



Personal learning environments in initial teacher education: Digital competence and self-regulated learning

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ABSTRACT

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Personal Learning Environments (PLEs) constitute an emerging pedagogical approach that integrates formal and informal education while promoting the development of self-regulation, self-management, and self-directed learning skills. In this context, the study aimed to describe the uses and challenges associated with incorporating PLEs into initial teacher education. To achieve this, a qualitative approach was adopted using a single-case study design aimed at gaining an in-depth understanding of participants' experiences regarding the configuration, organization, and use of learning environments. Data collection techniques included document analysis, the application of a digital tools inventory, learning mapping, and semi-structured interviews. The sample consisted of ten second-year students enrolled in an education programme. The findings reveal that the configuration of PLEs is broad, complex, and diverse; however, the use of Information and Communication Technologies (ICT) remains mainly oriented toward instrumental purposes, with limited engagement in the processes of creation, collaboration, critical reflection, and knowledge construction. In addition, the incipient development of self-regulation, self-management, and self-directed learning skills was identified, along with the weak progression of digital competencies within the training curriculum. These findings highlight the need to integrate digital competencies into the curriculum, strengthen digital literacy and technological infrastructure, and establish systematic mechanisms for the assessment, monitoring, and follow-up of these skills.

Contribution/Originality: This study provides empirical evidence on the configuration and use of PLEs in the education of future teachers as a means of managing their learning. Its relevance lies in the fact that this is a scarcely explored field, due to the limited number of studies conducted in Latin America. Likewise, it explains why PLEs fail to evolve pedagogically when there is no intentional curricular progression that articulates the development of digital and metacognitive skills.

1. INTRODUCTION

Personal Learning Environments (PLEs) are currently a relevant ally within the teaching-learning process in higher education. This approach fosters the development of skills such as self-regulated learning, self-management, and metacognitive regulation. From a techno-pedagogical perspective, it is conceived as a personal, social, and unique

space (Nan Cenka, Santos, & Junus, 2024) centered on the student and their capacity for agency over their own learning. In this sense, PLEs are configured by the students themselves, who integrate a variety of tools, resources, and learning strategies that adapt to their needs and interests. Thus, they decide how, what, when, and with whom to learn in an autonomous, active, and collaborative manner (Castañeda, Attwell, & Dabbagh, 2022).

PLEs are dynamic, flexible, and open environments that promote the development and strengthening of digital skills, as well as cognitive and metacognitive processes; they also foster cooperative learning, autonomy, and lifelong learning. These learning environments are not static but rather evolving and changing according to the needs, interests, skills, and motivations of students (Dabbagh, 2024; Dabbagh & Fake, 2017; Johnson, Rodriguez-Arciniegas, & Kataeva, 2023; Junaštíková, 2024). Likewise, strategies such as planning, self-reflection, and monitoring enable students to assume an active role in the construction and management of their own PLEs (Xu, Zhang, Lei, Qi, & Pan, 2025).

PLEs are conceived as a technological and pedagogical reality; however, they should also be understood as a hybrid reality, in which digital tools converge with educational, training, and self-regulation processes, actively constructed and managed by the student (Castañeda, Tur, & Torres-Kompen, 2019). From the perspective of a digital ecosystem, PLEs are articulated with the European Digital Competence Framework (DigComp), the European Framework for the Digital Competence of Educators (DigCompEdu), and the TPACK model.

