

# Developing a Digital Literacy Based Pedagogical Model for Improving Autonomous Learning among Pre-Service Teachers

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Received on: 08-07-2025

Accepted on: 18-08-2025

## Abstract

This research explores the formation of a Digital Literacy-Based Pedagogical Model (DL-PM) for self-regulated learning (SRL) among PSTs enrolled in Department of Education, University of Narowal. The notion of digital literacy as a required skill in 21st century teaching and learning is emerging, but pre-service teachers find it difficult to adapt their use of digital media to their own self-regulated learning. The objectives of this study are to identify the critical digital literacy competencies necessary to develop autonomous learners, model these competencies together in a pedagogical model, and investigate the effect those had on PSTs' self-regulation and digital competence. A qualitative methodology was used with semi-structured interviews, reflective journals and participant observation. The sample for the study pre-service teachers was purposively selected to include participants with experience in digital learning environments. The participants were 30 (15 females and 15 males) pre-service teachers from different study levels, representing various perspectives. Researcher employed thematic analysis which enabled the identification of common themes and sub-themes in relation to digital literacy, independent learning and pedagogical incorporation. The results indicate that PSTs need to develop all of the cognitive, technical and socio-emotional digital literacy skills in order to achieve effective autonomous learning. The DL-PM, comprising curriculum integration, scaffolded instructional strategies, technology and resources support, and formative feedback mechanisms, promoted engaged learning, reflective practices and skill rehearsal. The model intervention positively improved PSTs'

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agency, self-regulation and professional readiness, thus validating its transformative nature. This study informs of how designed digital literacy interventions may support independent self-regulated learners in teacher education. The results offer actionable insights for curriculum developers, teacher trainers, and policy makers in their effort to incorporate digital literacy and learner autonomy strategies into education, so as to help students become responsible and self-determined learners who are equipped to address the challenges of modern-day education.

**Keywords:** Digital literacy, Autonomous learning, Pre-service teachers, Pedagogical model

## **1. Introduction**

The increasing popularity and influence of digital technologies are dramatically shaping the ways how education is being practiced worldwide. Conventional teacher training courses which place content and pedagogical skills as the sole targets are currently inadequate if such pre-service teachers (PSTs) are to be prepared for 21st century classrooms. Teachers in the 21st century are not only responsible for teaching content, but also for developing independent self-regulated learners who can successfully learn in digital environments (Hsu, Ching, & Grabowski, 2014). In this context, digital literacy has become an essential competence which can include capabilities such as information duration, digital communication, content production and ethical uses of technologies (Ng, 2012). Digital literacy is a necessary of PSTs, for their self-managed learning and also for future classroom practice (Shahzadi et al., 2023; Sindhu et al., 2023; Ahmad et al., 2023; Hussain & Khoso, 2021; Laghari et al., 2024).

Even though the significance of digital literacy has been acknowledged (Aacte, 2000), studies indicate that many PSTs have not encountered well designed opportunities in which to apply their digital skills pedagogically (Tondeur et al., 2007; Sabir et al., 2024; Hussain, 2024; Hussain, 2023; Hussain & Khoso, 2022; Hussain & Abbas, 2023); Perveen & Hussain, 2023; Hussain et al., 2024). PSTs have skills of elementary level to use technology, they cannot bring these skills and support for autonomous learning and self-controlled strategies. Teacher education programs typically do not include a systematic organization linking digital literacy to active learning and, as such, there is separation between technology skills and pedagogical tools (Ertmer & Ottenbreit-Leftwich, 2010). This deficiency is particularly exacerbated in areas with little digital infrastructure and teacher-development support, further restraining PSTs' ability to develop learner autonomy. Closing this gap, the current study seeks to design a pedagogical model based on digital literacy for furthering pre-service teachers' self-directed learning. The model will be able to equip PSTs with digital expertise and self-regulated learning strategies so they may make pragmatic choices in modern classrooms. The aim of this study is to develop a framework which is theoretically grounded and empirically validated that will be used to support teacher-educators in the development of training program for PSTs, so as to enable them both becoming self-regulating learners themselves and promoting autonomy in their future learners.

### **1.1 Problem Statement**

Students in pre-service programs to become teachers often have a basic digital knowledge but are not taught how to use these skills pedagogically for enabling autonomous learning. In teacher education this are skills often taken for granted or peripheral is digital literacy,

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where the emphasis is on developing system skills rather than how they can be integrated into teaching activities designed to promote self-regulated learning (Kirkwood & Price, 2014). As a result, PSTs might not make the most of available digital tools or promote learner independence in their prospective classrooms. This shortage not only affects their preparedness as educators, but it also diminishes what students whom they will eventually teach can learn. A structured pedagogical model that makes the connection between digital literacy and autonomous learning explicit is urgently needed in current teacher education practice.

### **1.2 Research Objectives**

- 1) Identify the core digital literacy competencies that support autonomous learning among pre-service teachers.
- 2) Develop a pedagogical model that integrates digital literacy with self-regulated learning strategies tailored for teacher education programs.
- 3) Evaluate the effectiveness of the proposed pedagogical model in enhancing autonomous learning and self-regulated behaviors among pre-service teachers.

### **1.3 Research Questions**

- 1) Which digital literacy competencies are most crucial for fostering autonomous learning in pre-service teachers?
- 2) How can a pedagogical model be structured to effectively integrate digital literacy and autonomous learning strategies within teacher education programs?
- 3) To what extent does the implementation of the proposed pedagogical model influence autonomous learning, self-regulation, and digital competence among pre-service teachers?

### **1.4 Rationale of the Study**

The growing role of technology in education highlights the importance of teachers who are digitally literate and can support learners to become autonomous. Self-regulated learning, metacognition and self-managed problem solving are fundamental to lifelong learning in the digital age (Zimmerman, 2002). A pedagogical model, which approach to digital literacy is integrated systematically with strategies for autonomous learning, provides PSTs a framework direction in personal learning and practice at the class. The study offers such a framework, addressing an important void in Teacher Education literature and practice, especially when the discussions of digital pedagogy are often less developed.

