANIAN COMPARATIVE STUDY

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Fig. 5.1 Screenshot of the first page of the article in ERD Proceedings.

5.3 Results

To examine the demographic particularities of the pre-university teachers, a descriptive statistical analysis was run in SPSS. As table 5.2 shows, the two samples are similar in terms of gender predominance, environment, age and job position status.

The sample comprised 11 (11.2%) males and 87 (88.8%) females. Most of the participants' ages ranged from 30 to 39. The percentage of teachers holding a temporary job slightly overtakes that of participants who have a permanent job position.

Table 5.2

Demographic characteristic of Romanian teachers (in percentages)

Gender	Environment	Age	Position status
11.2 Male	38.8 Rural	5.1 under 25 years	46.9 Permanent
88.8 Female	61.2 Urban	17.3 Between 25-29	53 Temporary
		33.7 Between 30-39	
		23.5 Between 40-49	
		18.4 Between 50-59	
		2 over 60 years	

Another issue tackled by this research refers to the use of educational technology following two directions. The first one addressed the pre-university teachers' comfort when using technology in their classes, answer options including four categories: very uncomfortable, fairly uncomfortable, fairly comfortable and very comfortable. As shown in Table 2, teachers from both groups reported positively about their comfort when using technology. Most of the Romanian teachers considered educational technology as being very comfortable (57.1%).
The second direction aimed to find for how many years teachers have been using technology in teaching (Table 5.3.).

Table 5.3

Pre-university teachers' comfort of classroom technology use (in percentages)

	Pre-university teachers
I feel very uncomfortable using technology when teaching	4.1
I feel fairly uncomfortable using technology when teaching	3.1
I feel fairly comfortable using technology when teaching	35.7
I feel very comfortable using technology when teaching	57.1

Teachers seem to feel at least fairly comfortable using technology in teaching (92.8%). More than half of them is very comfortable with technology use and only a small proportion (7.2%) feel uncomfortable. We can conclude that technological discomfort is uncommon among this group.

Table 5.4.

Pre-university teachers' time of classroom technology use (in percentages)

Time of technology use	Pre-university teachers
1-3 years	7.1
4-5 years	37.8
6-9 years	11.2

10-14 years	16.3
15-19 years	11.2
20 years or more	9.2

The highest percentage (37.8%) of teachers have been using technology for 4-5 years and a percentage of 11.20 have been using it for 6-9 years (Table 5.4). This is not surprising considering the recent trends in integrating technology into teaching. Slight percentages of teachers have more extended experience in using technology. Thus, 16.3% have been using technology for 10-14 years, and 9.2% have been using technology for over 20 years.

Not only that teachers seem to have experience with technology and feel comfortable using it, but they also have a high level of wellbeing (Table 5.5).

Table 5.5

Wellbeing mean

	Mean	N	Std. Deviation	Median
Romania	59.418	98	7.317	60.000

Table 5.6

The association between digital competence and the wellbeing attributes

	DC	O	U	R	IP	LE	DW	CT	GS	CO	CF	OM	PL	IT	C
DC	1	.361**	.345**	.303**	.283**	.332**	.319**	.250*	.295**	.326**	.229*	.298**	.315**	.223*	.282**
O	.361**	1	.724**	.577**	.359**	.578**	.553**	.470**	.479**	.385**	.719**	.475**	.426**	.406**	.596**
U	.478**	.603**	1	.447**	.430**	.447**	.469**	.462**	.458**	.471**	.597**	.538**	.541**	.466**	.473**
R	.345**	.724**	1	.520**	.335**	.568**	.573**	.549**	.557**	.431**	.701**	.598**	.595**	.455**	.619**
IP	.303	.577	.520	1	.283	.542	.437	.406	.451	.202	.500	.310	.437	.273	.599

	**	**	**		**	**	**	**	**	*	**	**	**	**	**
LE	.283**	.359**	.335**	.283**	1	.358**	.421**	.373**	.328**	.453**	.366**	.392**	.395**	.465**	.326**
DW	.332**	.578**	.568**	.542**	.358**	1	.507**	.465**	.513**	.355**	.572**	.444**	.355**	.433**	.574**
CT	.319**	.553**	.573**	.437**	.421**	.507**	1	.605**	.513**	.384**	.568**	.616**	.414**	.384**	.408**
GS	.250*	.470**	.549**	.406**	.373**	.465**	.605**	1	.599**	.381**	.562**	.651**	.430**	.425**	.457**
CO	.295**	.479**	.557**	.451**	.328**	.513**	.513**	.599**	1	.433**	.700**	.538**	.541**	.363**	.593**
CF	.326**	.385**	.431**	.202*	.453**	.355**	.384**	.381**	.433**	1	.569**	.513**	.361**	.477**	.555**
OM	.229*	.719**	.701**	.500**	.366**	.572**	.568**	.562**	.700**	.569**	1	.631**	.554**	.535**	.688**
PL	.298**	.475**	.598**	.310**	.392**	.444**	.616**	.651**	.538**	.513**	.631**	1	.504**	.435**	.527**
IT	.315**	.426**	.595**	.437**	.395**	.355**	.414**	.430**	.541**	.361**	.554**	.504**	1	.386**	.609**
C	.282**	.596**	.619**	.599**	.326**	.574**	.408**	.457**	.593**	.555**	.688**	.527**	.609**	.472**	1

**. Correlation is significant at the 0.01 level (2-tailed).

A Pearson correlation was run in SPSS in order to analyse the association between preuniversity teachers' digital competence and the componets of wellbeing, such as optimism, usefulness, relaxation, interest in other people or in new things, level of energy, clarity of thinking, dealing well with problems, feeling good about one's self, closeness to others, confidence in the future, making the own mind, perception of being loved and cheerfulness. The results (Table 5.6) of the analysis indicated that there is a positive correlation between variables which ranges from r=.223 to .361, N=98, p=.000, the size effect being small to medium.

To further explore the relationship between wellbeing and digital competence we run a regression analysis. The results are presented in Table 5.7, Table 5.8 and Table 5.9.

Table 5.7

Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.555[a]	.308	.305	.46397

Predictors: (Constant), Digital competence
Dependent Variable: WellBeing

Table 5.8

ANOVA

Model		df	df	Mean Square	F	Sig.
1	Regression	1	1	23.749	110.319	.000[b]
	Residual		248	.215		
	Total	77.136	249			

a. Dependent Variable: WellBeing
b. Predictors: (Constant), Digital competence

Table 5.9

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.846	.109		26.175	.000

Digital competence	.322	.031	.555	10.503	.000

a. Dependent Variable: WellBeing

The regression analysis shows that digital competence is a significant predictor of teachers' wellbeing ($p<0.001$) and explains 30.8% of the variance in wellbeing ($R^2 = 0.308$) with a standardized Beta of 0.555. Otherwise, it seems that teachers with a higher level of digital competence not only will have a higher level of wellbeing as well but increasing teachers' digital competence will result in increasing their wellbeing as well.

5.4 Discussions and conclusions

Surprisingly, the result of this research shows that digital competence is not associated to anxiety, burnout or perceived stress among Romanian teachers. Instead, it seems that there is a positive relationship between digital competence and teachers' well-being. Furthermore, it seems that digital competence is a significant predictor of teachers' well-being. This study shows that pre-university teachers are largely embracing technology, and those with higher digital competence tend to report a higher level of wellbeing. Supporting teachers through ongoing digital training and resources will likely further improve not only their wellbeing but also their effectiveness and satisfaction in teaching roles. The regression analysis demonstrates that digital competence is a strong and significant predictor of teachers' wellbeing, explaining 30.8% of its variance.

This study offers valuable information on three important dimensions on technology and wellbeing in pre-university teachers: (1) Comfort with technology. (2) Experience with technology. (3) The relationship between digital competence and wellbeing.

Although a slight number of participants have extensive experience with technology (9.2%), most teachers argue that they do feel comfortable with using technology in teaching. In fact, digital competence seems to predict teachers' level of wellbeing, explaining 30% of wellbeing variance. The results of this study will not only be used in the development of a formative training program for teachers, focused on digital competence, but can also open new research horizons. For example, further research should consider teachers' experience with technology to identify potential differences between those with extensive experience using technology in teaching and those with light to moderate experience.

CHAPTER 6: Pre-University Teachers' Experiences with Digital Learning Technologies: A Thematic Analysis*

6.1 Introduction

Current research indicates that for the educational field the COVID-19 pandemic played the role of a catalyst, triggering a chain reaction not only for the students' digital skills development but for the teachers as well (Jena, 2020; Khamis et al., 2021). For teachers, the crisis encompassed a challenge that led also to pedagogical innovation (Moorhouse & Wong, 2021; Ellis et al., 2020; Kidd & Murray, 2020). Furthermore, digital technology can provide valuable educational experiences compared to traditional instructional design, but it is fundamental to have a scientifically grounded pedagogical basis for its use. This new pedagogical approach should be student-centered in a learning experience that improves knowledge and understanding (Gales & Gallon, 2020), the design of online learning being influenced by debates on issues related to the creation of student-centered supportive digital environments (Pountney et al., 2002).

6.2 Methodology

The present study has a qualitative research approach. This type of research was chosen to provide detailed, in-depth information on the teaching-learning process in the virtual environment. The reason for selecting a qualitative research approach for this study is based on the importance of obtaining the representations and personal stories of pre-university teachers regarding the experience of teaching and maintaining a didactic activity through digital technologies. The interview guide provided an opportunity to capitalize on the personal experiences shared by the interviewees in a safe environment. The use of open-ended questions was intended to allow teachers to share their perspectives. This type of method has the advantage of allowing the discussion framework to be created in advance to cover the areas needed to answer the research questions and to achieve the purpose of the study (Tutty, Rothery, & Grinnell, 2005). The research data were collected online between October and November 2021.

Based on this approach, the purpose of the research is to analyze the Romanian online educational process during the COVID-19 pandemic from the perspective of pre-university teachers.

The aim of the study is achieved by answering the following research questions:

- What is the perspective of pre-university teachers on the Romanian online educational process during the COVID-19 pandemic?
- How do pre-university teachers conceptualize the efficiency of digital tools?
- What are the main features of the virtual learning environment?
- What are the best practices and approaches to digital education innovation according to pre-university teachers?

6.2.1 Participants and sampling method

Eighteen Romanian pre-university teachers enrolled in a master's degree program at Babes-Bolyai University were asked to voluntarily participate in this study after receiving an informed consent procedure. The selection of teachers was made on a sample of availability, this type of selection encompassing representativeness issues.

The ages of the participants range between twenty-three and fifty-nine years old, and they come from both urban and rural areas.

6.2.2 Instruments

In order to answer the research questions, a design based on the application of a semi-structured interview guide was used. The interview guide (ANEX 4) was created by studying specialized literature to capture clues that allow the operationalization of digital teaching-learning. This instrument offered the possibility to capitalize on the personal experiences shared by the interviewees and included several dimensions: digital teaching, virtual learning environment, digital teaching tools, and best practices and approaches to digital education innovation.

6.2.3 Results

Thirteen codes were identified, grouped into five themes relevant to the present research: adapted learning tools, psychosocial adaptation, student activation, reduced generation gap, communication skills underpinning relationships, teaching expertise, digital competence, cognitive development, increased student motivation, enhanced teaching organizational skills, scarce assets, virtual environment assets and value available to meet learning expectations. Table 6.1 shows the five themes as well as the codes and the relevant excerpts for each theme.