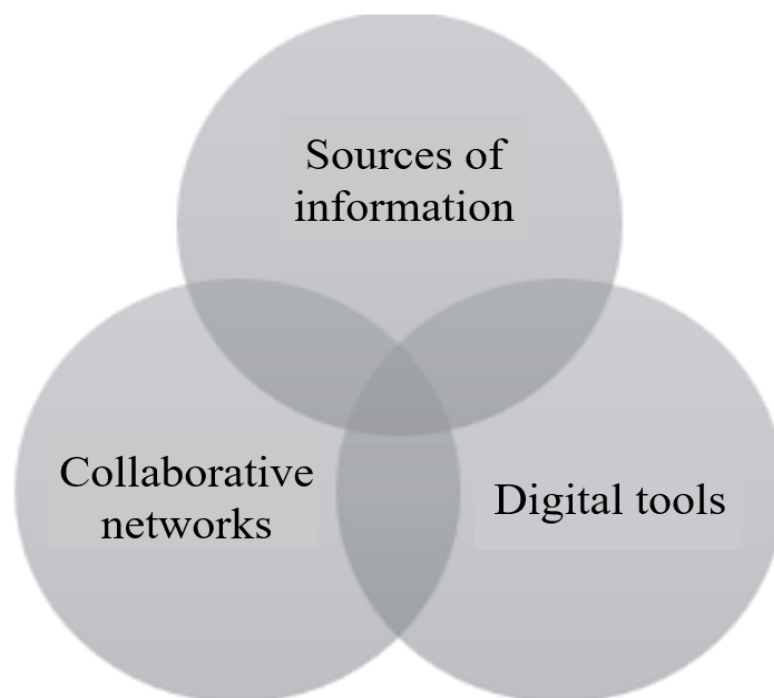


Figure 1. Elements of a PLE.

Figure 1 illustrates the configuration of the Personal Learning Environment (PLE) and the dynamic relationship among its main components: information sources, digital tools, and collaborative work, all of which enable its implementation and strengthen learning processes.

The European Digital Competence Framework (DigComp) seeks to standardize the digital skills that every 21st-century professional should possess, such as information literacy, communication, collaboration, digital content creation, safety, and problem-solving, to perform effectively and efficiently (Meyerhofer-Parra & González-Martínez, 2024; Vuorikari, Kluzer, & Punie, 2022). These skills are complemented by the European Framework for the Digital Competence of Educators (DigCompEdu), which establishes the skills that every teacher should develop to support the teaching–learning process, the management of digital resources, technology-mediated assessment, the

empowerment and development of students' digital skills, as well as professional engagement (Redecker, 2020). For its part, the TPACK model integrates three types of knowledge that contribute to the development of digital skills: content knowledge, pedagogical knowledge, and technological knowledge (Mishra & Koehler, 2006). All these skills promote competent teacher performance in digital environments, which contributes to the development of more reflective, integrated, meaningful, and lasting learning (Meyerhofer-Parra & González-Martínez, 2024; Monroy Correa & Vega Ventosilla, 2024).

In turn, the United Nations Educational, Scientific and Cultural Organization (Miao & Cukurova, 2024) highlights the importance of the AI Competency Framework for Teachers, aimed at strengthening the skills of teachers in training through the use of digital technologies and artificial intelligence, acting ethically and responsibly when managing digital content, and ensuring respect for copyright and the protection of personal data (Barragán-Sánchez, Corujo-Vélez, Palacios-Rodríguez, & Román-Graván, 2020; Ramírez-Mera & Tur, 2019). All these digital frameworks- DigComp, DigCompEdu, TPACK, and the AI Competency Framework- lay the foundations for students to design, build, and effectively manage their own PLEs (Fernández-Bringas & Chinchay Pajuelo, 2023; Florimandi Tapia, 2025; Miao & Cukurova, 2024). Nevertheless, there is still limited empirical understanding of how teachers in training actually configure their personal learning environments.

1.1. Components and Configuration of PLEs

Personal Learning Environments (PLEs) promote the integration of learning acquired in formal, non-formal, and informal contexts (Saz, Engel, & Salvador, 2016). They are composed of three categories: reading, writing, and sharing. Their implementation requires sources of information to search, select, classify, and manage knowledge, digital tools, and learning networks. The interaction of all these elements enables access to information, its processing, and connection with others, which leads to autonomous, personalized, collaborative, and lasting learning (Pereira-Medina, 2021). To successfully implement a personal learning environment, it must be aligned with the principles of Universal Design for Learning (UDL), as this approach promotes the creation of personalized, flexible, and inclusive educational environments that respond to the diverse needs of students and support the removal of barriers that limit learning (Lambert, McNiff, Schuck, Imm, & Zimmerman, 2023; Xu, Zhu, & Chan, 2023). PLEs can also act as assessment tools, as they facilitate the monitoring and follow-up of the learning process through the skill of learning to learn (Nan Cenka et al., 2024; Serrano-Sánchez, López-Vicent, & Gutiérrez-Portlán, 2021).

1.2. Background

Recent studies highlight the potential and benefits of Personal Learning Environments in higher education. PLEs foster self-regulation, self-direction, and the development of skills necessary to use technology and academic resources effectively, in addition to contributing to reducing the gap between theoretical and practical knowledge; however, factors such as digital inequality, limited technological infrastructure, and resistance to change limit their benefits (Msimango, Mtshali, & Ajani, 2025). In this same vein, Nan Cenka et al. (2024) argue that the PLE acts as both a tool and a guide for students; likewise, they function as a personal assistant, facilitating the planning, monitoring, and evaluation of the learning process.