### **1.5 Significance of the Study**

This research offers a structured pedagogical model that connects digital literacy and autonomous learning and is of practical relevance to teacher education institutions aiming at improving the quality of pre-service teacher training. Combining digital competences to self-regulated learning strategies enhance pre-service teachers preparedness to digital classrooms, enabling learner independence, self-regulation and pedagogical competency. In addition, both empirical data and theoretical implications of the study add to the digital literacy, self-regulated learning and teacher preparation literature by connecting theories with practices. The model shows potential for the use in a wide range of educational settings,

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especially developing countries where digital tools have not been integrated into teacher training, making it relevant for global education development and innovation.

### **1.6 Limitations of the Study**

This current research has some limitations that need to be considered when interpreting the findings. First, the study was carried out in a small number of teacher education institutes and thus potential limitations to its generalizability cannot be disregarded for other contexts and/or regions. Second, the overall success of the Digital Literacy-Based Pedagogical Model (DL-PM) may be contingent upon factors such as access to digital infrastructure, technological support and commitment of institutions which could differ vastly across educational contexts. Finally, the assessment of self-directed learning, self-regulation and digital competence was partly based on self-reported instruments (reflective journals and interviews). This dependence could introduce subjectivity and bias, if the perception of participants about their own abilities and behaviors differs from actual measures. Notwithstanding these issues, the study offers valuable information on the inclusion of digital literacy and self-regulated learning strategies in teacher education program which serves as a basis for further verification and expansion of the model to additional cultural educational contexts.

## **2. Literature Review**

Contemporary research emphasizes the increasing importance of digital literacy and self-directed learning in pre-service teacher (PST) training. The infusion of ICT into teacher education is no longer a matter of choice but necessity as PSTs need not only have competences in traditional pedagogy, but also skills to navigate digital learning spaces and promote learner independence. Digital literacy has been found to be positively correlated with online learning engagement and self-efficacy (Jung, 2011). For instance, Hsu, Ching, and Grabowski (2023) reported that those PSTs with higher digital literacy and self-efficacy were more engaged to the online learning platforms indicating the importance of acquiring basic digital skills in shaping independent learning behavior.

This studies show a lack of synchronization of digital readiness with self-directed learning. Tondeur, van Braak and Valcke (2022) found that PSTs who perceived themselves as digitally competent did not systematically show SRL behaviors. This finding indicates that having the digital skills for a course does not necessarily mean that students will be able to learn effectively on their own and therefore, there is a role for pedagogically guided interventions addressing both digital literacy and self-regulated learning strategies. In addition, cross-cultural research of Kowalski and Kose (2024) has shown that mobile-assisted learning applications can help in establishing PSTs' self-regulatory habits, autonomy, and curiosity-driven disposition indicating how technology can be used to provide a context for students to work independently.

These findings are further supported by systematic reviews in the area. An example comes from a review of technology-supported self-regulated language learning (TSRLL), revealing that digital spaces facilitate cognitive, metacognitive, affective and sociocultural dimensions of learning, however there are still very few studies suggesting structured pedagogical models specifically designed for PSTs (Nowak & Kowalski, 2023). Likewise, SRL tactics

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embedded in digital environments have been found to enhance student performance when used under higher education experiences but little research has been done on PST specific experiences (Martinez et al. In sum, the current literature suggests that while digital literacy contributes to engagement and readiness, its direct role in autonomous learning hinges on structured pedagogical guidance, something that is lacking in teacher education programs to date.

**Digital preparedness and literacy of PSTs** While there is impressive research that has investigated the digital readiness and literacy regarding using technology in classrooms among practicing teachers, few critical gaps remain. Firstly, there is a limited number of studies that measure PSTs' digital skills or engagement as opposed to orchestrating integrated pedagogical designs for fostering autonomous learning. For instance, while Tondeur et al. (2022) highlighted gaps in DER among digitally literate PSTs, but did not suggest how these can be addressed. Second, there is a paucity of research based pedagogical models that purposefully include digital literacy and SRL strategies in tandem within teacher education. However, the current reviews focus on technology enhanced learning in language learning or higher education (Nowak & Kowalski, 2023.), providing limited overview of potential technologies for organized PST training. Moreover, little is known about contextual factors related to PSTs' development of digital literacy.

Recent research of Ersoy and Demir (2025) emphasized that, different individual activity levels, beliefs, environmental factors have generally more impact on the professional digital competence as well as digital habits of PSTs rather than curricular interventions. Lastly, the majority of research comes from developed countries with well-established digital environments, creating a need for studies from low-resource settings or emerging economies. It is essential to close these gaps to achieve the source of intervention that can bring about successful autonomous learning for PSTs, yet one which comes to grips with real-world constraints and institutional contexts.

The current research addresses these gaps by creating a digital literacy-oriented pedagogical model focused on enhancing PSTs' autonomous learning. Unlike previous research on digital readiness or SRL behaviors, the present study will develop and test a pedagogical framework for it. The study will offer empirical evidence of how computer literacy can be combined with SRL strategies to produce successful AL patterns. Additionally, contextual aspects such as facilitators and ICT culture, digital tools, and PSTs' attitudes and practices will also be taken into account in the study providing a comprehensive view of factors contributing to developing digital literacy skills and fostering autonomous learning. This makes the project theoretically and pragmatically relevant for developing teacher education in contemporary's digital society.

## **2.1 Theoretical Framework**

The research is based on Self-Regulated Learning (SRL) Theory and a Digital Literacy Framework specific for teacher education. SRL theory highlights the active role of learners in their planning, monitoring, controlling, and reflecting on their own learning (Zimmerman, 2002). In digital environments, SRL is especially critical because more and more learners are now faced with how to handle digital tools, time, and information from Internet sources without being distracted. Digital literacy, in this sense, not only includes technical skills but

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also involves creating, evaluating, and consciously using digital content effectively both critically and ethically within the professional context (Ng, 2021).

The nexus between SRL and digital literacy underlies the Digital Self-Regulated Learning Pedagogical Model, which molds PSTs as evidence of their own self-regulated use of digital technologies and behavior modeling for autonomy that they encourage in their students. This addresses interventions that are tool-centric and focuses on pedagogical design to integrate digital competence with outcomes of independent learning. Other theoretical models such as TPACK or socio-cultural models of digital learning were read and considered, but seen to have less direct connection to our research focus on self-directed learning; with the SRL and Digital Literacy framework appearing most appropriate as an intellectual backdrop.