Table 6.1 Themes, codes and relevant excerpts

Themes	***Codes***	***Excerpt samples***
Adaptation	Adapted learning tools	"I turned the paper book into an

		audiobook with flipping pages, and that captivated them a lot.”
	Psychosocial adaptation	“During the emergency, when I was online with my class and my three children… it was a difficult period.”
Enhanced communication	Student activation	“Provides interactive teaching”; “students are no longer passive recipients of information, but are actively involved in their own training.”
	Reduced generation gap	“Digital materials are relevant to the Z generation we educate”; “teachers are no longer the key source of information and knowledge transmission, but collaborators of students…”
	Communication skills underpinning relationships	“it depends on how the communication is managed … The use of devices can also lead to the development of other social relationships with other people, not necessarily nearby, but also to the degradation of relationships with those nearby.”; “It is not beneficial for pre-school and primary school students to learn online, they need socialization, direct contact.”
Competence achievement	Teaching expertise	“If you know how to find the right methods for teaching and training the participants, online learning is a positive endeavor”
	Digital competence	“At the beginning of the pandemic, I was not prepared to teach online, although I had a fairly high level of technology

		use.”
Efficacy	Cognitive development	“helped to better understand the subject”; “digital tools have increased the efficiency of the teaching-learning”; “caught the children's attention”
	Increased student motivation	“students are delighted with the use of these learning materials and are very attracted”;
	Enhanced teaching organizational skills	“From my experience in virtual vs. traditional teaching, I found that I was more efficient and well organized online than in the classroom, physically.”
Assets	Scarcity of assets	“Not all students have proper devices and internet.”
	Virtual environment assets	“Self-assessment games or interactive worksheets make online learning a success”
	A value available to meet learning expectations	“I do not consider that the use of digital devices affects the educational environment, on the contrary, it has brought them a plus. We just have to use them rationally and at the right times to prove their true value”.

6.3 Conclusions and discussions

Following the data analysis, five themes were identified. These are relevant to the perspective of pre-university teachers regarding the online teaching period: adaptation, communication, competence achievement, efficacy, and assets.

Regarding the adaptation, the participants in the interview highlighted a series of factors that shaped their experience as a teacher during the virtual environment teaching period. Thus, participants consider adaptation as an essential aspect of online teaching. Adapting and transforming classical teaching materials into digital teaching materials are fundamental aspects related to the interest and positive attitude of students towards certain subjects. Also, the perspective on the online teaching period is outlined by the psychosocial adaptation process, encompassing the integration of different roles, namely the roles of teacher and parent.

From the teachers' perspective, enhanced communication is another defining aspect of teaching in a virtual environment, with students being more active and involved in classes. Also, the generation gap is reduced because teachers use the new technologies that are defining for the generation they teach. At the same time, the teachers state that digital technology is not a substitute for prior acquired communication skills, and they highlight the importance of using technology with care at preschool and primary school levels due to age development particularities.

The competencies acquired by the participants during the online teaching period are an important aspect of teachers' perspectives on the use of technology in teaching. The interviewed participants believe that certain skills acquired during these years of online teaching will be useful to them in face-to-face classes. Thus, digital teaching skills will be used to enhance the classic teaching design. They also mentioned they observed that the general digital competence was not sufficient for teaching online successfully, and they had to refine their skills.

With the acquisition of digital skills, teachers have developed a detailed perspective on the effectiveness of teaching in the virtual environment. Thus, they expect to obtain positive results in the teaching-learning process, considering that they can use efficiently the digital resources available because they are helped by technology in organizing better classes. Also, the teachers expressed their opinion that the use of digital tools in teaching facilitates students' cognitive development, respectively a deeper understanding of the subject. Moreover, digital teaching tools contribute to classes' efficacy by drawing students' attention and increasing their motivation.

Therefore, teaching in the virtual environment is an essential experience for teachers, an experience for which they have positive expectations and for which they are consistently preparing. Although teachers have positive expectations about technology-facilitated teaching, students' access to digital devices and the Internet is considered inappropriate by the interviewed participants. Thus, they believe that an adequate endowment of students with digital resources should make the educational process a success, and this could be achieved through a rational use of digital devices. Teachers agree that the gamification of education can improve students' learning process, and the form of assessment through digital games or interactive worksheets is more age-appropriate than an assessment made by traditional methods.

The aim of this research is to assess the perceptions of pre-university teachers about learning through digital technology and to investigate how they relate to experiencing online teaching during the COVID-19 pandemic.

Through research methods, information relevant to the topic and purpose of this research was collected. Following the analysis of the data obtained from the interviews conducted with the pre-university teachers, it was possible to identify five major themes related to the teachers' perspective on digital technology facilitated teaching.

The main research question addressed the pre-university teachers' opinions regarding the Romanian online educational process. Relevant information on this topic was obtained as a result of the analysis. Respondents describe online learning as determining the development of students' and teachers' digital skills.

Another research question focused on the manner teachers conceptualize the efficacy of digital education tools. The pre-university teachers that participated in the present study agreed that the educational efficacy of the digital learning technologies is given by the students' cognitive development it generates, and also by the increase of students' motivation to involve in learning activities during online classes. Moreover, teachers emphasized that digital technologies enhance students' attention and allow in-depth learning of the subject. The respondents also observed that their organizational skills when teaching improved due to technology use.

Regarding the main features of the virtual learning environment, the pre-university teachers focused on digital assets like learning apps and devices that increased communication, knowledge transfer, and students' class involvement. These features make the digital learning tools a valuable pedagogic resource not only for remote teaching but also for in-person teaching. When addressing the opportunities offered by digital learning tools, the pre-university teachers that participated in the present study also highlight a fundamental problem of the Romanian education system during the COVID-19 pandemic, namely the scarce capacity to secure for all the students the necessary digital educational assets.

The last research question raised by this study aimed to find out teachers' opinions about the best practices and approaches to digital education innovation. According to the respondents, the best practices in the field of digital pedagogy are those developed through constant and reflexive practice in order to learn how to choose the proper teaching strategies and adapt them using the digital learning tools. In addition, teachers see educational innovation expressed in the form of the gamification of educational approaches that are implemented in the teaching activities designed to answer to the digital natives' mindset.

In conclusion, teachers' perspective on digital teaching is essential for the efficacy of this type of teaching. The data obtained from these individual interviews may be the basis for improving face-to-face teaching through the use of digital tools or may be the starting point for more detailed research focused on this topic. Also, the results presented in this report can be a starting point for conducting research related to this topic, such as empowering students in the digital learning process. Further research is also desirable to extend our knowledge about the social and emotional effects of the virtual learning environments according to different age groups and developmental particularities, this being an issue addressed by the pre-university teachers, especially concerning pre-school and primary school educational levels.

CHAPTER 7: Exploring the Relationships Between Digital Competence, Metacognitive Awareness, and Teachers' Virtual Learning Environment Success

Variables' definition and operationalization

To clearly understand the central concepts of this study, Table 7.1 presents how each variable included in the study is operationalized and measured.

Table 7.1

Variables' operationalization

Construct	Dimensions	Measurements
VLE Success (Virtual Learning Environment Success)	Information Quality	Accuracy, Relevance, Sufficiency, Format, Currency, Timeliness & Reliability.
	System Quality	Availability, Usability, Accessibility & Reliability.
	Service Quality	Responsiveness, Assurance, Empathy & Tangible.
	Intention to Use	Future Intention to Use/Reuse
	Use	Regularity of Use, Nature of Use
	User Satisfaction	User Survey, Enjoyment & Overall Satisfaction.
	Net Benefits	Time-Saving, Improved Productivity & Personal Valuation.
Digital competencies (DigCompEdu)	Professional engagement	Organizational Communication, Professional Collaboration, Reflective Practice, Digital Continuous Professional Development.
	Digital resources	Selecting Digital Resources, Creating and Modifying Digital Content, Managing, Protecting and Sharing Digital Resources
	Teaching and learning	Teaching, Guidance, Collaborative Learning, Self-Regulated Learning
	Assessment	Assessment Strategies, Analysing Evidence, Feedback and Planning
	Empowering learners	Accessibility and Inclusion, Differentiation and Personalization, Actively Engaging Learners
	Facilitating learners' digital competence	Information and Media Literacy, Digital Communication and Collaboration, Digital Content Creation, Responsible Use, Digital Problem Solving
Metacognitive awareness (MAI)	Metacognitive knowledge	Declarative Knowledge, Procedural Knowledge, Conditional Knowledge
	Metacognitive regulation	Planning, Information Management Strategies, Monitoring, Debugging Strategies and Evaluation of Learning

The present study

The research study aims to analyze the Romanian preuniversity teachers' metacognitive awareness, digital competence, and their perspective on the virtual learning environment success. The following hypothesis were tested:

H1: Teachers' metacognitive awareness mediates the relationship between their digital competence and the success in VLE. Teachers with higher digital competence will reveal a greater metacognitive awareness, which in turn will enhance their perceived success in VLE usage.

H2: Teachers' metacognitive awareness moderates the relationship between teachers' digital competence and their success in Virtual Learning Environments. The positive effect of digital competence on VLE success will be stronger for teachers with higher levels of metacognitive awareness.

Methodology

Participants and sampling

A group of 123 teachers with ages that range from 23 to 59 years were included in the study. The participants were all females who were teaching at pre-university levels in Romania. The highest percentage regarding participants' age is between 30-39 years (31.7%), followed by the 40-49 years range (29.3%), but high percentages are also represented by participants under 25 years (23.6%). The percentage distribution of teachers according to their position status is as follows: 56.1% hold a permanent position, while 43.9% hold a temporary one. Most of the participants come from the rural environment (53.7%).

The sampling is a non-randomized convenience one.

Measurements

- The Validated Measurement for Virtual Learning Environment Success (VLE) (Awang et al, 2018) (ANEX 5) is a self-reported scale with 45 items measured on a 5-point Likert scale. The scale has 7 dimensions: (1) information quality (7 items), system quality (7 items), service quality (9 items), intention to use (4 items), use (9 items), user satisfaction (4 items) and net benefits (5 items). Participants are asked to rate their agreement on a 5-point scale, ranging from strong disagreement to strong agreement. The VLE scale has very good psychometric properties reported in the literature, with alpha Cronbach of each variable within 0.95 to 0.97. The scale has also strong content validity, with s-CVI/Ave values ranging from 0.81 to 0.93 (for the seven dimensions of the scale) (Awang et al, 2018). The factor structure analysis revealed that all Kaiser-Meyer-Olkin (KMO) values were above 0.81 (with the highest value of 0.93), the Eigen Values were higher than 1 for all seven dimensions and the Sphericity Bartlett Test lower than 0.5 for all seven dimensions (Awang et al, 2018).

- The DigCompEdu questionnaire (Anex 3) was developed according to The European Commission's framework (2017) for the Digital Competence of Educators. The questionnaire has 22 statements that assess teachers' digital technology practice, which are organized into 6 areas: professional engagement (4 items), digital resources (3 items), teaching and learning (4 items), assessment (3 items) and empowering learners (3 items) and facilitating learners' digital competence (Punie & Redecker, 2017). The DigiCompEdu questionnaire asseses the frequency, confidence and impact of digital tools in the educational field and has both multiple-choice and Likert-scale items. Good psychometric properties of the DigiCompEdu survey have been reported in the literature: CFI = 0.994; KMO = 0.977 and a Sphericity Bartlett Test lower than 0.5 (Párraga et al., 2022). Further studies also reported very good psychometric properties of the scale: Camero-Almenara et al., 2020; Horváth et al., 2025; Gallardo-Echenique et al., 2023.
- The Metacognitive Awareness Inventory (MAI) (ANEX 6) was developed by Scraw and Sperling-Dennison in 1994. The scale has 52 items which are measured on a 5-point Likert scale. Although the scale has not been validated on the Romanian population, it has been widely used in different Romanian studies, so it has been translated in Romanian by many researchers. The main two dimensions of the scale are knowledge of cognition and regulation of cognition. The first dimension has the following sub-scales: declarative knowledge, procedural knowledge and conditional knowledge. The second one comprises planning, information management strategies, monitoring, debugging strategies and evaluation of learning. The literature reports good psychometric properties for MAI, with CFI = .968, IFI = .965, SRMR =.047 and RMSEA = .040 (Gutierrez de Blume, 2024).