In this regard, Castañeda et al. (2023) conducted a study on academic tasks and student agency. The findings show that the implementation of tasks aimed at promoting PLEs is still under development, with room for improvement in aspects such as assessment, metacognition, and students' self-regulation; they also indicate that the use of specific or paid platforms may limit students' flexibility, access, and autonomy. The PLE, as a decentralized approach in higher education contexts, recognizes the ways in which individuals learn and interact to transform the learning process. It also enhances autonomy and on-demand, lifelong, and continuous learning; however, its implementation in university settings implies a change in the role of the teacher and in institutional structures (Dabbagh, 2024) as well as technological and cultural barriers (Van De Werfhorst, Kessenich, & Geven, 2022). In

this context, rigid organizational cultures hinder the incorporation of new active learning approaches (Greenan & Napolitano, 2024), which restricts the development of digital skills in both teachers and students. Likewise, a certain resistance to change is observed among teachers, motivated by the fear of losing leadership in the teaching process, especially considering that PLEs prioritize student autonomy (Córica, 2020; Shaikh & Khoja, 2012).

Based on the issues described, the objective of the study was to analyze the configuration of Personal Learning Environments (PLEs) in teachers in training and their relationship with the development of digital skills within the framework of autonomous, collaborative, and technology-mediated learning.

2. MATERIALS AND METHODS

The study was conducted using a qualitative approach that allows for the examination of practices situated in specific contexts (Hernández-Sampieri & Mendoza Torres, 2022). The design was a single-case study, as it enables an understanding of the phenomenon in its real context (Yin, 2018). According to Stake (2005) classification, the research corresponds to an intrinsic case study, whose objective is to understand a particular case.

2.1. Participants

The participants in the sample were in their second year of university studies and had passed at least one of the two courses related to the use of ICT that are part of the curriculum. Ten students participated in the study (eight women and two men), all from the Primary Education Professional Program (EPEP) of the Faculty of Education at the National University Federico Villarreal. The sample size was determined based on the criterion of theoretical saturation, which was reached in the eighth interview, as no new categories emerged thereafter (Fusch & Ness, 2015). Likewise, the ethical principles of informed consent, anonymity, and confidentiality were respected. Participants voluntarily agreed to take part in the research, and the protection of their personal data was guaranteed.

2.2. Data Collection Techniques and Instruments

The following techniques were used for data collection.

Document analysis included the review of the study plan and the curriculum of subjects related to Information and Communication Technologies. The digital tools inventory (PLE) was adapted from the EPA (2024) and designed to identify the type of students' digital participation. The graphic map allowed students to represent the applications, resources, and virtual spaces integrated into their PLEs. Semi-structured interviews were conducted to explore students' perceptions of the advantages of using PLEs within their learning process, self-regulation, and learning management.

2.3. Data Analysis Procedure

Given that the volume of data was manageable, manual coding and interpretation were carried out. In this regard, Braun and Clarke (2006) and Miles, Huberman, and Saldaña (2014) argue that manual qualitative analysis is valid when the processes of categorization, coding, and data synthesis are clearly documented; therefore, the use of specialized software is not necessary. Data analysis was conducted in three phases. In the first phase, open coding was carried out. Inventories, maps, and interview transcripts were read in detail to identify meaningful units related to perceptions of ICT use. Initial codes were generated inductively and remained close to the participants' language. In the second phase, axial coding was performed, allowing for the comparison and grouping of analogous codes. In the third phase, selective coding was conducted, enabling the integration of emerging subcategories into broader categories that explain the configuration and management of Personal Learning Environments (PLEs).

Table 1 presents an illustrative example: codes such as "searching for information on Google," "watching tutorials on YouTube," and "consulting ChatGPT to obtain quick answers" were grouped into the subcategory "information consumption," contributing to the category "instrumental use of ICT." This final phase made it possible

to identify central analytical categories that explain how teachers in training configure, manage, and, in some cases, limit their Personal Learning Environments (PLEs) in formal and informal educational contexts.

Table 1. Process of transition from initial codes to final categories.