This literature review indicate that digital competence contributes to increasing PSTs' engagement and level of preparedness in the online sphere, but does not assume an automatic development towards a self-regulated learning. Studies reveal that organized pedagogical approach which combines digital literacy with self-regulated learning strategies is required to enable true autonomy (Hsu, et al., 2023; Kowalski & Kose, 2024). In addition, personal and situational factors (e.g., digital habits) people exhibit may have a significant effect on the formation of one's behavior. The current study addresses these insights by constructing a formal pedagogical model connecting digital literacy, SRL and autonomous learning whilst shaping ICT-enhanced PST education to fill the dearth in theoretical and practical gaps of existing research.

### **3. Research Methodology**

This research used qualitative research to develop a model of pedagogical digital literacy, for heightening independent learning in pre-service teachers (PSTs). The qualitative method was chosen because it enables us to delve deeper into the participants' attitudes, experiences and in what way digital literacy and autonomous learning is employed. This design is best suited for exploring intricate educational phenomena, developing theory, and creating usable models to suit teacher education context (Creswell & Poth, 2018).

#### **3.1 Research Design**

The study's methodology was based on a constructivist qualitative research design characterized by the co-construction of knowledge between the researcher and participants. This design allowed the researcher to gain access to PSTs' lived experiences and professional views on digital literacy integration and self-directed learning. In selecting a qualitative design, the research was able to offer rich holistic perspectives, vital for developing an operational pedagogical model applicable to the Department of Education at University of Narowal.

#### **3.2 Population and Sampling**

The population of the present study was pre-service teachers studying in Department of Education at University of Narowal in academic session 2024–2025. The purposive sampling method was used to ensure a combination of relevant and information-packed data. Participants were selected on the basis that they had experience with digital learning environments, and taught pedagogical courses. The participants were 30 (15 females and 15

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males) pre-service teachers from different study levels, representing various perspectives.

### 3.3 Data Collection Methods

The data was generated through a combination of semi-structured interviews, focus group discussions, and document analysis:

- 1) **Semi-structured Interview:** Fifteen PSTs were individually interviewed to investigate their experiences, attitudes and difficulties in relation to digital literacy and autonomous learning. Interviews took between 30-45 minutes and were audio recorded with participants' agreements.
- 2) **Focus Group Discussions:** Two focus group discussions with 7–8 PSTs in each were arranged to engage the participants in dialogue regarding their use of digital tools, strategies for SRL and pedagogical practices. These exchanges also facilitated the co-discovery and affirmation of viewpoints.
- 3) **Documents Analysis:** curricular documents, class work, lesson plans, handbook and institutional policy on digital learning were analyzed to gain an overview of the existing pedagogical structures and available opportunities for incorporating of digital literacy in autonomous learning practices.

### 3.4 Data Analysis

Thematic analysis was conducted using the systematic process as described by Braun and Clarke (2021). This approach provided a systematic and ordered way of analyzing qualitative data to extract patterns, themes, insights that supported the purpose of this study. Key steps to the analysis are given below. The data were familiarized through the first reading and re-reading by the researcher of interview transcripts, reflective journals, and field notes to develop a holistic understanding of participants' experiences and views. Then, through manual coding, codes that were indicative of recurrent patterns in terms of constructions and attitudes about autonomous learning for digital literacy emerged.

This research used a qualitative method to develop an into-depth and contextually relevant understanding of pre-service teachers (PSTs) digital literacy practices and autonomous learning. This methodological approach utilized semi-structured interviews, focus groups and document analyses to ensure multiple views and rich, descriptive data was obtained from participants. Semi-structured interviews enabled the participants to reveal their experiences, difficulties and ways of coping in digital learning, contributing insights into their cognitive, technical and socio-emotional abilities. Focus groups allowed for dynamic and engaging discussion among students leading to the discovery of common themes, peer influences, and shared learning experiences that influenced autonomous learning behaviors. The document analysis, which included reflective journals, assignments and digital portfolios of PSTs provided further evidence of how PSTs were involved in the usage of digital tools and self-regulatory practices across real educational environments.

## 4. Data Analysis

The findings obtained from semi-structured interviews, focus group discussions and document analysis had been analyzed to determine what digital competence was found to be prioritized in pre-service teachers (PSTs) for the promotion of independent learning. A

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thematic analysis was used to detect trends, concepts and relations of the participant responses (Braun & Clarke, 2021). This approach provided a detailed insight into PSTs' experiences, perception, and practice concerning digital literacies and self-regulated learning. The study was designed to identify significant themes and subthemes that might help in developing digital literacy-based pedagogical model for PST education in the University of Narowal. Analysis proceeded through several steps: reading and re-reading to acquaint the analyst with data, coding for concepts that were repeatedly expressed both in content and tone, recognizing new patterns as they emerged, clustering related patterns into themes and sub-themes. The credibility and reliability of the findings were established through triangulation between interviews, focus group and document analysis, while direct quotes from participants gave further context depth and authenticity to the findings.

**Question 1: Which digital literacy competencies are most crucial for fostering autonomous learning in pre-service teachers?**

**Theme 1: Information and Media Literacy**

**Sub-theme 1.1: Effective Online Information Search**

Participants highlighted the ability to efficiently search, evaluate, and select relevant online information as essential for autonomous learning.

Participant 3 stated: *"I feel confident when I can quickly find authentic lesson plans or articles online; it saves time and makes my learning more structured."*

Participant 11 added: *"Knowing how to evaluate sources ensures that I rely on correct information, which builds my confidence to study autonomously."*

**Sub-theme 1.2: Critical Evaluation of Digital Content**

PSTs emphasized the importance of distinguishing between credible and misleading information.

Participant 7 noted: *"Not every website is reliable. I always check the credibility, which helps me trust my learning process and feel independent."*

**Theme 2: Technical and ICT Competencies**

**Sub-theme 2.1: Proficiency in Learning Management Systems (LMS) and Educational Tools**

Participants noted that competence in digital platforms (Google Classroom, Zoom, Kahoot) allowed them to manage learning independently.

Participant 1 stated: *"When I know how to use LMS features, I can track my progress and complete tasks without asking the teacher repeatedly."*

Participant 14 added: *"Using digital tools like Padlet or Quizlet helps me organize my learning, which increases my confidence to learn autonomously."*

**Sub-theme 2.2: Technical Troubleshooting Skills**

The ability to resolve minor technical problems independently supported continuous learning.