Although neither the VLE nor the MAI scale are validated on the Romanian population, we followed the standard procedures for instruments translation and adaptation described in the 1st study of this paper.

Results

The first analysis was conducted to text the following hypothesis:

H1: Teacher's' metacognitive awareness mediates the relationship between their digital competence and the success in VLE. Teachers with higher digital competence will reveal a greater metacognitive awareness, which in turn will enhance their perceived success in VLE usage.

To assess the validity of the hypothesis concerning the mediating role of the metacognitive awareness between digital competence and VLE success we have used the *Jamovi cloud* environment for statistical computing (2004), due to the limitations of the SPSS 21 package. With the Bootstrapping procedure set at 5000 samples and a confidence interval of 95%, the results of the mediation analysis comprised in the table below indicate that while digital competence significantly and directly influences VLE Success ($p= 0.011$), the mediating role of metacognition is not statistically supported ($p= 0.062$) (Table 7.2), suggesting the possibility of an indirect effect that asks for a further investigation.

Table 7.2

Mediation effects of metacognitive awareness

Mediation Estimates

			95% Confidence Interval			
Effect	**Estimate**	**SE**	**Lower**	**Upper**	**Z**	**p**
Indirect	0.0357	0.0191	-0.00175	0.0731	1.87	0.062
Direct	0.1376	0.0541	0.03162	0.2437	2.54	0.011
Total	0.1733	0.0553	0.06498	0.2817	3.14	0.002

The mediation analysis revealed that digital competence significantly predicted VLE success, both directly ($p= 0.011$) and in total ($p= 0.002$). However, the indirect effect mediated by metacognition was not statistically significant. These findings highlight the direct contribution of digital competence to VLE success and suggest the fact that the metacognitive processes may play a limited role in this relationship as shown by the present sample. Thus, we may conclude that the hypothesis highlighting metacognition as mediating the relationship between teachers' digital competence and VLE success has not been confirmed, the near-threshold significance and the indirect effect size that has been observed (Estimate = 0.0357) allow us to think of further exploration of this model. This result could imply the fact that the mediating role of metacognition hypothesized is context-dependent or affected by external variables not included in the current model, such as technostress or TPACK integration skills.

To test the second hypothesis, we introduced metacognitive awareness as a moderator, to check if the relationship between the digital competence of teachers and the success of VLE depends on the teachers' level of the metacognition.

H2: Teachers' metacognitive awareness moderates the relationship between teachers' digital competence and their success in Virtual Learning Environments. The positive effect of digital competence on VLE success will be stronger for teachers with higher levels of metacognitive awareness.

The results of the analysis are illustrated in the table below (Table 7.3).

Table 7.3

Moderation effects of metacognitive awareness

Moderation Estimates

			95% Confidence Interval			
	Estimate	**SE**	**Lower**	**Upper**	**Z**	**p**
DigComp	0.0915	0.0506	-0.00769	0.191	1.808	0.071
Metacog	0.3993	0.1190	0.16614	0.632	3.357	<.001
DigComp* Metacog	-0.1228	0.1301	-0.37785	0.132	-0.944	0.345

With an effect size value for Digital Competence of 0.0915 and a confidence interval situated between -0.00769, 0.191 and a Z = 1.808, ($p = 0.071$) we conclude that the effect of digital competence on the outcome is positive but not statistically significant ($p > 0.05$). The confidence interval includes 0, suggesting uncertainty about the direction of the effect.

Metacognition revealed to have an Estimate value of 0.3993 at a confidence interval within [0.16614, 0.632] and a Z moderator variable of 3.357 ($p < 0.001$). Therefore, we may conclude that metacognition has a statistically significant positive effect on the outcome. The confidence interval does not include 0, and the p-value indicates a strong evidence for the effect.

The interaction effect between Digital Competence * Metacognition reached an Estimate equal to -0.1228 with a Confidence Interval of [-0.37785, 0.132]. The moderating value of -0.944 ($p = 0.345$) enables us to say that the interaction between digital competence and metacognition is not statistically significant ($p > 0.05$). As the confidence interval includes 0, this clearly indicates no evidence of moderation.

To sum up the direct effect of metacognition on the outcome is significant, indicating its importance in the model. The interaction term is non-significant, suggesting that teachers' Digital Competence does not significantly moderate the relationship between metacognition and the outcome. However, this might indicate that the influence of metacognition is relatively stable regardless of digital competence levels.

The moderating model, since the effect is both statistically significant and has a meaningful size, metacognition contributes valuable predictive power to the model, having a fundamental role in explaining variations in the outcome. The results suggest the fact that teachers with higher levels of metacognition (awareness and regulation of their thinking processes) are more likely to achieve better outcomes, independent of their digital competence or its interaction.

Conclusion & discussion

To sum up, the findings of the present study highlight that teachers' metacognitive awareness and digital competence play different roles in predicting VLE success. While metacognition has a strong independent impact, its mediating and moderating roles are not supported in this study. The insights provided by these research findings are valuable as they may guide both theoretical developments and formative interventions in the field of education technology.

As the results for the mediation and moderation models were not significant, we consider for future research to adjust the models with other factors such as motivation, self-efficacy, technological anxiety or TPACK integration skills that might mediate or moderate the relationship between teachers' digital competence and the success perceived by them when using VLE in their practice.

Nevertheless, some of the limits of the present study stand in the sampling characteristics. Therefore, expanding the sample size would be a great way of improving the statistical power and generalizability of the findings. Other methodological constraints are represented by reliance on self-report instruments.

The practical and educational implications of the study rely on how the findings might guide interventions or training programs**.** For example, metacognition and digital competence could be addressed in teacher training programs.

CHAPTER 8: Investigating the Relationships between In-service Teachers' Technology Pedagogy Content Knowledge and Virtual Learning Environment Success

Introduction

Nowadays, the integration of technology in education has a great contribution in transforming teaching practices, offering new opportunities that enhance students' learning and engagement (Mishra & Koehler, 2006; Selwyn, 2011). The Technological, Pedagogical, and Content Knowledge (TPACK) framework provides a comprehensive model for understanding how technology can be integrated effectively into teaching practice by considering the interplay between pedagogy, content, and technology (Mishra & Koehler, 2006). As Koehler and colleagues (2013) has shown teachers are able to create more engaging and effective learning experiences for their students if they manage to influence the synergy between technological tools, pedagogical strategies, and content knowledge in a meaningful and contextually adapted manner.

With the growing prevalence of Virtual Learning Environments (VLEs), which facilitate remote and blended learning through digital platforms, teachers must adapt their practices to leverage these technologies effectively (Bates, 2019; Picciano, 2017). VLEs offer different kinds of tools and functionalities that support teaching and learning, yet their successful implementation requires a deeper understanding of how technology, pedagogy, and the domain-specific content intersect (Aydin & Gumus, 2016).

Although there are some previous studies that have highlighted the importance of the TPACK framework in the effectiveness of integrating technology (Chai et al., 2013; Koehler & Mishra, 2009), limited research has examined its specific impact on teachers' perceived success in what concerns VLEs usage in their classroom practice. Therefore, the present study aims to cover this gap by investigating the way in which in-service pre-university teachers' TPACK level influences their perceived success in using VLEs in teaching highlighting the importance of understanding the integration of technology, pedagogy, and content knowledge in modern educational contexts.

The present study

The paper aims to provide a comprehensive overview of teachers' practice regarding the integration of TPACK in the teaching process, presenting the relationships between TPACK and the success in the virtual learning environment as perceived by pre-university teachers.

Research questions

This study seeks to investigate the following research questions:

1. What are the differences between teachers' TPACK usage in terms of age, teaching environment, academic background, subject they teach and position status?
2. What is the relationship between in-service teachers' TPACK and their perceived success in implementing VLEs in their teaching practice?
3. Is teachers' TPACK level a predictor for virtual learning environment success?

Research hypothesis

H1: There are significant differences in the level of TPACK integration among teachers belonging to different age categories.

H2: There are significant differences in the level of TPACK integration among teachers teaching in different environments (rural, urban).

H3: There are significant differences in the level of TPACK integration among teachers with different academic backgrounds.

H4: There are significant differences in the level of TPACK integration among teachers of different specializations (e.g., Mathematics, Science, Social Sciences, Languages, Primary Education, Vocational Education).

H5: There are significant differences in the level of TPACK integration between teachers holding temporary or permanent positions.

H6: There is a significant relationship between the level of integration of pedagogical technology and content knowledge and the success in using the virtual learning environment, the TPACK level of **the teachers predicting the success of the VLE.**

Methodology

Participants and sampling

The study included 107 pre-university teachers from the public school system who voluntarily participated to the study. A convenience sampling method was employed, and data collection was conducted through an online questionnaire distributed on Google Forms platform. The participants are represented by a diverse group of educators of various age ranges, teaching environments, academic backgrounds, subject specialization, and position status.

The majority of participants were comprised in the 30 to 39 years old range (38.3%) and in the 40- 49 years range (32.7%). Younger teachers (under 25 and 25-29) accounted for 8.4% and

11.2% of the sample, respectively, while older participants (50-59 and over 60) comprised 8.4% and 0.9%. Also, the most part of the participants worked in urban environments (66.4%), while 33.6% were based in rural areas.

In what concerns the academic background of the teachers, nearly all participants held higher education qualifications. The majority had earned a bachelor's degree (52.3%), followed by master's degree holders (43%). A small proportion reported having a Ph.D. (1.9%), while 2.8% declared high school as their highest level of education.

The largest proportion of participants were primary education teachers (43.9%), followed by vocational educators (18.7%), language teachers (15.9%), social sciences teachers (10.3%), sciences teachers (8.4%), and mathematics teachers (2.8%). Moreover, in terms of the position status, the majority of participants (61.7%) have indicated to held a temporary position, while 38.3% indicated their position as a permanent one.

Instruments

The Virtual Learning Environment Success (VLES) Scale developed by Awang and collaborators (2018) was used to assess in-service teachers' satisfaction regarding the use of VLE in their teaching practice. The VLES scale comprises 45 items grouped in 7 dimensions, namely the information quality, system quality, service quality, intention to use, use, user satisfaction and the net benefits perceived by the teachers. The scale has an optimal internal consistency, the alpha Cronbach value stated by the authors of the scale being between 0.95 to 0.97 for each variable (Awang et al., 2018). For the sample of this study the Virtual Learning Environment Success Scale exhibited a Cronbach's alpha of .967, indicating an excellent level of reliability.

The TPACK questionnaire (Liu et al., 2015) (ANEX 7) was employed for measuring teachers' TPACK as it is a well-known and validated instrument that aligns with study's focus on teachers' technological pedagogical content knowledge. This questionnaire consists of 29 items organized in 7 dimensions: Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Knowledge (TK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), Technological Pedagogical Content Knowledge (TPACK). The TPACK questionnaire showed a Cronbach's alpha of .944 for the current sample, suggesting an excellent level of reliability.

Procedure

The participants to the study are pre-university in-service teachers who are enrolled in a master's degree or a professional conversion program to another teaching subject at a well-known Romanian University. Teachers were informed about the purpose of the study, and their informed consent was obtained prior to the data collection. The participation was voluntary, ensuring that the teachers could withdraw at any stage without providing a reason. In order to complete the items of the questionnaire they had to access the link to the Google Forms platform. The online questionnaire included clear instructions and took approximately 15 minutes to complete.