Interview Excerpt	Initial Code	Category
"I search for information on Google," "I use YouTube to understand assignments," "I consult ChatGPT when I have questions"	Information search	Instrumental use of ICT

3. RESULTS

Based on the analysis of the data and the interrelation of the various informational resources, emerging categories were identified to guide the presentation of the results.

3.1. Document Analysis

The review of official and regulatory documents shows that one of the institutional objectives of the university is to promote research and technology transfer within the university community through the implementation of standards and best practices. In line with this objective, the curriculum establishes in the graduate profile that students must demonstrate competence in the use of ICT. However, this is not reflected in the curriculum of the Primary Education Professional Program (EPEP), which shows a limited presence of courses aimed at developing digital skills. Only two courses directly related to the pedagogical integration of digital technologies were identified: Pedagogical Innovations and Virtual Environments (1st year) and Virtual Teaching Resources in Primary Education (3rd year). The syllabi of both courses declare the use of student-centered methodologies, such as project-based learning (PBL); however, they do not include other innovative strategies, such as flipped classroom or gamification. Likewise, the curriculum review revealed that some courses incorporate the use of ICT in at least one of their units, as is the case of the course *Innovation and Knowledge Management*. These findings show a limited progression in the development of digital skills and reveal a gap between what is established in the graduate profile and what is observed in training practices, a situation that negatively impacts the professional preparation of future teachers.

3.2. Analysis of the PLE Inventory

The results show that students have knowledge of and proficiency in various digital tools, as well as academic, social, recreational, and well-being resources. Their digital ecosystems are diverse and extensive; however, there is a predominance of instrumental use of technologies, mainly oriented toward access to information rather than the construction of collaborative learning. The following categories emerged: a) Predominance of information consumption: the most frequent category is that of the consumer, which reflects passive and receptive learning, with limited content production. The most commonly used platforms are YouTube, TikTok, Google, and Wikipedia. b) Functional but limited academic use: tools such as Google Scholar, ChatGPT, Word, Canva, Kahoot, and GeoGebra are used for academic purposes; however, their use is mainly operational (completion of tasks, presentations, or information searches), without fostering deeper learning that promotes critical and creative thinking. c) Integration into knowledge communities: participation is almost nonexistent, limited in some cases to forum participation or information searches in repositories. d) Personal learning management: the primary use of tools such as Google Calendar and OneDrive for organizing activities reflects an incipient development of self-regulation skills. e) Use of digital social networks: Instagram, Facebook, TikTok, and WhatsApp are mainly used as informal learning environments for communicative and informational purposes, and only occasionally for educational purposes, indicating a strong presence of these networks in personal learning environments. f) Integration of generative artificial intelligence: ChatGPT stands out as the most widely used tool among students, becoming a relevant source of academic information for quick searches, writing, text correction, and general task support.

3.3. Analysis of the PLE Digital Mind Map

The analysis shows that students manage various Personal Learning Environments (PLEs). However, the consumption of academic information predominates, accompanied by limited articulation between formal learning tools such as Canva, Kahoot, Socrative, Quizizz, institutional Microsoft Teams, and academic databases such as EBSCO, and informal learning spaces such as social networks (YouTube and TikTok), personal or educational blogs, online learning communities, and knowledge management tools such as Notion, Evernote, or Diigo. Self-regulation and digital creation among teachers in training are incipient and are mainly focused on design and organizational platforms such as Canva and Google Calendar. The level of digital interaction and collaboration is limited and is more related to academic coordination than to networked learning. Likewise, there is a growing trend toward autonomous language learning through digital platforms such as Duolingo; however, there is an absence of participation in online learning platforms such as Coursera or edX. Overall, the PLEs analyzed reveal a profile of an autonomous student in the process of consolidation, with a still limited orientation toward more creative, collaborative, and metacognitive digital practices.