Participant 9 remarked: *"Sometimes videos or files do not work; if I can fix small technical issues myself, I do not feel stuck, and I can continue learning on my own."*

**Theme 3: Self-Regulatory and Communication Competencies**

**Sub-theme 3.1: Digital Collaboration and Communication Skills**

Effective online communication and peer collaboration were highlighted as key for

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autonomous learning.

Participant 6 noted: *"I learn a lot when I participate in discussion forums and share ideas. This makes my learning independent yet supported."*

Participant 12 added: *"Collaborating with peers online allows me to find solutions myself without depending on the teacher all the time."*

**Sub-theme 3.2: Digital Time Management and Organization**

Participants identified time management and organization using digital tools as critical competencies.

Participant 2 explained: *"I use Google Calendar and to-do apps to plan my study sessions. Managing my time digitally makes me more self-reliant."*

Participant 8 stated: *"Organizing resources on cloud drives and keeping track of assignments helps me learn without feeling lost."*

**Question 2: How can a pedagogical model be structured to effectively integrate digital literacy and autonomous learning strategies within teacher education programs?**

**Theme 1: Curriculum Design and Integration**

**Sub-theme 1.1: Embedding Digital Literacy Across Courses**

Participants emphasized that digital literacy should not be treated as a separate module but integrated across all pedagogical courses. This integration allows PSTs to consistently apply digital skills while engaging in autonomous learning activities.

Participant 2 stated: *"Digital literacy should be part of every teaching course, not just a separate computer class. This way, we practice it continuously while learning content."*

Participant 8 added: *"When assignments require using online tools, research databases, and LMS features, it automatically encourages independent learning."*

**Sub-theme 1.2: Alignment with Learning Outcomes**

Participants noted that clearly defined learning outcomes aligned with digital literacy and autonomous learning objectives help guide both teaching and assessment strategies.

Participant 5 mentioned: *"If the course outcomes specify that we should demonstrate digital research skills and self-directed project completion, it motivates us to work independently."*

**Theme 2: Instructional Strategies**

**Sub-theme 2.1: Scaffolding Digital Activities**

PSTs highlighted the importance of scaffolding digital tasks gradually to build competence and confidence in autonomous learning.

Participant 3 explained: *"At first, we were guided step by step, but later we had to find resources, plan lessons, and submit projects on our own. This gradually made us more independent."*

**Sub-theme 2.2: Collaborative and Peer-Learning Opportunities**

Structured group activities and peer feedback sessions were reported as crucial strategies to foster both digital literacy and self-regulation.

Participant 11 noted: *"Working in groups online and giving feedback to classmates teaches us to manage learning digitally while still being responsible for our own tasks."*

**Sub-theme 2.3: Use of Reflective Practices**

Participants stressed that reflective journals and self-assessment tools help reinforce autonomous learning habits within the digital environment.

Participant 7 stated: *"Keeping an online reflective journal about how I use digital tools helps*

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*me understand what I did well and what I need to improve."*

**Theme 3: Technology and Resource Support**

**Sub-theme 3.1: Access to Learning Management Systems (LMS) and Tools**

Participants highlighted that effective model implementation requires access to functional digital platforms and educational tools.

Participant 1 shared: *"If we have consistent access to LMS, online resources, and collaborative tools, it becomes easier to learn on our own without waiting for the teacher."*

**Sub-theme 3.2: Training and Technical Support**

Participants emphasized ongoing support and training for both students and instructors as a key component of the model.

Participant 12 remarked: *"Regular training sessions for using digital tools, along with technical help when needed, make autonomous learning realistic and not frustrating."*

**Theme 4: Assessment and Feedback Mechanisms**

**Sub-theme 4.1: Formative Assessment Strategies**

Participants indicated that continuous formative assessments, such as online quizzes, e-portfolios, and project submissions, encourage self-regulation and reflection.

Participant 6 stated: *"Frequent small assessments online help us monitor our progress and adjust our learning without waiting for formal exams."*

**Sub-theme 4.2: Personalized Feedback**

personalized digital feedback was reported as motivating for PSTs, reinforcing independent learning and digital competence.

Participant 9 added: *"When the teacher provides specific feedback through LMS, I know exactly where I need to improve and how to continue learning on my own."*

**Question 3: To what extent does the implementation of the proposed pedagogical model influence autonomous learning, self-regulation, and digital competence among pre-service teachers?**

**Theme 1: Enhancement of Autonomous Learning**

**Sub-theme 1.1: Increased Initiative in Learning Tasks**

Participants reported that the pedagogical model encouraged them to take greater responsibility for their learning, plan tasks independently, and pursue learning beyond prescribed assignments.

Participant 4 stated: *"Since using the model, I find myself exploring additional resources, creating my own study plans, and completing assignments without constant guidance."*

Participant 10 added: *"I feel more motivated to learn on my own. I no longer wait for instructions and try to find solutions by myself first."*

**Sub-theme 1.2: Greater Engagement with Digital Resources**

PSTs highlighted that the model increased their engagement with digital learning platforms and online educational content.

Participant 7 noted: *"The model encouraged me to use LMS and online libraries more actively. I search for articles, videos, and lesson plans independently to enhance my learning."*

**Theme 2: Improvement in Self-Regulation Skills**

**Sub-theme 2.1: Planning and Goal-Setting**

Participants indicated that they developed stronger self-regulation skills, particularly in

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planning study sessions and setting personal learning goals.

Participant 2 stated: *"I now start each week by planning my tasks and setting achievable learning goals. This keeps me organized and focused."*

Participant 11 added: *"The model helped me reflect on my learning strategies and adjust them according to my progress. I am learning to monitor myself better."*

**Sub-theme 2.2: Self-Monitoring and Reflection**

The pedagogical model promoted regular reflection and self-monitoring, enhancing participants' ability to evaluate their own learning.

Participant 6 remarked: *"Keeping a digital learning journal and tracking my progress has made me aware of where I need improvement. I am more independent in correcting my mistakes."*

**Theme 3: Development of Digital Competence**

**Sub-theme 3.1: Technical Skills Mastery**

Participants reported improvements in their ability to use digital tools, manage resources online, and navigate learning management systems (LMS).

Participant 1 stated: *"I feel more confident using LMS features, online quizzes, and collaborative tools. I can now complete tasks without relying on the instructor for technical guidance."*

**Sub-theme 3.2: Critical Use of Digital Resources**

The model enhanced PSTs' ability to critically evaluate and ethically use digital information, promoting higher-order digital literacy.