Results

The investigation of the results started with a normality test of the VLE success and TPACK scores. Therefore, we used the Kolmogorov-Smirnov and Shapiro-Wilk tests. The results indicated that while VLE success scores were approximately normally distributed (Kolmogorov-Smirnov statistic = 0.056, $p = 0.200$; Shapiro-Wilk statistic = 0.979, $p = 0.094$), TPACK scores deviated from normality (Kolmogorov-Smirnov statistic = 0.117, $p = 0.001$; Shapiro-Wilk statistic = 0.975, $p = 0.042$). Therefore, non-parametric tests like Spearman's correlation were used. Moreover, the Kruskal-Wallis test was applied in order to compare groups that have more than two categories (e.g., age groups, specialization), while the Mann-Whitney U test was employed for making comparisons between two groups (e.g., rural vs. urban teaching environments, temporary vs. permanent position status of the teachers).

Based on these findings, we proceeded to verify the validity of the following research hypothesis:

H1: There are significant differences in the level of TPACK integration among teachers belonging to different age categories.

In order to determine if there were differences in the level of TPACK integration based on teachers' age a Kruskal-Wallis test was conducted. The results showed no statistically significant difference between the success level of TPACK integration perceived by teachers when teaching in the virtual environment according to the age group they belong to, $\chi^2(4) = 4.689$, $p = .321$. Therefore, we fail to reject the null hypothesis (Table 8.1).

Table 8.1

Kruskal-Wallis Test: Age & TPACK

Age Group	N	Mean Rank	Test	df	p-value

			Statistic		
Under 25	9	74.50			
25-29	12	54.29			
30-39	41	53.67	$\chi^2 = 4.689$	4	p = .321
40-49	35	50.69			
50-59	10	48.15			

H2: There are significant differences in the level of TPACK integration among teachers teaching in different environments (rural, urban).

The Mann-Whitney U test was performed in order to compare the level of TPACK integration between teachers based in rural and urban environments. The results showed no significant difference between these two groups, U = 1101.0, p = .243. Hence, the null hypothesis could not be rejected (Table 8.2).

Table 8.2

Mann-Whitney Test: Environment & TPACK

Environment	N	Mean Rank	Test Statistic	p-value
Rural	36	58.92	U = 1101.0	p = .243
Urban	71	51.51		

H3: There are significant differences in the level of TPACK integration among teachers with different academic backgrounds.

To assess the relationship between teachers' academic background and the level of TPACK integration a Kruskal-Wallis test was conducted, the results revealing no significant differences, $\chi^2(3) = 1.870$, p = .393, consequently supporting the null hypothesis (Table 8.3).

Table 8.3

Kruskal-Wallis Test: Academic background & TPACK

Academic Background	N	Mean Rank	Test Statistic	df	p-value
High School	3	29.33			
B.A. Degree	56	53.52	$\chi^2 = 1.870$	2	p = .393
M.A. Degree	46	53.91			

H4: There are significant differences in the level of TPACK integration among teachers of different specializations (e.g., Mathematics, Science, Social Sciences, Languages, Primary Education, Vocational Education).

The Kruskal-Wallis test was performed in order to check for the differences concerning the level of TPACK integration across the different subject specializations. The results showed no significant differences, $\chi^2(5) = 1.623$, $p = .898$, suggesting there was no effect of the subject taught by the teachers upon the TPACK score registered by the teachers (Table 8.4).

Table 8.4

Kruskal-Wallis Test: Subject taught & TPACK

Specialization	N	Mean Rank	Test Statistic	df	p-value
Mathematics	3	39.33			
Sciences	9	46.28			
Social Sciences	11	57.95			
Languages	17	57.47	$\chi^2 = 1.623$	5	p = .898
Primary	47	54.04			
Vocational	20	54.45			

H5: There are significant differences in the level of TPACK integration between teachers holding temporary or permanent positions.

For assessing whether the position status held by the teachers has an impact on the level of TPACK integration a Mann-Whitney U test was carried out. With a U = 1273.5 and a p = .610 (Table 8.5), it has been found that there is no significant difference between the temporary and permanent position holders, indicating that the position status does not affect the level of TPACK integration.

Table 8.5

Mann-Whitney Test: Position Status & TPACK

Position Status	N	Mean Rank	Test Statistic	p-value
Temporary	66	55.20	U = 1273.5	p = .610
Permanent	41	52.06		

TPACK & VLE Success Relationship

H6: There is a significant relationship between the level of integration of pedagogical technology and content knowledge and the success in using the virtual learning environment, the TPACK level of **the teachers predicting the success of the VLE.**

A linear regression analysis was performed to investigate the relationship between TPACK and VLE success among pre-university teachers. The results showed that teachers' TPACK level significantly predicts the VLE success ($\beta = 0.486$, $p < .001$), explaining 23.6% of the variance in VLE success as $R^2 = 0.236$, and with a $F(1,105) = 32.391$, ($p < .001$). The unstandardized regression coefficient ($B = 0.595$) indicates that for each unit increase in TPACK, VLE success increases by 0.595 units (Table 8.6, Table 8.7, Table 8.8).

Table 8.6

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.486[a]	.236	.228	.46790

a. Predictors: (Constant), TPACK Overall
b. Dependent Variable: VLE Success Overall

Table 8.7

ANOVA

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7.091	1	7.091	32.391	.000[b]
	Residual	22.988	105	.219		
	Total	30.079	106			

a. Dependent Variable: VLE Success Overall
b. Predictors: (Constant), TPACK Overall

Table 8.8.

Regression coefficients

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.588	.431		3.682	.000
	TPACK Overall	.595	.105	.486	5.691	.000

For the purpose of assesing the relationship between teachers' TPACK level and VLE succes a non-parametric alternative was used due to the fact that the distribution of the TPACK variable is not normal. Therefore, in this case, Spearman's rank-order correlation has been used to assess the strength and direction of the relationship between the levels of TPACK and VLE success. This test does not assume normality and is suitable for ordinal data or continuous data that are not normally distributed. The Spearman's rho coefficient (r_s= .515, p < .001, N = 107) (Table 8.9) has confirmed a strong positive correlation between the two variables of the study, namely teachers' pedagogical technology and content knowledge integration level and the success they perceived concerning the virtual learning environment usage in their classroom practice. These results confirm the robustness of the relationship identified by parametric test.

Table 8.9

Correlation coefficients

Correlations

			TPACK Overall	VLE Success Overall
Spearman's rho	TPACK Overall	Correlation Coefficient	1.000	.515**
		Sig. (2-tailed)	.	.000
		N	107	107
	VLE Success Overall	Correlation Coefficient	.515**	1.000
		Sig. (2-tailed)	.000	.
		N	107	107

**. Correlation is significant at the 0.01 level (2-tailed).

As may be seen in the table below, we have addressed not only the relationship between the overall TPACK and VLE Success scores achieved by the in-service teachers, but also deeper insights into the relationships between the components of the TPACK framework and the components of the Virtual Learning Environment Success (VLES) scale. Therefore, the Spearman's rho coefficients were computed in order to assess these relationships, the results indicating several significant associations (Table 8.10).

Table 8.10

Correlation coefficients VLE and TPACK

VLE Success components	TPACK components***						
	CK	**PK**	**TK**	**PCK**	**TCK**	**TPK**	**TPACK**
Information Qualit	0.127	0.337**	0.315**	0.292**	0.332**	0.303**	0.310**
System Quality	0.183	0.358**	0.278**	0.318**	0.263**	0.322**	0.293**
Service Quality	0.307**	0.486**	0.284**	0.224*	0.223*	0.376**	0.280**
Intention to Use	0.203*	0.404**	0.462**	0.291**	0.455**	0.453**	0.490**
Use	0.202*	0.418**	0.375**	0.175	0.326**	0.303**	0.333**
User Satisfaction	0.279**	0.507**	0.328**	0.273**	0.428**	0.395**	0.370**
Net Benefits	0.204*	0.439**	0.245**	0.127	0.230**	0.254**	0.312**

*** Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Knowledge (TK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), Technological Pedagogical Content Knowledge (TPACK)

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

As clearly illustrated by the table above PK, TK, PCK, TCK, TPK and TPACK components have registered moderate positive significant correlations with the Information Quality and the System Quality of the VLE, with correlation coefficients ranging between r_s= 0.263 and r_s= 0.358, with a p< 0.01, highlighting the contribution of these integrative knowledge forms to information and system quality perceived as offered by the VLE.

Significant moderate correlations were also found across the majority of components in terms of Service Quality, operationalized as responsiveness, assurance, empathy and tangibility. In this case, stronger associations were observed for PK (r_s= 0.486, p<0.01) and TK (r_s= 0.284, p< 0.01), but also CK has shown to have a significant association (r_s= 0.307, p< 0.01). These findings empower us to imply that both pedagogical and technological expertise enhance teachers' satisfaction with VLE services.

Teachers' Intention to Use VLE was observed to correlate stronger with TK (r_s= 0.462, p< 0.01) and TPACK (r_s = 0.490, p< 0.01), this suggesting the fact that technological and integrative TPACK knowledge significantly impact their intention to use VLEs. Nevertheless, in what concerns the VLE usage, understood as frequency and nature of usage (testing students, gathering educational information, accessing resources or communicating to students and colleagues), PK and all the technology-related dimensions demonstrated strong correlations, particularly TK (r_s= 0.462, p< 0.01) and TPACK (r_s= 0.490, p< 0.01). Whereas VLE success is concerned, the critical roles are played by PK (r_s= 0.507, p<0.01) and TPK (r_s= 0.395, p< 0.01) in enhancing teachers' satisfaction.

When it comes to VLE's Net benefits, namely perceiving VLE as being time-saving or improving teachers' productivity and contributing to their personal development, significant positive correlations were found specially with PK (r_s= 0.439, p< 0.01) and the TPACK dimension (r_s= 0.312, p< 0.01).

As it has been shown, the current results indicate that the integrated components of TPACK, particularly TPACK, TPK, and PK, reliably show moderate to strong positive correlations with the dimensions of VLE success, particularly with Intention to Use, User Satisfaction, and Net Benefits. This suggests that teachers' ability to synthesize technological, pedagogical, and content knowledge significantly influences their effective use and perceptions of virtual learning environments. However, CK component alone showed weak and in majority non-significant correlations, indicating that domain-specific content knowledge is less directly relevant to the success of VLE without the integration of the technological and pedagogical dimensions.

The findings of the present study highlight the critical role played by the integration of the TPACK components in driving the success of the VLE. To sum up, we may advocate that teacher training programs should focus on fostering a holistic integration of technology, pedagogy, and content knowledge in order to maximize the effectiveness and the benefits of the virtual learning environments perceived by in-service pre-university teachers.

Conclusion and discussion

The main concern of the paper was to analyse the relationship between in-service teachers' perceived TPACK integration in their teaching practice and the success level registered through the usage of the virtual learning environment. To our knowledge, this is the first Romanian study to examine the link between the two educational constructs. We have also considered the consequences of some demographic factors that may have an implication in integrating the TPACK framework in the educational process.

Summing up the results of the study, it can be concluded that teachers' TPACK level plays a significant role in the success of virtual learning environments perceived by the teachers. However, no significant differences were observed when considering the demographic factors such as teachers' age, environment, academic background, specialization or position status. Furthermore, the linear regression analysis revealed that TPACK significantly predicts VLE success, a finding reinforced by the Spearman's correlation analysis conducted due to the non-normality of the TPACK scores. These results highlight the need for focused professional development programs that enhance TPACK competencies for virtual teaching success no matter the demographic variables. Therefore, an important implication of these findings resides in the fact that enhancing TPACK skills could lead to more effective use of digital tools, fostering better outcomes in terms of virtual learning environments usage.