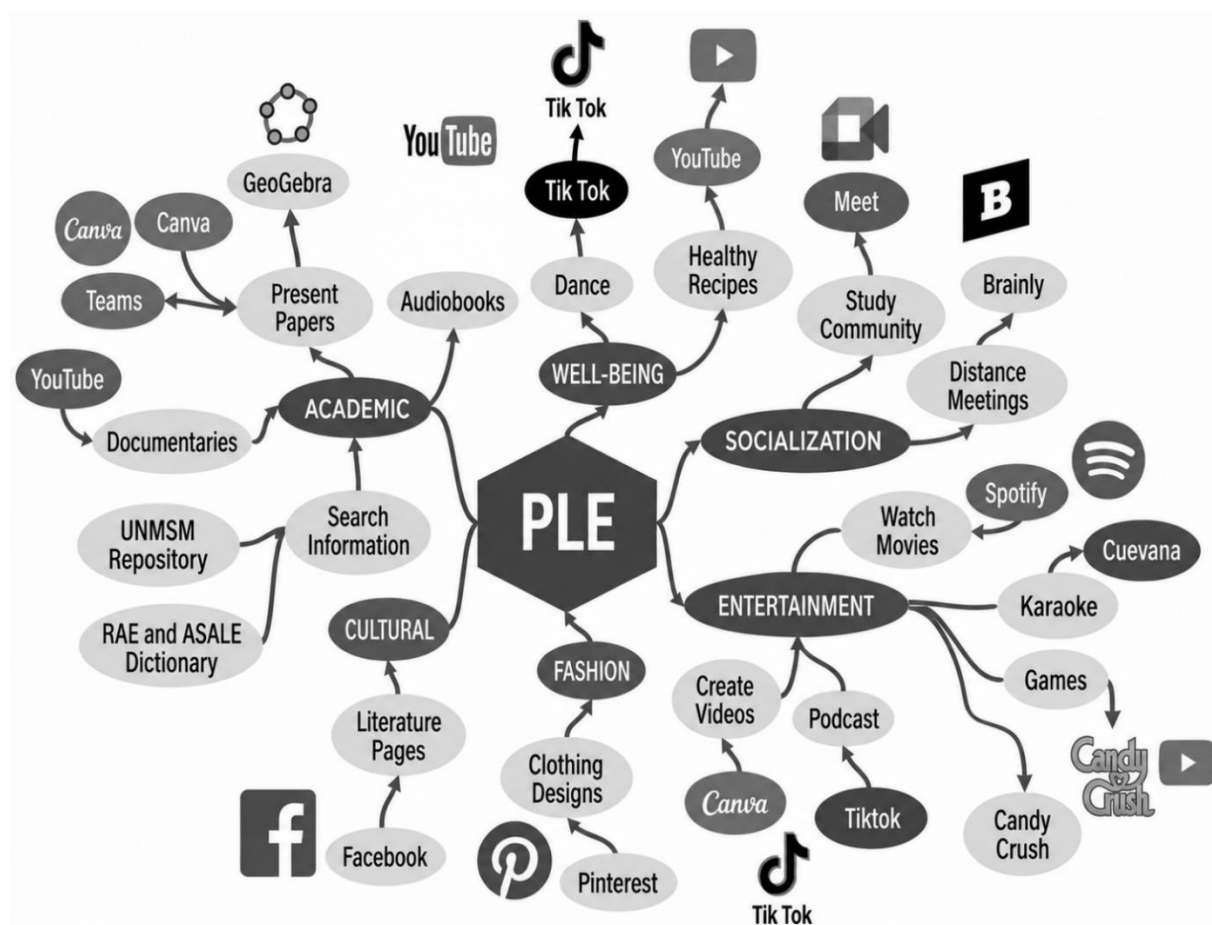


Figure 2. Mapping of a PLE.

Figure 2 illustrates the map of the personal learning environment of pre-service teachers, integrating the main tools they use for learning, socializing, entertainment, and accessing cultural content. Together, these dimensions articulate and reflect the configuration of digital practices within the academic context.

3.4. Interview Analysis

Students' digital participation is mainly oriented toward the role of a consumer. Some participants indicated that ICT is primarily used as a support resource in the development of academic activities, which highlights a

predominance of instrumental use of Information and Communication Technologies (ICT). Some interviewees stated:

“For my academic activities, I search for everything on Google.” (MMD, interview 5).

“I use YouTube to understand assignments.” (MRZ, interview 8).

“I consult ChatGPT if I have questions.” (NVA, interview 3).

These responses show that ICT is mainly used as a tool to support the completion of academic tasks. Likewise, they highlight that students more frequently resort to general search tools (Google), rather than using specialized academic databases (Google Scholar, SciELO, Scopus, or ERIC). This suggests that the use of technology is oriented toward the rapid location of information, but also reflects possible limitations in the development of more advanced academic search skills.

At a second level, the role of commentator is identified. In this regard, participants were mentioned.

“I use TikTok for entertainment and comment on what I find amusing.” (RLC, interview 1).

“I have made presentations with Kahoot or Padlet, but the one I use the most is Canva.” (SBC, interview 5).