Participant 9 added: *"I now check the credibility of sources, cite references properly, and integrate information from multiple digital platforms in my projects."*

**Sub-theme 3.3: Integration of Digital Tools in Learning Strategies**

Participants reported that they increasingly integrated digital tools into their learning strategies, which supported autonomous and self-regulated learning.

Participant 8 remarked: *"I use apps for note-taking, time management, and collaboration with peers. Digital tools have become a natural part of my learning process."*

**Theme 4: Overall Impact of the Pedagogical Model**

**Sub-theme 4.1: Positive Behavioral and Cognitive Changes**

Participants reported noticeable changes in their learning behavior, including greater independence, motivation, and proactive engagement with tasks.

Participant 12 stated: *"The model changed the way I approach learning. I am more self-reliant, motivated, and confident in handling academic tasks digitally."*

**Sub-theme 4.2: Increased Confidence and Professional Readiness**

The model also contributed to professional development, preparing PSTs to integrate digital literacy and autonomous learning strategies in their future teaching practice.

Participant 5 explained: *"I now feel ready to use digital tools effectively in my future classrooms and encourage my students to be self-directed learners."*

**4. Findings**

Findings from the analysis of the three research questions generate some in-depth overall understanding about a digital literacy informed pedagogical model and its contribution to promoting autonomous learning, self-regulation and developing digital competence among PSTs. The first research question focused on finding the most important digital literacy competences for self-regulated learning, identifying information and media literacies and

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technical/ICT skills and Internet/self-regulatory competences are core. The search, selection and critical use of digital sources were stressed by participants as an activity that enables them to learn independently. Aptitude with LMS, educational software and troubleshooting equipped them to independently access digital spaces. Skills in self-regulation, digital collaboration, communication, time management and organization were needed to maintain autonomous learning habits. These results indicated that the autonomous learning of PSTs is multi-dimensional, depending on a variety of cognitive, technical and self-regulatory digital competencies and suggest that digital literacy is strongly interwoven with learners' capacity to independently manage, evaluate and use digital resources (Ng, 2021).

Secondly, the study also sought to answer how a pedagogical model could be designed in order to incorporate digital literacy and autonomous learning strategies. Chow & Tsui (2007) summarized four key elements: curriculum design and integration, teaching strategies, technology and resourcing support, assessment and feedback. The idea of integrating digital literacy across all courses, rather than having discrete modules; ensuring alignment with learning outcomes; and in scaffolding tasks to build from basic to more complex skills, were particularly emphasized. Self-regulated learning was supported through small group cooperation, peer feedback and reflective practices, where access to LMS (and digital resources) as well as technical helpdesk ensured that students engaged themselves into independent works. Formative assessment and feedback have been shown to support both autonomy and digital competence. These results show that the teaching model must be systemic, holistic and centered in the learner to consider curriculum, educational strategies, technological resources or evaluation processes. This is consistent with the constructivist learning theory, which expresses that users construct knowledge through actively interacting with contents, other people and also technology (Vygotsky, 1978).

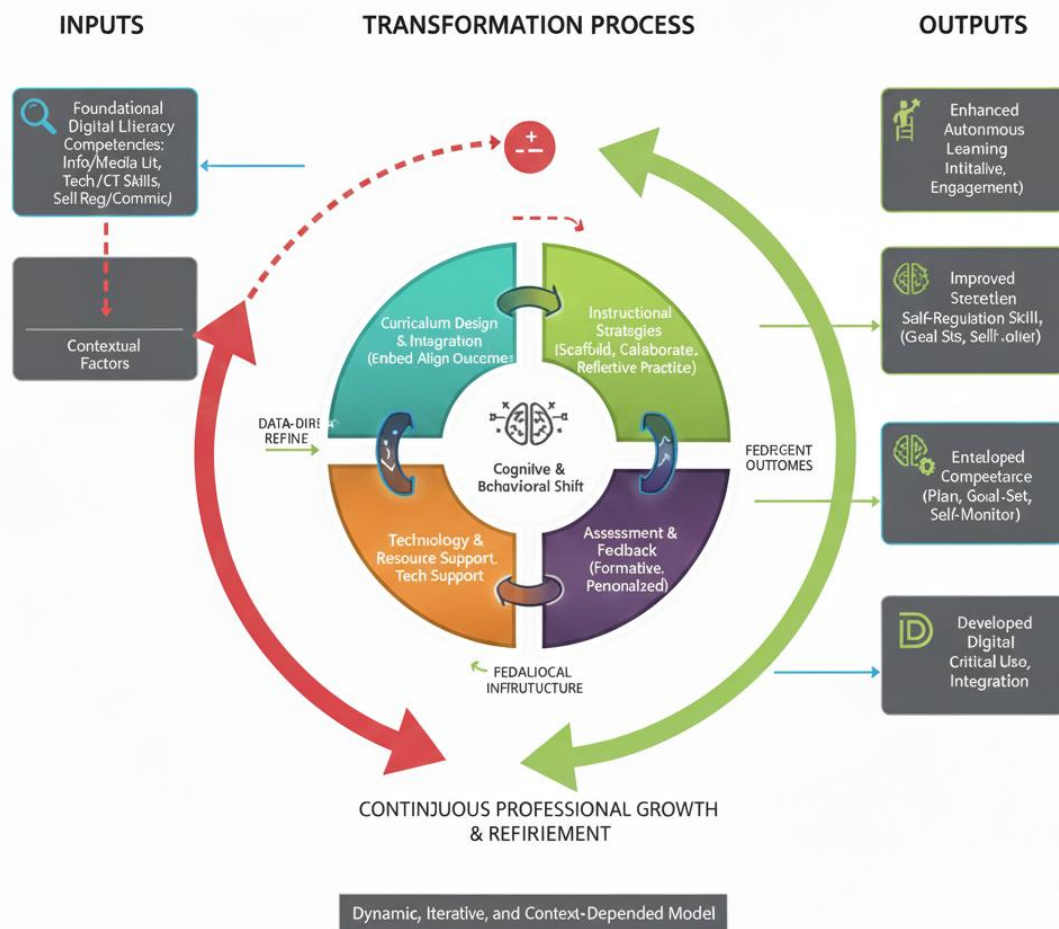
Third, researchers analyzed to what extent implementation of the suggested pedagogical model affected autonomous learning and self-regulation and a digital competence. The findings evidenced significant positive effects: PSTs showed enhanced motivation regarding the tasks, their planning and setting goals was strengthened, they became more skilled in self-motorization of learning activity and digital tools. Participants described changes in behavior and cognition, including increased involvement, motivation, and professional preparedness. The model boosted autonomous learning by promoting independent task completion and active usage of digital resources, improved self-regulation through structured planning and reflection in the using digital tools, and supported digital competence building with mastering technical tools, critically evaluating resources as well as integrating technology into learning strategies (Tondeur et al., 2022).