The paper clearly has shown that higher levels of TPACK are associated with higher levels of success in the virtual learning environment. Therefore, enhancing teachers' ability to integrate technology with pedagogy and content can lead to better outcomes in virtual teaching environments. Moreover, the results are of direct practical relevance, consequently we may state that in order to improve teachers' TPACK skills and also the effectiveness of their teaching practice in the virtual environment some of the following measures may be implemented:

- integrating TPACK into initial and continuing training programs;
- promoting the exchange of good practices;
- updating educational policies.

One of the first limitations that should be acknowledged involves of the use of a convenience sampling which may have restricted the generalizability of this study's findings. Additionally, the reliance on self-reported measures may present the possibility of a response bias. With a view to overcoming the limitations of this investigation mixed-methods research appears to be needed for a better understanding of the relationship between teachers' TPACK levels and VLE outcomes in different educational contexts. Nevertheless, future research could explore longitudinal impacts of TPACK training on VLE outcomes and investigate the contextual factors that affect its application in different learning environments.

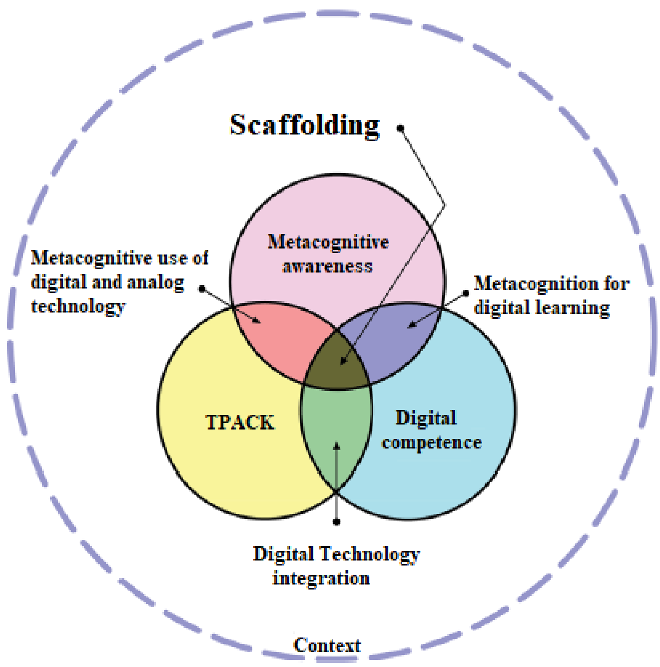
CHAPTER 9. FORMATIVE INTERVENTION PROGRAMS

9.1 Introduction. Theoretical background

The reflections highlighted in the preliminary studies have enabled us to draw the conclusions on the design, content and focus of the formative intervention program, following the conceptual model developed across the research, namely the "Scaffolded Digital, Technological and Metacognitive Learning Framework" (SDTMLF).

Figure 9.1

The Scaffolded Digital, Technological and Metacognitive Learning Framework (SDTMLF)



The above illustrates how TPACK, digital competence, and metacognitive awareness interact and overlap. The TPACK framework focuses on integrating technology, pedagogy, and content knowledge, while digital competence encompasses digital resource management and teaching strategies aligned with technological skills. Metacognitive awareness includes metacognitive knowledge and metacognitive regulation.

The overlaps of these three main components of the Framework proposed above are the following:

- Scaffolding: representing the core of the proposed intervention model that would enhance the digital, TPACK and metacognitive competences.
- Digital technology integration (at the intersection of TPACK and digital competence) - highlighting the effective use of digital tools in pedagogy.
- Metacognitive use of digital and analog technology (at the intersection of TPACK and metacognitive awareness) - highlighting the reflective integration of technology with teaching strategies.
- Metacognition for digital learning (at the intersection of Digital Competence and metacognitive awareness) – refers to applying the metacognitive strategies in order to manage and adjust digital learning environments.

Mainly, the preliminary studies' research results determined us to consider which activities to include in the SDTMLF- based intervention programs for Metacognitive, VLE success, Digital competence and TPACK development through scaffolding:

- digital competence training of future teachers in terms of critically choosing, changing or creating educational digital resources;
- metacognitive awareness, developing a reflective practice pattern while designing a VLE-based lesson plans respecting an online adapted form of the 5E learning cycle and by applying metacognitive strategies like reflexive journaling, collaborative learning, addressing the right questions while getting theoretical and practical competence during tasks.

9.2 Scaffolding considerations

During the program participants were the beneficiaries of one-to-one scaffolding from the instructor/ researcher and from the peer group as all the main tasks were solved in the context of collaborative learning. The metacognitive scaffolding provided by the instructor was done by demonstrating the process during seminar activities, explaining metacognition to students, demonstrating what it means to learn metacognitively, and asking them to share their own metacognitive experiences. The scaffolding strategy refers to guidance according to the level of the students with a gradual reduction of the support as students' skills increase, and by guiding students to share information and ideas to solve tasks in particular during collaborative learning (Pifare & Cobos, 2010).

9.3 The Relationship Between Metacognition and TPACK

The relationship between metacognition and the Technological, Pedagogical, and Content Knowledge (TPACK) framework is an emerging area of interest in educational research. Metacognition, which involves the awareness and regulation of one's cognitive processes, plays an essential role in how educators can integrate technology, pedagogy, and content knowledge effectively.

In terms of metacognitive awareness and TPACK Development, Doering et al. (2009) show that teachers who took part in TPACK-based professional development programs showed significant improvements in their metacognitive awareness of TPACK domains. This suggests that enhancing metacognitive skills can lead to better integration and understanding of TPACK components (Doering et al., 2009).

Metacognition could be considered as a driver for TPACK integration. A study on computer programming skills highlighted the importance of metacognition in navigating and integrating technological, pedagogical, and content knowledge, recommending combining TPACK with metacognitive strategies to help learners achieve their goals by maintaining high self-awareness and effectively managing their cognitive processes (Pavan et al., 2023). Moreover, there are also authors like Zeng and colleagues (2022) showing that teachers' confidence in using technology is linked to better TPACK integration, which can be enhanced through metacognitive strategies. This research highlights a strong relationship between metacognition and TPACK, as enhancing metacognitive awareness and strategies can significantly improve teachers' ability to integrate technology, pedagogy, and content knowledge. This relationship is further supported by the positive correlation between self-efficacy in technology use and TPACK, suggesting that metacognitive skills are essential for effective educational technology integration.

9.4 The 5E model as a promoter of metacognition

The 5E model (Engage, Explore, Explain, Elaborate, Evaluate) is a widely used instructional framework designed to enhance learning by promoting active engagement and inquiry-based learning. This model has been shown to be effective in various educational settings, particularly in fostering metacognitive skills, which involve self-awareness and self-regulation of one's cognitive processes.

The literature on the 5E Learning Cycle highlights the fact that this model enhances critical thinking skills. The 5E Learning Cycle combined with metacognitive techniques significantly improves students' critical thinking skills in mathematics compared to the 5E model alone and

conventional learning methods. This enhancement is seen across different levels of students' mathematical prior ability (Runisah et al., 2017).
Another evidence of these model’s benefits comes from research on the development and validation of this type of lesson plans. For example, Meher & Baral (2022) state in their study that the development of 5E metacognitive lesson plans has been proved to have good content validity, making them effective for teaching high school students, these plans being designed to integrate metacognitive strategies within the 5E framework, and consequently to promote metacognitive skills.
Moreover, the 5E Learning Cycle has been also investigated for the stimulation of metacognitive abilities in early education. Yusuf and colleagues (2023) have shown that a learning model that incorporates the 5E continuum approach effectively stimulates the metacognitive abilities of kindergarten children. This model integrates a science process approach that fosters curiosity and creative thinking, which are essential for developing the metacognitive skills.
Additionally, the model facilitates the improvement in students' mathematical creative thinking skills more effectively than the 5E model alone or conventional learning. This improvement is consistent across different levels of students' mathematical prior ability (Runisah, 2019).
The 5E model was selected for this formative intervention programme as it significantly promotes metacognitive skills by enhancing critical thinking skills, particularly when it is combined with the metacognitive techniques. This approach was proved to be effective across various educational levels, from kindergarten to high school, and it is validated as practical and effective in stimulating metacognitive skills. Integrating metacognitive strategies within the 5E framework provides a robust method for developing students' self-regulation in the learning processes.

Table 9.1

Variables’ operationalization

<table>
<tr><th>Construct</th><th>Dimensions</th><th>Measurements</th></tr>
<tr><td rowspan="4">VLE Success (Virtual Learning</td><td>Information Quality</td><td>Accuracy, Relevance, Sufficiency, Format, Currency, Timeliness & Reliability.</td></tr>
<tr><td>System Quality</td><td>Availability, Usability, Accessibility & Reliability.</td></tr>
<tr><td>Service Quality</td><td>Responsiveness, Assurance, Empathy & Tangible.</td></tr>
<tr><td>Intention to Use</td><td>Future Intention to Use/Reuse</td></tr>
</table>

Environment Success)	Use	Regularity of Use, Nature of Use
	User Satisfaction	User Survey, Enjoyment & Overall Satisfaction.
	Net Benefits	Time-Saving, Improved Productivity & Personal Valuation.
Digital competencies (DigCompEdu)	Professional engagement	Organizational Communication, Professional Collaboration, Reflective Practice, Digital Continuous Professional Development.
	Digital resources	Selecting Digital Resources, Creating and Modifying Digital Content, Managing, Protecting and Sharing Digital Resources
	Teaching and learning	Teaching, Guidance, Collaborative Learning, Self-Regulated Learning
	Assessment	Assessment Strategies, Analysing Evidence, Feedback and Planning
	Empowering learners	Accessibility and Inclusion, Differentiation and Personalization, Actively Engaging Learners
	Facilitating learners' digital competence	Information and Media Literacy, Digital Communication and Collaboration, Digital Content Creation, Responsible Use, Digital Problem Solving
Metacognitive awareness (MAI)	Metacognitive knowledge	Declarative Knowledge, Procedural Knowledge, Conditional Knowledge
	Metacognitive regulation	Planning, Information Management Strategies, Monitoring, Debugging Strategies and Evaluation of Learning
TPACK Only for 2023-2024 generation	Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Knowledge (TK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), Technological Pedagogical Content Knowledge (TPACK).	

9.5 Research hypotheses

H1: Students who participate in a formative program based on scaffolding will have higher levels of metacognitive awareness, digital competence and success in Virtual Learning Environments (VLE) at the end of the program.

H2: Students who participate in a formative program based on scaffolding will have higher levels of metacognitive awareness, digital competence, success in Virtual Learning Environments (VLE) and TPACK integration at the end of the program.

9.6 Research Design

To achieve the present study' s objectives we have adopted a design-based research approach that enabled us to investigate the development of pre-service teachers' TPACK, digital competence, metacognitive awareness and VLE Success in the context of virtual learning environments usage.

Design-based research has been described as having several defining features, namely:

- Pragmatism, as the methodology focuses on investigating practical issues while also drawing on theory. Both theory and practice are integral parts of the design-based approach and mutually influence each other.
- Theoretically grounded within existing theories and designs, and it is embedded in ecological contexts.
- Characterized by interactive, cyclical, and adaptable processes, researchers actively participating in the design process, working closely with the participants to the study using iterative cycles of analysis, design, implementation, and redesign.
- Integrative, since researchers use mixed methods across different phases as new needs and issues emerge throughout the study.
- Contextual: The research process and outcomes evolve dynamically throughout the study, which are correspondingly documented. Furthermore, the findings are contextualized to the specific process and environments, reflecting variations in what concerns the content and depth of the design principles (Wang & Hannafin, 2005).