These statements show that the role of collaborator and participation in online learning communities are practically nonexistent.

In contrast, functions associated with the role of creator are still at an early stage. In summary, the interviews indicate that there is broad and varied knowledge of resources and digital tools; however, their use is predominantly functional and oriented toward information consumption. On the other hand, content creation is very limited, as is participation in learning networks, suggesting that students are in a process of transition toward more autonomous and connected forms of learning.

This situation is explained, according to the students themselves, by the limited training in digital skills during Regular Basic Education. In that context, digital literacy was mainly limited to the use of Office 365, a stage in which most students acquired only basic skills in the use of office tools such as Word, Excel, and PowerPoint. This digital gap becomes evident in higher education, where the development of digital skills is affected, especially among students from public universities, most of whom come from urban-marginal areas and educational institutions with insufficient technological infrastructure.

In addition to these gaps, there are gender-based digital inequalities. In this regard, the United Nations (UN) reported that more than 89 million women in Latin America and the Caribbean do not have access to the internet. In this context, Miao and Cukurova (2024) emphasizes that information and communication technologies have great potential to transform learning processes and strengthen educational inclusion. These findings show that limitations in digital self-regulation are not only due to structural factors but also to the lack of systematic pedagogical integration of PLEs in initial teacher education.

Table 2 reveals that pre-service teachers tend to engage in superficial information consumption, characterized by limited in-depth exploration of sources.

Likewise, low levels of digital content creation and a scarcity of practices regarding learning planning and organization within these environments have been observed. Furthermore, although their ecosystems are extensive, they appear fragmented and disjointed, highlighting a weak connection between academic and personal resources and virtually non-existent peer collaboration.

From a curricular perspective, ICT integration is limited and lacks structured progression, thereby restricting the systematic development of digital competencies. Finally, while future teachers use applications independently, this process, though autonomous, lacks sufficient guidance, reflecting a form of self-directed learning that is in its early stages and receives little pedagogical support.

Table 2. Categorization of thematic analysis.

Main Category	Subcategories	Emerging Codes	Sources of Information
Instrumental use of ICT	Information consumption	"I search everything on Google," "I use YouTube to understand assignments," "I consult ChatGPT when I have questions"	Inventory, interviews
	Superficial search	"I watch summaries on TikTok." "I use Wikipedia for quick references"	Inventory, interviews
	Low digital creation	"I only make presentations in Canva." "I do not participate in academic groups"	Interviews
Incipient digital self-regulation	Limited organization	"I use Calendar for my tasks." "I write things down in Notion"	Mapping, interviews
	Low digital planning	Sometimes I forget to check my apps." "I don't know how to organize my resources"	Interviews
Disarticulation between formal and informal tools	Broad but fragmented digital ecosystems	Simultaneous use of: YouTube, TikTok, WhatsApp, EBSCO, Classroom, Canvas	Inventory, mapping
	Limited connection between academic and personal resources	"I use Teams only when the teacher asks for it"	Interviews
Limited digital participation	Predominant role of the consumer	90% of activities focused on receiving information	Inventory
	Minimal interaction	"Sometimes I comment on TikTok." "I do not participate in forums"	Interviews
	Almost nonexistent collaboration	"I prefer to work alone." "I do not know any learning communities"	Interviews
Insufficient techno-pedagogical training	Curriculum with limited ICT presence	Only two ICT courses across 10 semesters	Document analysis
	Absence of digital progression	Lack of innovative methodologies in syllabi (PBL, flipped classroom, gamification)	Document analysis
Self-organized learning through apps	Use of apps for independent learning	Duolingo, YouTube, tutorials, ChatGPT	Inventory, mapping
	Autonomous but unguided learning	"I learn on my own by watching videos, but without guidance"	Interviews

The triangulation of these sources made it possible to compare information from institutional and academic documents with the testimonies and practices of future teachers, thus strengthening the internal validity of the study.

4. DISCUSSION

The analyses highlight that in the PLEs of teachers in training, there is a predominance of the role of information consumer (90%), followed by the role of commentator (9%) and, to a lesser extent, the role of creator or collaborator in networks (1%). These percentages were obtained from the frequencies reported in the inventory and were confirmed through the interviews. These findings show a primarily functional use of Information and Communication Technologies (ICT). Students use digital tools mainly for information search, rather than for more cognitively complex activities such as reflecting, organizing, comparing, creating digital content, or participating in learning communities (Ordaz Guzmán & Arellano Vega, 2021). Likewise, it is observed that digital self-regulation is carried out through personal-organization tools such as Google Calendar, Notion, and Google Drive; however, without pedagogical and metacognitive guidance, their formative potential and the development of connectivist learning are limited.