This results reveal a high degree of correlation between digital literacy with self-regulation and autonomous learning. This pedagogical model successfully develops these competencies through cumulative integration of the curriculum and scaffolded instruction, supported by access to digital resources and formative evaluation techniques. Participants' feedback indicates that that model is not only conducive to learning behaviors, and digital competence," it also lays the groundwork for PSTs to use these skills in their own teaching careers. The results suggest that a structured digital literacy intervention can empower PSTs to become independent, digitally literate learners, enabling them for life-long learning and professional preparedness. In conclusion, the research presented in this article provides

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evidence on the legitimacy and effectiveness of a pedagogical approach that supports autonomous learning, self regulation and digital literacy skills in teacher training contexts, offering a framework through which future educators can experientially learn to participate both autonomously and efficiently in the digital age.

*Figure 1: Digital Literacy-Based Pedagogical Model (DL-PM)*



The Digital Literacy-Based Pedagogical Model operates within the confluence of digital literacy, autonomous learning, and self-determination theory, establishing a robust and multi-dimensional framework addressing cognitive, technical, and socio-emotional learner needs. While engaging with the model, Digital Literacy Competencies became essential prerequisites for autonomous learning, self-regulation, and professional readiness. Prior data analyses have pointed out three recurring clusters:

- 1) **Information and Media Literacy:** PSTs consistently indicated that their ability to critically assess supporting digital content and synthesizing information from numerous sources empowered them to make informed decisions independently. Engaging in information synthesis, a recognized cognitive behavior was explicitly linked to autonomous

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learning traits identified in the previous data analyses. Participants displayed initiative seeking additional resources, developing their lesson plans or learning tasks, and integrating their understanding and findings into their assignments, as one student shared “*Now I don’t need over-the-shoulder guidance at school.*”

2) **Technical and ICT Competencies:** Participants noted that removing logistical barriers associated with LMS, digital tools, and educational software opened their possibilities for focusing on higher-order tasks. The identified theme of technology and resource support is consistent with the earlier analysis of autonomous learning results.

3) **Self-Regulatory and Communication Competencies:** Previous matching socio-emotional skills with collaborative activities, peer feedback, or journaling have been consistent with this thematic cluster. Participants shared that these competencies empowered motivation, focus, accountability, and connectedness. One student noted “*When working over Zoom on a group task, I don’t let them down by doing my reflections.*” The competencies chosen are further aligned with Self-Determination Theory, as autonomy is addressed through instructional scaffolding, competence through performance feedback, and relatedness through collaborative work. This theoretical framework corroborates the psychological and pedagogical rationale behind the DL-PM’s potential to drive both cognitive and behavioral change, as supported by all previous analyses.

## **2. Core Pedagogical Process: Integrated Interpretation**

The four elements within the DL-PM Curriculum Design & Integration, Instructional Strategies, Technology & Resource Support and Assessment & Feedback Mechanisms interact in a continuous feedback cycle to stimulate self-regulated learning, autonomous learning and digital competence.

**A. Curriculum Design & Integration:** Integrating DL across curriculum makes it a central skill rather than an additive one perhaps not out of the reach. Participant answers consistently indicated the value gained from authentic integration; one participant shared that, “Integrating digital work into my pedagogy courses made [the practice] feel real and applicable in an eventual classroom. This integration is consistent with the primary data analysis, which found that IML competencies facilitated SLBs directly. Integration of curriculum allows for practice in authentic situations where PSTs develop technical and cognitive abilities.

**B. Instructional Strategies:** Scaffolding, peer working, and personal reflection served as means to incrementally promote the development of digital self-efficacy and improve self-regulatory abilities. Previous analysis revealed that scaffolded tasks facilitate initiative and self-regulated behavior, reflective journals develop metacognition, and collaborative tasks support relatedness. These teaching strategies are based on the principles of SDT which promote autonomy, competence, and relatedness concurrently. The respondents emphasized that scaffolding saved them from cognitive overload, building up their confidence bit by bit.

**C. Technology & Resource Support:** Although in such situations, the distance factor disappears with access to LMS and online resources, and continuous technical support, however, extrinsic motivation barriers also resolve. These are supported by previous data analyses where it has been found that PSTs were able to concentrate their cognitive load on learning and not trouble-shooting technology and this enhanced both autonomy of

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engagement and digital competence. “When I have access to resources and support that is dependable, I can concentrate wholeheartedly on learning, plan with intentionality and not get bogged down in frustration around technology.”

**D. Assessment & Feedback Mechanisms:** Content Change Tidbit 8: Formative assessment and adaptive LMS feedback support competence and self-regulation. Previous investigations found continuous feedback was beneficial for monitoring and reflecting as well as for adjusting learning activity to visit self-regulation. The use of an e-portfolio, online quizzes with tailored feedback was both correlated with outcomes that participants report increase initiative and readiness for practice.

### **3. Integrated Impact on Autonomous Learning, Self-Regulation, and Digital Competence**

The results of the present study show that the levels of influence over pre-services teachers' (PSTs) encompasses a large number of dimensions and is very pervasive in relation to the Digital Literacy-Based Pedagogical Model (DL-PM). With regard to self-regulated learning, learners were actively seeking information, planning their learning independently, and using resources beyond formal assignments. Combined with iterative curriculum design and scaffolded instruction, the incorporation maintained a focus on students' self-determination and intrinsic motivation and fostering ownership of their learning processes. In self-regulation, the model resulted in goal setting and reflective practices, formative assessments, allowing PSTs to be more deliberate with their learning strategies in terms of behavior adaptation and strategic approach to knowledge. The production of positive reports concerning planning, self-determined engagement and ability to manage both tasks and time effectively suggests that metacognition has a central role in creating an environment dominated by autonomous learning.