The design-based research approach soundly aligns with the study of teachers' development of Technological Pedagogical Content Knowledge (Pareto & Willermark, 2018), especially due to the situated and contextualized nature of TPACK development, in which teachers engage with technology, pedagogy, and content in specific classroom settings (Zhang & Tang, 2021). Moreover, recent TPACK research has highlighted the importance of providing scaffolding to support teachers in integrating technology with pedagogy and content knowledge (Pareto & Willermark, 2018). Such scaffolding can take the form of modeling, peer collaboration, and just-in-time support, all of which are central to the design-based research process. The iterative cycles of the design-based approach also allow for the exploration of how teachers' TPACK develops over time through these various forms of support (Pareto & Willermark, 2018).

Table 9.2

Formative intervention

<table>
<tr><th>Phase</th><th>Duration</th><th>Activities</th></tr>
<tr><td>Pretest</td><td>1h</td><td>Initial asssesment of:
- Metacognitive awareness,
- Digital Competence,
- VLE Success,
- TPACK (only 2023-2024 generation).</td></tr>
<tr><td>Intervention</td><td>2h each</td><td>❖ Meetings, 1 per week
❖ 2 types of scaffolding (One-to-one & peer group);
❖ Activities:
1. introducing students to the general importance of planning, monitoring, and evaluating, and to the Ace Your Self-Study mobile application that supports self-regulated learning by prompting metacognitive strategies.
2. Reflective practice through a critical analysis of the online/ virtual reality lessons study cases according to the criteria from the grid;
3. Planning a lesson according to the 5 E adapted model for online/ blended learning educational design
4. Creating a robot/ prototype Design Journal according to the design-decision pentagon (Barlex, 2007).
5. Reflecticting on the process of designing and creating the prototype.
6. LEGO® Education SPIKE™ Essential (only 2023-2024 generation).</td></tr>
<tr><td>Posttest</td><td>1h</td><td>Final asssesment of :
- Metacognitive awareness,
- Digital Competence,
- VLE Success,
- TPACK (only 2023-2024 generation).</td></tr>
</table>

9.7 Participants

All the participants to the studies were enrolled in the Bachelor’s degree program at a well-known Romanian university, studying to become pre-primary and primary school teachers.

The first formative intervention program involved 59 students in their last year of undergraduate studies (3rd year – 2022-2023 generation). They were all females with a mean age was around 21.44 years old.

For the second intervention program, we had 28 students in their last year of undergraduate studies (3rd year – 2023-2024 generation) with a mean age of 22.54 years old.

The inclusion into the sample criteria comprised the participation to all the seminar tasks and the filling of both pretest and posttest questionnaires.

9.8 Instruments

- The Validated Measurement for Virtual Learning Environment Success (VLE) (Awang et al, 2018) (ANEX 5) is a self-reported scale with 45 items measured on a 5-point Likert scale. The scale has 7 dimensions: (1) information quality (7 items), system quality (7 items), service quality (9 items), intention to use (4 items), use (9 items), user satisfaction (4 items) and net benefits (5 items). Participants are asked to rate their agreement on a 5-point scale, ranging from strong disagreement to strong agreement. The VLE scale has very good psychometric properties reported in the literature, with alpha Cronbach of each variable within 0.95 to 0.97. The scale has also strong content validity, with s-CVI/Ave values ranging from 0.81 to 0.93 (for the seven dimensions of the scale) (Awang et al, 2018). The factor structure analysis revealed that all Kaiser-Meyer-Olkin (KMO) values were above 0.81 (with the highest value of 0.93), the Eigen Values were higher that 1 for all seven dimensions and the Sphericity Bartlett Test lower than 0.5 for all seven dimensions (Awang et al, 2018). The Cronbach' Alpha of VLE in our first intervention study was 0.923 and for the second one was 0.829.
- The DigCompEdu questionnaire (Anex 3) was developed according to The European Commission's framework (2017) for the Digital Competence of Educators. The questionnaire has 22 statements that assess teachers' digital technology practice, which are organized into 6 areas: professional engagement (4 items), digital resources (3 items), teaching and learning (4 items), assessment (3 items) and empowering learners (3 items) and facilitating learners' digital competence (Punie & Redecker, 2017). The DigiCompEdu questionnaire asseses the frequency, confidence and impact of digital tools in the educational field and has both multiple-choice and Likert-scale items. Good psychometric properties of the DigiCompEdu survey have been reported in the literature:

CFI = 0.994; KMO = 0.977 and a Sphericity Bartlett Test lower than 0.5 (Párraga et al., 2022). Further studies also reported very good psychometric properties of the scale: Camero-Almenara et al., 2020; Horváth et al., 2025; Gallardo-Echenique et al., 2023. In the first intervention program data analysis revealed an Cronbach' Alpha value of 0.878 and in the second one the value was 0.881.

- The Metacognitive Awareness Inventory (MAI) (ANEX 6) was developed by Scraw and Sperling-Dennison in 1994. The scale has 52 items which are measured on a 5-point Likert scale. Although the scale has not been validated on the Romanian population, it has been widely used in different Romanian studies, so it has been translated in Romanian by many researchers. The main two dimensions of the scale are knowledge of cognition and regulation of cognition. The first dimension has the following sub-scales: declarative knowledge, procedural knowledge and conditional knowledge. The second one comprises planning, information management strategies, monitoring, debugging strategies and evaluation of learning. The literature reports good psychometric properties for MAI, with CFI = .968, IFI = .965, SRMR =.047 and RMSEA = .040 (Gutierrez de Blume, 2024). The reliability coefficient (Cronbach' Alpha) of the MAI was 0.890 in the first intervention program and 0.791 in the second intervention.
- The TPACK questionnaire (Liu et al., 2015) was employed for measuring teachers' TPACK as it is a well-known and validated instrument that aligns with study's focus on teachers' technological pedagogical content knowledge. This questionnaire consists of 29 items organized in 7 dimensions: Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Knowledge (TK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), Technological Pedagogical Content Knowledge (TPACK). The TPACK questionnaire showed a Cronbach's alpha of .898 for the current sample, suggesting a very good level of reliability.

9.9 Data collection

Pretest and posttest data was gathered during the course of Technology Education Didactics, held by an experienced professor, and all the formative tasks were performed during the seminar classes of this. The data collection was realized after a prior consent stating the purpose of the present research and the voluntary nature of the participation to the study. The questionnaire was in the paper and pencil format. Participants were asked to think of them as in-service teachers, with their actual competences and mindset, and respond as they would act in the situation described by the items of the questionnaire.

9.10 Results of the 1st formative intervention

The main hypothesis of the study asserts that students who participate in a formative program based on scaffolding will have higher levels of metacognitive awareness, digital competence and succes in Virtual Learning Environments (VLE) at the end of the program. The paired-samples t test was used to check the effect of scaffolding on each dependent variable included in the study. The results are illustrated in the following section.

1. Metacognitive awareness

H1: Students who will participate in a formative program based on scaffolding will have higher levels of metacognitive awareness at the end of the program.

If our training program has an impact on metacognitive awareness, then students who participate in it should have higher levels of metacognitive awareness at the end of the program compared to the level they had before entering the program. The results of the statistical analysis are presented in Table 9.3.

Table 9.3

Paired-samples t test for metacognitive awareness

	Pre-test		**Post-test**		**t**	**df**	**Sig**	**d**
Variable	**M**	**SD**	**M**	**SD**				
Metacognitive awareness	3.87	.33	4.04	.21	40.034	58	.000	0.614
Regulation of cognition	3.83	.37	4.04	.25	-3.620	58	.001	0.665
Knowledge of cognition	3.92	.39	4.06	.30	-2.157	58	.035	0.402
Declarative knnowledge	3.96	.42	3.98	.44	-1.313	58	.194	0.046
Conditional knowledge	3.87	.45	4.07	.51	-1.373	58	.175	0.415
Procedural knowledge	3.89	.60	4.03	.54	-2.464	58	.017	-
Planning	3.86	.50	3.88	.36	-.159	58	.874	-
Comprehension monitoring	3.56	.48	4.05	.58	-5.331	58	.000	0.920
Information management strategies	4.05	.37	4.12	.48	-.849	58	.399	-
Debugging	4.13	.51	4.16	.41	-.360	58	.720	-
Evaluation	3.54	.49	3.99	.56	-4.378	58	.000	0.855

According to Table 9.3, we can conclude that scaffolding increases students' metacognitive awareness. The mean differences between students' metacognitive awareness scores differ significantly between the time of entering the program and the end of the program: t(58) = 40.034, p = 0.000. Scaffolding increases both students' metacognitive knowledge (t = - 2.157, p = 0.035) and regulation of cognition (t = - 3.620, p = 0.001). The lowest impact of scaffolding seems to be on planning, debugging, and declarative knowledge. The effect size coefficient indicates high effects for comprehension monitoring (d = 0.920) and evaluation (0.855). The effects sizes shoes medium effects (d = 0.402) to large ones (d = 0.920). However, the overall effect of scaffolding on metacognitive awareness is medium (d = 0.614). Considering these results, we reject the null hypothesis.

The highest increase in scores is for comprehension monitoring and evaluation sub-dimensions of metacognitive awareness.

2. <u>Digital competence</u>

The second hypothesis tested in the study is listed below:

H1: Students who will participate in a formative program based on scaffolding will have higher levels of digital competence.

The paired-samples t test is illustrated in Table 9.4.

Table 9.4

Paired-samples t test for digital competence

	Pre-test		**Post-test**		**t**	**df**	**Sig**	**d**
Variable	**M**	**SD**	**M**	**SD**				
Digital competence	53.61	12.48	61.30	9.28	-4.536	58	.000	0.665

Scaffolding significantly increases students' digital competence (t(58) = -4.526, p = 0.000), having an average effect on digital competence, with d = 0.665.

The mean in students' scores on digital competence increases with almost 10 points after attending the formative program based on scaffolding.

3. <u>Success in Virtual Learning Environments (VLE)</u>

How scaffolding influences success in Virtual Learning Environments (VLE) is analyzed through testing the following hypothesis:

H1: Students who will participate in a formative program based on scaffolding will have higher levels of VLE success.

The related-samples t test results can be seen in Table 9.5.

Table 9.5

Paired-samples t test for VLE success

	Pre-test		**Post-test**		**t**	**df**	**Sig.**	**d**
Variable	**M**	**SD**	**M**	**SD**				
VLE	4.04	.409	4.11	.428	-.833	58	.408	-
Information quality	4.00	.518	4.09	.498	-1.418	58	.161	-
System quality	4.19	.482	4.15	.449	.620	58	.537	-
Service quality	3.51	.594	3.69	.676	-1.951	58	.056	-
Intention to use	4.31	.558	4.33	.577	-.338	58	.736	-
Use	4.05	.466	4.23	.605	-2.494	58	.016	0.336
User satisfaction	4.27	.520	4.28	.522	-.181	58	.857	-
Net benefits	4.01	.572	4.05	.611	-.589	58	.558	-

Scaffolding does not appear to significantly increase student success on the VLE. For the overall scale, we obtained a t = - 0.833 and p = 0.408. All other comparisons were non-significant, except for the Use dimension for which we obtained a t = - 2.494 and p = 0.016. However, the effect size for the Use dimension was low (d = 0.336).

9.11 Results of the 2nd formative intervention

This study aims to offer an answer to the following question: "*Does scaffolding affects students' metacognitive awareness, digital competence, VLE success and TPACK scores*?". To answer this question, we measured students' level of metacognitive awareness, digital competence, VLE success and TPACK before benefiting from scaffolding and after the scaffolding intervention program.

This research is based on the hypotheses that students who engage in a scaffolded teaching program will have higher levels of metacognitive awareness, digital literacy, VLE success, and TPACK after completing the program. To test this general hypothesis, we formulated four secondary hypothesis, for each dependent variable included in the study.

Because the sample of this study was below 30 (n = 28) and the data do not follow the normal distribution we decided to use the Wilcoxon Signed Ranks Test, the non-parametric equivalent of the between-samples t test.

1. <u>Metacognitive awareness</u>

In the case of metacognitive awareness, we verified the following hypothesis:

H1: Students who will participate in a formative program based on scaffolding will have higher levels of metacognitive awareness at the end of the program.

The Wilcoxon Signed Ranks Test (Table 9.7) was used to test the effect of scaffolding on metacognitive awareness. To identify the effect size, instead of using the Cohen d coefficient, we used the r coefficient after Rosenthal's (1994) proposal and we divided each z value by the square root of N. A value lower or close to 0.10 indicates a small effect, one around 0.30 a medium effect and values higher than 0.50 show large effects (Rosenthal, 1994).

Table 9.7

Wilcoxon Signed Ranks Test - metacognitive awareness

	Ranks						
		N	**Mean Rank**	**Sum of Ranks**	**z**	**p**	**r**
Metacognitive awareness post-test - Metacognitive awareness pre-test	Negative Ranks	7[a]	10.43	73.00			
	Positive Ranks	19[b]	14.63	278.00	-2.603	.009	0.491
	Ties	2[c]					
	Total	28					
Metacognitive knowledge	Negative Ranks	20[1]	30.15	603.00			
	Positive Ranks	39[2]	29.92	1167.00	-2.129	.003	0.402
	Ties	0[3]					
	Total	59					
Metacognitive regulation	Negative Ranks	18[4]	23.22	418.00			
	Positive Ranks	40[5]	32.33	1.293	-3.387	.001	0.640
	Ties	1[6]					
	Total	59					
Declarative knowledge post-test - Declarative Knowledge pre-test	Negative Ranks	6[d]	11.67	70.00			
	Positive Ranks	19[e]	13.42	255.00	-2.503	.012	0.473
	Ties	3[f]					
	Total	28					
Procedural Knowledge post-test - Procedural Knowledge pre-test	Negative Ranks	4[g]	10.88	43.50			
	Positive Ranks	16[h]	10.41	166.50	-2.311	.021	0.436
	Ties	8[i]					
	Total	28					
Planning pre-test – Planning post-test	Negative Ranks	6[j]	9.75	58.50			
	Positive Ranks	15[k]	11.50	172.50	-1.990	.047	0.376
	Ties	7[l]					

	Total	28					
	Negative Ranks	8[m]	12.31	98.50			
Comprehension Monitoring post-test - Comprehension Monitoring pre-test	Positive Ranks	16[n]	12.59	201.50	-1.481	.139	-
	Ties	4[o]					
	Total	28					
	Negative Ranks	9[p]	9.22	83.00			
Information Management Strategies post-test - Information Management Strategies pre-test	Positive Ranks	15[q]	14.47	217.00	-1.917	.055	-
	Ties	4[r]					
	Total	28					
	Negative Ranks	4[s]	12.50	50.00			
Debugging post-test – Debugging pre-test	Positive Ranks	18[t]	11.28	203.00	-2.495	.013	
	Ties	6[u]					0.471
	Total	28					
	Negative Ranks	10[v]	14.95	149.50			-
Evaluation post-test – Evaluation pre-test	Positive Ranks	15[w]	11.70	175.50	-0.352	.725	
	Ties	3[x]					
	Total	28					

a. Metacognitive awareness post-test < Metacognitive aareness pre-test / b. Metacognitive awareness post-test > Metacognitive awareness pre-test / c. Metacognitive awareness post-test = Metacognitive awareness pre-test

d. Declarative knowledge post-test < Declarative Knowledge pre-test / e. Declarative knowledge post-test > Declarative Knowledge pre-test / f. Declarative knowledge post-test = Declarative Knowledge pre-test / g. Procedural knowledge post-test < Procedural Knowledge pre-test / h. Procedural knowledge post-test > Procedural Knowledge pre-test / i. Procedural knowledge post-test = Procedural Knowledge pre-test / j. Planning post-test < Planning pre-test / Planning post-test > Planning pre-test / Planning post-test = Planning pre-test / m. Comprehension Monitoring post-test < Comprehension Monitoring pre-test / n. Comprehension Monitoring post-test > Comprehension Monitoring pre-test / o. Comprehension Monitoring post-test = Comprehension Monitoring pre-test / p. Information Management Strategies post-test < Information Management Strategies pre-test / q. Information Management Strategies post-test > Information Management Strategies pre-test / r. Information Management Strategies post-test = Information Management Strategies pre-test s. Debugging post-test < Debugging pre-test / t. Debugging post-test > Debugging pre-test / u. Debugging post-test = Debugging pre-test / v. Evaluation post-test < Evaluation pre-test / w. Evaluation post-test > Evaluation pre-test / x. Evaluation post-test = Evaluation pre-test

[1]Metacognitive knowledge post-test < Metacognitive knowledge pre-test / [2]Metacognitive knowledge post-test > Metacognitive knowledge pre-test / [3]Metacognitive knowledge post-test = Metacognitive knowledge pre-test / [4]Metacognitive regulation post-test < Metacognitive regulation pre-test / [5]Metacognitive regulation post-test > Metacognitive regulation pre-test / [6]Metacognitive regulation post-test = Metacognitive regulation pre-test

A Wilcoxon signed-rank test indicated that students' metacognitive awareness was significantly higher after completing the scaffolding program compared to their level before getting in the program. The median score on metacognitive awareness was 4.048 after completing the scaffolding formative program compared with 3.881 before entering the program. The results of the Wilcoxon Signed - Rank Test revealed a significant difference between the scores before and after the intervention, with $z = -2.603$, $p = .009$. Apart from comprehension monitoring, information management strategies and evaluation, all other subdimensions of metacognitive awareness were significantly influenced by our intervention.

A close analysis of Table 9.7 allows us to analyze the data in more detail. The positive ranks from the table show us the cases in which the post-test score exceeds the pre-test scores, the negative ones the opposite and the tied ranks show us that the two scores or measurements were equal. In the case of the metacognitive global score, we can establish that 7 scores were higher in the first or pre-test measurement (N=7; Mean rank = 10.43; Sum of ranks = 73.00), 19 were higher in the post-test measurement (N=19; Mean rank = 14.63; Sum of ranks = 278.00) and 2 scores were equal in both moments of assessment.

The effects sizes are medium to large, ranging between 0.376 and 0.640.

2. Digital competence

The hypotheses formulated to test the effect of scaffolding on digital competence are:

H1: Students who will participate in a formative program based on scaffolding will have higher levels of digital competence.

The hypothesis that students will increase their digital competence after participating in the scaffolding program was tested using the Wilcoxon Signed Ranks Test. In the Table 9.8 below we summarize our findings.

Table 9.8

Wilcoxon Signed Ranks Test – digital competence

	Ranks						
		N	**Mean Rank**	**Sum of Ranks**	**z**	**p**	**r**
Digital competence post-test – Digital competence pre-test	Negative Ranks	9[a]	10.83	97.50	-2.199	.028	0.415
	Positive Ranks	18[b]	15.58	280.50			
	Ties	1[c]					
	Total	28					

[a] DIG2 < Digital competence / [b] DIG2 > Digital competence / [c] DIG2 = Digital competence

The results in Table 9.8 show that the digital competence level was significantly higher after students complete the scaffolding program than before getting in the program, with z = -2.603, p = .009. Nine scores were higher in the pre-test (N= 9, Mean Ranks = 10.83, Sum of Ranks = 97.50), eighteen in the post-test (N= 15.58, Mean Ranks = 15.58, Sum of Ranks = 280.509) and one score remained unchanged. The effect size of the intervention is medium for digital competence.

3. VLE success

Another relevant hypothesis of the study is that students' success in VLE will increase after attending the scaffolding program. The alternative hypothesis concerning the VLE success are:

H1: Students who will participate in a formative program based on scaffolding will have higher levels of VLE success.

Table 9.9 summarizes the results for this variable.

Table 9.9

Wilcoxon Signed Ranks Test – VLE success

Ranks		N	Mean Rank	Sum of Ranks	z	p	r
VLE post-test – VLE pre-test	Negative Ranks	5[v]	14.70	73.50	-2.591	.010	0.489
	Positive Ranks	21[w]	13.21	277.50			
	Ties	2[x]					
	Total						
Information Quality Post-test - Information Quality Pre-test	Negative Ranks	8[a]	10.88	87.00	-2.642	.008	0.499
	Positive Ranks	20[b]	15.95	319.00			
	Ties	0[c]					
	Total	28					
System Quality Post-test - System Quality Pre-test	Negative Ranks	5[d]	7.10	35.50	-3.701	.000	0.699
	Positive Ranks	22[e]	15.57	342.50			
	Ties	1[f]					
	Total	28					
Service Quality Post-test - Service Quality Pre-test	Negative Ranks	15[g]	14.57	218.50	-1.095	.273	-
	Positive Ranks	11[h]	12.05	132.50			
	Ties	2[i]					
	Total	28					
Intension to Use Post-test - Intension to Use Pre-test	Negative Ranks	5[j]	8.10	40.50	-3.307	.001	0.625
	Positive Ranks	20[k]	14.23	284.50			
	Ties	3[l]					
	Total	28					
Use Post-test - Use Pre-test	Negative Ranks	6[m]	12.67	76.00	-2.719	.007	0.513
	Positive Ranks	21[n]	14.38	302.00			
	Ties	1[o]					
	Total	28					
User satisfaction Post-test - User satisfaction Pre-test	Negative Ranks	5[p]	8.80	44.00	-3.394	.001	0.641
	Positive Ranks	21[q]	14.62	307.00			
	Ties	2[r]					
	Total	28					
Net beneficies Post-	Negative Ranks	10[s]	12.90	129.00			

test - Net beneficies Pre-test	Positive Ranks	17[t]	14.65	249.00	-1.446	.148	-
	Ties	1[u]					
	Total	28					

a. Information Quality Post-test < Information Quality Pre-test / b. Information Quality Post-test > Information Quality Pre-test / c. Information Quality Post-test = Information Quality Pre-test / d. System Quality Post-test < System Quality Pre-test / e. System Quality Post-test > System Quality Pre-test / f. System Quality Post-test = System Quality Pre-test / g. Service Quality Post-test < Service Quality Pre-test / h. Service Quality Post-test > Service Quality Pre-test / i. Service Quality Post-test = Service Quality Pre-test / j. Intension to Use Post-test < Intension to Use Pre-test / k. Intension to Use Post-test > Intension to Use Pre-test / l. Intension to Use Post-test = Intension to Use Pre-test / m. Use Post-test < Use Pre-test / n. Use Post-test > Use Pre-test / o. Use Post-test = Use Pre-test / p. User satisfaction Post-test < User satisfaction Pre-test / q. User satisfaction Post-test > User satisfaction Pre-test / r. User satisfaction Post-test = User satisfaction Pre-test / s. Net beneficies Post-test < Net beneficies Pre-test / t. Net beneficies Post-test > Net beneficies Pre-test / u. Net beneficies Post-test = Net beneficies Pre-test / VLE Post-test < VLE Pre-test / VLE Post-test > VLE Pre-test / VLE Post-test = VLE Pre-test

The results in Table 9.9 show the effect of scaffolding on VLE success. VLE success was significantly higher after students completed the scaffolding program compared to their VLE success before attending the program, with z = -2.603, p = .009. Effect sizes range between 0.489 and 0.699, which indicate large effect sizes. The largest effect sizes were for system quality subscale, user satisfaction and intention to use.

4. <u>TPACK</u>

The last variable for which we tested the impact of scaffolding is TPACK, for which we have the following hypothesis.

H1: Students who will participate in a formative program based on scaffolding will have higher levels of TPACK.

The results of the Wilcoxon Signed Ranks Test are illustrated below (Table 9.10).