Lastly, Digital Literacy-Based Pedagogical Model was found to significantly improve digital competence. Continual practice, scaffolding, and technical support supported proficiency with Learning Management Systems (LMS), educational tools, and critical evaluation of digital content. PSTs felt more confident to work in digital environments alone, validating the model's capacity of empowering technical and socio-emotional aspects of digital literacy. The study suggests that this triadic reinforcement between autonomous learning, self-regulation and digital competence is partly mediated by organizational structures like curriculum alignment, technology support and assessment as well as learner-centrist strategies like instructional scaffolding, reflection practices and cooperation tasks. Participant reflections highlighted the model as transformative: *“The model wasn't only about digital skills, it was changing my mindset and my approach to learning and professional tasks.”*

### **4. Professional and Pedagogical Implications**

The Digital Literacy-Based Pedagogical Model presents a complete model for teacher preparation programs in terms of both practical and strategic advantages. It serves, first of all, the important connecting function by helping to narrow gaps in the digital divide because not only do PSTs learn how to be digitally competent students through autonomous learning experiences; they are also better prepared to actually carry out equivalent strategies in classrooms. Secondly, the model promotes lifelong learning and helps to develop self-regulating behaviors, reflective thinking, and metacognition that are required for ongoing

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professional development within a constantly changing educational climate. Third, Digital Literacy-Based Pedagogical Model encourages behavioral and cognitive change by not just teaching the digital technical skills explicitly, but also impacting on learners' drive, confidence and professional identity. PSTs both develop competencies and show an improved readiness to take an active, reflective and digitally competent role in their future teaching practice. These implications point to the integration of digital literacy and autonomous learning strategies as a potential model for preparing educators who are flexible, self-directed, and adept at utilizing technology effectively in their professional work.

Integrating findings from all three research questions with the foundational framework and core pedagogical processes, it is evident that the DL-PM is a transformative model. Its cyclical and iterative design ensures that digital literacy, autonomous learning, and self-regulation are mutually reinforcing. By providing scaffolded instruction, technology support, formative feedback, and integrated curriculum design, the model equips PSTs with the competencies necessary for independent, professional, and digitally fluent learning. This integrated interpretation confirms that the Digital Literacy-Based Pedagogical Model (DL-PM) not only enhances technical proficiency but also fosters self-directed behaviors, reflective habits, and professional readiness, creating a sustainable foundation for lifelong learning and teaching excellence.

Combining results of the three research questions with the underlying architecture and central pedagogical methods, it seems that the Digital Literacy-Based Pedagogical Model (DL-PM) is a transformational model. Its functional and cyclic arrangement makes digital literacy, self-determination learning and self-regulation mutually supportive. Scaffolded teaching, technology support, formative feedback, and infused curriculum are the ways through which the model prepares PSTs with the competencies required of them to work as autonomous experts who have learned professionally in a digital age. This understanding is consistent with the fact that the Digital Literacy-Based Pedagogical Model (DL-PM) not only facilitates the technical competences, but also self-directed behaviors, reflective habits and professional readiness as well which in turn, leads to inception of successful lifelong learning and teaching excellence.

## **5.Discussion**

The study focused on the development of a Digital Literacy-Based Pedagogical Model (DL-PM) for promoting self-regulated learning in pre-service teachers (PSTs) at the Department of Education, University of Narowal. Applying interpretive research methods, data were gathered via semi-structured interviews, reflective journals and participant observations. The method of thematic analysis (Braun & Clarke, 2021) was used for the generation of key themes and sub-themes. The analysis was centered around three main research questions: which digital literacy competences are relevant for support of autonomous learning; how a pedagogical model may integrate these competences effectively; and to what extent implementation of this model impacts on autonomous learning, self-regulation, and digital competence.

In the first data set, skills that PSTs felt were necessary for autonomous learning emerged. Participants frequently mentioned information and media literacy, technical/ICT capabilities, and self-regulatory and communication skills. Media and Information Literacy

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enabled participants to critically analyze online content, identify reliable sources, and be able to put together information for the purpose of self-directed learning. A participant said, "I will now do a comparison with many references in order to include them in my project and it makes me confident too to work at alone. Technical and ICT skills, such as the proficiency with LMS platforms and educational technologies, were found to eliminate logistical obstacles for students and allowed them to direct their attention toward cognitive engagement. Self-regulated and communicative skills and regular time-planning, digital collaboration, and peer communication in an online environment were identified as key to keep up the motivation level and responsibility. Together, these skills corresponded to the cognitive, technical and socio-emotional aspects of digital literacy identified in the model and facilitated gateway to autonomous learning behavior.

**Themes and Sub-Themes:**

1. Cognitive Dimension: Critical evaluation, synthesis, and decision-making.
2. Technical Dimension: LMS proficiency, digital tool mastery.
3. Socio-Emotional Dimension: Collaboration, self-regulation, online communication.

The second research question centered on how a pedagogical model could successfully incorporate digital literacy and self-directed learning strategies. Four underlying components were identified through analysis: Curriculum Design & Integration, Instruction Strategies, Technology & Resource Support, and Assessment & Feedback mechanisms. The need to integrate digital literacy into all courses as a basic, rather than a voluntary or optional, requirement was stressed by participants. "Bringing digital skills into everything we do," one of the participants said, "helped me really see how our work was meaningful and will help me in my classroom. Learning activities such as scaffolding tasks and reflective journals facilitated the transformation from traditional to student centered learning; in addition, it helped learners become aware of their thinking process (i.e., making them learn how to use metacognitive control) through relatively complete self-regulation. Technology and resource access to things like consistent LMS access and continual technical support served to reduce the extrinsic barriers, meaning that for at least these two students cognitively there was more "funding" available to do the work related to their learning. Last, formative assessment and personalized feedback supported a sense of competence and the regulation level. The interaction of these elements further verified the cyclical and iterative characteristics of the DL-PM, evidencing how organizational and instructional frameworks mutually developed learner autonomy.

**Themes and Sub-Themes:**

- 1) Curriculum Integration: Embedding digital literacy in pedagogical content.
- 2) Instructional Strategies: Scaffolded activities, reflective journals.
- 3) Technology & Resource Support: LMS access, technical assistance.
- 4) Assessment & Feedback: Formative assessments, personalized feedback.