Table 9.10

Wilcoxon Signed Ranks Test – TPACK

Ranks		N	Mean Rank	Sum of Ranks	z	p	r
TotalTPACKpost - TPACK Total Pre-test	Negative Ranks	7[a]	7.93	55.50			
	Positive Ranks	19[b]	15.55	295.50	-3.049	.002	0.576
	Ties	2[c]					
	Total	28					
PKpost - PK Pre-test	Negative Ranks	8[d]	9.00	72.00			
	Positive Ranks	17[e]	14.88	253.00	-2.443	.015	0.461
	Ties	3[f]					
	Total	28					
CKpost - CK Pre-test	Negative Ranks	5[g]	11.90	59.50			
	Positive Ranks	19[h]	12.66	240.50	-2.607	.009	0.504
	Ties	4[i]					
	Total	28					
TKpost - TK Pre-test	Negative Ranks	10[j]	9.75	97.50			
	Positive Ranks	14[k]	14.46	202.50			-
	Ties	4[l]			-1.511	.131	
	Total	28					
PCKpost - PCK Pre-test	Negative Ranks	7[m]	13.00	91.00			
	Positive Ranks	17[n]	12.29	209.00			-
	Ties	4[o]			-1.703	.089	
	Total	28					
TPKpost - TPK Pre-test	Negative Ranks	9[p]	8.72	78.50			
	Positive Ranks	18[q]	16.64	299.50			0.505
	Ties	1[r]			-2.674	.007	
	Total	28					
TCKpost - TCK Pre-test	Negative Ranks	8[s]	9.94	79.50			
	Positive Ranks	15[t]	13.10	196.50	-1.789	.074	-
	Ties	5[u]					
	Total	28					
TPACKpost - TPACK Pre-test	Negative Ranks	7[v]	8.21	57.50			
	Positive Ranks	19[w]	15.45	293.50	-3.005	.003	0.567
	Ties	2[x]					
	Total	28					

a. TotalTPACKpost < TPACK Total Pre-test / b. TotalTPACKpost > TPACK Total Pre-test
c. TotalTPACKpost = TPACK Total Pre-test / d. PKpost < PK Pre-test / e. PKpost > PK Pre-test
f. PKpost = PK Pre-test / g. CKpost < CK Pre-test / h. CKpost > CK Pre-test / i. CKpost = CK Pre-test / j. TKpost < TK Pre-test / k. TKpost > TK Pre-test / l. TKpost = TK Pre-test
m. PCKpost < PCK Pre-test / n. PCKpost > PCK Pre-test / o. PCKpost = PCK Pre-test
p. TPKpost < TPK Pre-test / q. TPKpost > TPK Pre-test / r. TPKpost = TPK Pre-test
s. TCKpost < TCK Pre-test / t. TCKpost > TCK Pre-test / u. TCKpost = TCK Pre-test
v. TPACKpost < TPACK Pre-test / w. TPACKpost > TPACK Pre-test / x. TPACKpost = TPACK Pre-test

Students' TPACK competence was significantly higher after the scaffolding-based intervention ($z = -3.049$, $p = .002$, $r = .576$), indicating a large effect size.

Conclusions and discussions

With scaffolding, students developed a greater awareness of their thinking and learning processes, significant differences being identified between their pre-test and post-test scores at the metacognitive awareness inventory. Not only they become more aware of how they learn, but also they developed better digital, and TPACK competencies. In addition, higher scores were identified for VLE success between the two measurements included in the study.

CHAPTER 10. GENERAL CONCLUSIONS AND DISCUSSIONS. ORIGINAL CONTRIBUTIONS. LIMITS AND FUTURE RESEARCH DIRECTIONS

10.1 Theoretical Implications

The main subject addressed in this paper (TPACK and digital competence) is not only a topical one, but one that is just beginning to be studied intensively in specialized literature. TPACK and digital competences will shortly become indispensable in teaching, due to the extremely rapid pace of technological development. Considering their current and future importance, we must ask ourselves how these two types of competences can be developed in teachers. The present study addresses this issue, starting from exploring how a series of variables are linked and ending with a formative intervention whose main goal is to increase teachers' digital and TPACK competencies. The studies from the first part of the paper are investigating how variables like scaffolding, metacognitive awareness, digital competence, wellbeing, and virtual learning environments interrelate and influence each other. All these 1st part studies were conducted to use their results in developing and implementing the formative program integrated into the second part of our researchers. The second part of the research covers a formative program focused on increasing metacognitive awareness, digital competence, and TPACK in pre-service and in-service teachers through scaffolding.

Scaffolding has been known for its impact on learning and has the advantage of considering the needs of students, so they can receive the support they need to perform a task at their highest potential. The ability to provide individualized or group or class-level scaffolding makes this strategy flexible and adaptable, taking students' needs into consideration. Although sometimes teachers may provide scaffolding without being aware of it, it is important for them to understand how to correctly apply scaffolding and to develop this competence.

The contributions of each chapter comprised by the present thesis are summarized in the following table highlighting the connections between the chapters containing theoretical background, the preliminary studies and the formative intervention.

Table 10.1

Research Studies' Interconnected Contributions

Chapter	Contributions to the	Contributions to the

	preliminary research studies	**formative intervention plan**
THEORETICAL BACKGROUND		
Chapter 1. Introduction **Chapter 2. Learning in Virtual Environments** **Chapter 3. Metacognitive Scaffolding**	-Targeted the identification of the gaps existing in the national and international specialty literature, stating the problem and the proposed objectives. -Clarification and definition of concepts employed in all the research studies.	-Preliminary conceptual operationalization of the variables. - Part of the conceptual clarifications were used to develop the SDTMLF intervention plan.
PRELIMINARY RESEARCH		
Chapter 4. The Zone of Proximal Development in Romanian Pre-University Teachers' Practice	-Examined teachers' scaffolding practices (ZDP) particularities in their teaching due to its role in metacognition. -Provided important empirical data connected to Chapter 7 on teacher's metacognitive competences by analyzing metacognitive scaffolding strategies.	-A general intervention plan for teachers belonging to all the categories no matter of the academic background and didactic degree or other socio-demographic characteristics. - Connected to Chapter 9 by contributing insights into scaffolding practices.
Chapter 5. Pre-University Teachers' Digital Competence and Wellbeing in the Context of Virtual Learning	- Analyzed the link between digital competence and teacher wellbeing in VLE contexts.	**-** wellbeing was considered a contextual or background variable rather than an active element for intervention, as by improving digital competence and developing metacognitive strategies, teachers' wellbeing may naturally improve without being directly targeted.
CHAPTER 6: Pre-University Teachers' Experiences with Digital Learning Technologies: A	- Investigated teachers' mindset regarding the use of digital technologies. - Connected to the ZPD	-Provided foundational analysis for the intervention activities, emphasizing the importance of metacognitive

Thematic Analysis	discussions in Chapter 4, and to Chapter 7 as it highlights that the best digital pedagogy practices are developed through constant and reflexive practice.	teaching.
Chapter 7: Teachers' digital and metacognitive competence profiles and virtual learning environment perspectives	- Identified digital and metacognitive competence profiles of teachers regarding VLE Success. - Complemented Chapter 6 by offering a deeper understanding on teachers' digital and metacognitive competence trends. - Contributed to Chapter 8 by providing the insight for a deeper analysis by adding TPACK integration to the research model.	- Linked the competences profile to the goals of the intervention program. - Contributed to the intervention program's variables selection.
Chapter 8: Investigating the Relationships between In-service Teachers' Technology Pedagogy Content Knowledge and Virtual Learning Environment Success	- Extended the theoretical framework in Chapter 2 to practical applications. - Extended the findings in Chapter 7, adding the TPACK to the conceptual model and correlating it with VLE success.	- Completed the information necessary for developing the formative intervention by showcasing TPACK's predictive role in designing successful interventions. - shaped the final selection of the formative intervention's variables.

From the research that has been conducted, it is possible to conclude that the theoretical implications reveal the contribution of the thesis to the expansion of the theoretical framework regarding metacognition through the understanding of how metacognitive awareness interacts with digital competencies and TPACK frameworks, especially within VLEs. Moreover, the present research extends the TPACK framework by emphasizing the role of metacognition in TPACK development, introducing an additional layer to this framework.

The findings of our research also reveal context-specific insights as they provide valuable cultural and demographic personalized theoretical models for the context of Romanian pre-service and in-service teachers.

10.2 Practical Implications

The results obtained in the thesis indicate that the SDTMLF intervention model proposed can serve as a plan for designing custom-made teacher training programs that integrate metacognitive scaffolding, digital competence and TPACK integration development, which could lead to more effective formative interventions regarding VLEs usage and greater alignment with 21st-century educational requirements in what concerns the teaching strategies.

Moreover, the SDTMLF intervention plan, developed in the thesis, could be adapted for the use in other educational contexts, providing flexible guidelines for enhancing students and teachers' outcomes in virtual and blended learning scenarios.

Another area that could benefit due to the insights from the present research refers to the curriculum design for teacher education by focusing on the scaffolding strategies to develop both metacognitive and digital competencies. Likewise, by incorporating the TPACK framework and metacognitive training into the teacher formative process, educators' readiness could be enhanced in what concerns the digital pedagogies.

As initially stated in the rationale of the thesis, policymakers are also among the interested parts of the findings provided by the present research as these results could be used to support initiatives regarding the prioritization of digital literacy and metacognitive development in teacher professional development. Furthermore, the thesis emphasizes, in consistency with specialty literature, the need for policies that promote the integration of open educational resources and platforms (Mara et al., 2024) and scaffolded learning strategies in schools as "incorporating metacognition into the scaffolding process involves helping students become aware of their own thought processes and strategies" (Bocoș et al., 2024).

10.3 Limits and future research directions

The present research thesis encompasses both limits regarding the statistics that were employed and the conceptualization of the research design. For instance, the findings are limited by the sample size, which might not allow the generalization to other educational settings, even if it is sufficient for the context of the present study. Moreover, the cultural context of the study focuses on Romanian pre-service and in-service teachers, fact that limits the applicability to a broader international context. Therefore, future studies should explore the way in which the findings generalize across diverse educational systems, cultures, and demographic profiles. Certainly, some comparative studies between developed and developing countries could provide important insights into the different impacts of digital competence and scaffolding strategies.

Another aspect that must be tackled is regarding the statistical methods that were adopted, which, even if robust, don't provide a deep causal relationship exploration as the advanced multivariate techniques like the structural equation modeling. To overcome this limit future research may use more advanced statistical methods for obtaining deeper understandings about the causal relationships between variables.

An additional limit is represented by a common limit for many studies, namely the use of self-reported measures as relying on self-reports may create biases like responding according to the social norm or like inaccurate self-assessment. Future research may consider adopting observational methods or mixed methods.

The way the research design has been conceptualized also brought some limits to the study. For instance, the fact that the intervention was focused on specific aspects of teacher training like TPACK, digital competences and metacognitive scaffolding may not address important issues that enhance VLE success, such as motivation, self-efficacy or broader pedagogical strategies.

The duration of the intervention might not have been sufficient to observe the long-term impact of the formative intervention. Therefore, future studies should investigate the long-term effects of scaffolding, metacognitive strategies, and TPACK integration on teacher performance and student outcomes. Moreover, longitudinal designs could also determine the way in which sustained exposure to the formative intervention impacts teacher wellbeing and professional growth.

Another limit of the conceptualization of the research design is represented by the availability and type of technology used in the interventions. To be precise, not exploring emerging technologies like AI-enhanced learning tools or augmented reality might have left gaps on the VLE practices and outcomes as the inclusion of these cutting-edge tools and learning platforms, and personalized learning algorithms could provide a more comprehensive understanding of the VLE success.

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