The third research question examined the impact of implementing the DL-PM on PSTs' autonomous learning, self-regulation, and digital competence. Participant responses consistently indicated enhanced **initiative, self-monitoring, and professional readiness**. PSTs reported developing greater confidence in planning tasks, investigating additional information, and handling self-directed learning. "The model not only taught me digital skills, but also helped me to plan and monitor my learning," said one learner in a feedback session.

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Reflection and scaffolded instruction built metacognitive skills with a focus on making strategic decision and time management. Proficiency on LMSs and online tool, the evaluation of information was praised for implying increased digital competency which is a critical aspect for self-directed learning as well as professional readiness. These results support the transformative role of the DL-PM, suggesting that the model fosters not only technical competencies but also social and cognitive abilities critical for self-regulated learning.

**Themes and Sub-Themes:**

1. Autonomous Learning: Initiative, independent task completion, resource exploration.
2. Self-Regulation: Planning, monitoring, reflective practice, metacognition.
3. Digital Competence: LMS proficiency, tool mastery, information evaluation.

The results are consistent with both Self-Determination Theory (SDT) and constructivist learning theories. The SDT theory suggests that autonomy, competence and relatedness create intrinsic motivation and engagement (Ryan & Deci, 2017). In the DL-PM, scaffolded instruction promoted autonomy, formative feedback facilitated competence, whilst collaborative digital activities nurtured relatedness. Constructivist approach highlights the process of knowledge construction taking place through active involvement, reflection and real application (Vygotsky, 1978). PSTs' descriptions of reflective journals, collaborative tasks and scaffolded assignments establish that they actively generated knowledge associating digital literacy skills to teaching practice settings.

Combining the data across the three research questions shows that the DL-PM is conducive to synergistic competencies. Digital literacy encompasses cognitive, technical, and socio-emotional competencies; autonomous learning and self-regulation can only function when these are operationalized within the system framework offered by structured curriculum, scaffolded instruction, technological support and ongoing formative assessment. The recursive nature of the model permits PSTs to repeatedly do, think about, and improve upon resulting in enduring behavioral and cognitions changes. The data analysis validates the DL-PM as an holistic, transformative pedagogical model. It can successfully combine digital literacy skills and self-regulated learning strategies contributing to the development of self-regulation, digital competency and the professional readiness of PSTs. The model illustrates how including organized curricula, scaffolded instruction, technical assistance and ongoing feedback work together to develop autonomous, reflective and digitally fluent PSTs that are ready for the current educational environment.

**6.Conclusion**

The indented purpose of the current research was to formulate a Digital Literacy-Based Pedagogical Model (DL-PM) to promote self-directed for learning style having by Pre-service Teachers' (PSTs) at Department of Education, University of Narowal. The study systematically examined three aspects: the digital-literacy competencies needed to promote AL; how these competencies were structured in a pedagogical model, and the effects of this model on PSTs' altitude toward AL, self-regulation, and digital competence. The findings, based on semi-structured interviews, reflective journals and participant observations, were particularly valuable in shedding light into the concrete as well as theoretical aspects of digital literacy development within teacher education.

The contributions are twofold: theoretical and practical. The study provides support for the

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relevance of SDT and constructivist ideas in teacher education from a theoretical perspective but also inferences about how psychological needs and learner centred methods intersect with digital competencies to engender autonomy. It is conceptually a structured, scalable and replicable training model for teacher education programs who want more autonomous learning and more digital literacy in their students. Further study might go on to consider the long-term effects of DL-PM adoption within various educational settings, examine its efficacy in hybrid and full online contexts, and also evaluate its influence on PSTs when they become professional teachers. Further, they may consider investigating how the model might be adapted for use by in-service teachers or with other subjects to ascertain its generalizability.

The Digital Literacy-Based Pedagogical Model (DL-PM) is an innovative Teacher Education model that incorporates cognitive, technical and socio-emotional skills to develop autonomous learning, self-regulation and digital literacy. The results highlight that the combination of provision, scaffolded opportunities and supportive technology can together develop autonomous, reflective and digitally fluent pre-service teachers enabling them to be professionally successful in evolving educational settings.

## **7.Recommendations**

This study presents several practical and strategic implications to promote PSTs' autonomous learning, digital literacy and self-regulated strategy using the results according to this study:

- 1) Digital Literacy should be integrated into all courses as a teacher education program component not an individual course. Including assignments, collaborative projects and research that require the use of digital tools for budding PSTs to practice skills in real pedagogical settings may help fortify both the technical and cognitive skill sets.
- 2) Scaffolding student-centered methods, which successively transfer the responsibility for learning to students, should be used by instructors. The use of scaffolding activities, project-based learning and reflective digital journals will promote autonomy, metacognitive skills and self-regulated learning to enable PSTs' confidence and initiative in managing their own work in the digital environment.
- 3) Institutions need to guarantee equitable access to online platforms, LMS and digital pedagogical tools. Technical support, troubleshooting information and help desks should be in place to reduce extrinsic barriers so that PSTs can concentrate on learning rather than overcoming technology-related obstacles.
- 4) Respectively, teacher education program should embed formative assessment tools such as portfolio, online quizzes and peers evaluation. Digital personal feedback can facilitate PST monitoring progress, plugging of gaps and the development of self-regulatory competence and digital capabilities.
- 5) Learning to work digitally on discussion boards, group projects and peer reviews need to be a priority. Working together supports relatedness, motivation and accountability which in turn can drive both SDT's psychological needs and the socio-emotional values in digital settings.
- 6) Teacher trainers should be trained on how to incorporate digital literacy and self-directed learning strategies into their instruction. Scaffolding, reflection, formative

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assessment and technology-integrated instruction need to be emphasized in the professional development programs, so as to facilitate teachers' successful implementation of DL-PM principles.

7) Institutions need to devise strategies for evaluation of the long term effect of DL-PM on PSTs such as autonomous learning, teaching practices and professional preparedness. Iterative evaluation could provide information about enhancements, sensitivities in different subjects, and the scale of the model from one educational setting to another.

8) PSTs recognized the need to keep reflective journals and digital portfolios as they engage in their journey towards professionalism. These strategies promote metacognition, self-regulation and a disposition to continual learning, so that the competent use and autonomous development of digital resources are achieved beyond initial training into ongoing careers.

These recommendations reflect systematic embedding, learner focus, continued support and ongoing assessment to address the pre-service teachers' needs for the acquisition of knowledge, skills and attitudes required for independent, digitally skilled and reflexive teacher practice.

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