Castañeda et al. (2019); Chaudhry and Kazim (2022); Peng, Ma, and Spector (2019) and Torres-Gordillo and Herrero-Vázquez (2017) argue that PLEs have an impact on emerging pedagogical practices, self-regulated learning,

and learning management; however, their influence on teacher professional development remains limited. These results are consistent with the findings of García-Martínez, Rosa-Napal, Romero-Tabeyo, López-Calvo, and Fuentes-Abeledo (2020) and López-Meneses, Sirignano, Vázquez-Cano, and Ramírez-Hurtado (2020), who state that university students more frequently use tools oriented toward access to information and, to a lesser extent, those intended for interaction with peers or content creation. In the same vein, Xu et al. (2025) conclude that using pedagogical strategies in the development of PLEs promotes the acquisition of research skills, while Torres-Gordillo and Herrero-Vázquez (2017) highlight the value of PLEs as self-management tools.

Berbel Gimenez and Borrás-Gene (2023) argue that students perceive this approach as a self-managed learning strategy, mainly for information search and networked collaboration. Wei, Mejia, and Qi (2021) identified effective teaching and learning strategies for both students and teachers. Additionally, Tolentino Escarcena, Medina Gamero, Flores Apaza, and Gonzales Torres (2024) compared the use of personal learning environments between teachers and students, highlighting the need to strengthen digital skills among all educational stakeholders.

The results highlight the need to implement curricular courses related to the pedagogical use of ICT, educational innovation, and digital citizenship, aimed at developing digital civic competence. This implies strengthening information literacy among both students and teachers, promoting the ethical and responsible use of information, the development of critical thinking, and self-regulated learning through the reflective, critical, and transversal integration of ICT in initial teacher education. Likewise, collaborative spaces should be promoted to allow the exchange of experiences regarding the use and benefits of PLEs, as well as processes of self-evaluation and reflection. Finally, the implementation of tutoring and mentoring programs with a gender perspective is recommended to reduce existing digital gaps.

5. CONCLUSIONS

This study reveals the existence of a significant digital gap between the availability of technological tools and the development of digital skills in teacher education, evidenced by a mismatch between the graduate profile and the digital practices developed by future teachers. These limitations hinder students' ability to respond effectively to the demands of current and future classrooms. These findings show that the use of Personal Learning Environments (PLEs) is not yet fully integrated into initial teacher education and that mastery of digital tools does not guarantee self-regulated learning or the development of advanced digital skills.

The scarcity of research in this area highlights the need to incorporate smart learning environments, adaptive personalization, and artificial intelligence into education degree curricula, as these promote autonomy, self-regulation, and students' sense of agency (Peng, Ma, & Spector, 2019). These digital ecosystems allow for the automation of exam design and activity grading, leaving teachers with more time for monitoring and personalized feedback (Chaudhry & Kazim, 2022). However, it is emphasized that teacher education curricula must include courses with a gender perspective aimed at reducing digital gaps, as well as training proposals focused on the techno-pedagogical use of ICT, digital citizenship, and educational innovation, in order to foster more inclusive and equitable participation in digital environments.

6. LIMITATIONS

First, the study is limited by the size and scope of the sample, which is restricted to a single professional program. Second, the use of self-assessment instruments may introduce bias in the interpretation of the data. Third, the lack of institutional diversity represents another relevant limitation, as the findings come exclusively from a specific group, the Primary Education Professional Program, and not from the entire Faculty of Education or other universities. Nevertheless, the results contribute to expanding the understanding of Personal Learning Environments as a relevant techno-pedagogical approach in teacher education. These limitations should be taken into account when interpreting the results and generalizing the study's conclusions.

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Institutional Review Board Statement: The ethics committee of the Faculty of Education (Dean's Resolution No. 408-2025-SA-FE-UNFV) at the National University Federico Villarreal, Lima, Peru, approved the authorization of this study through Act No. 001-2026-CEI-FE-UNFV.

Informed Consent Statement: Informed verbal consent was obtained from all participants prior to their participation in the study. All data were anonymized to ensure participant confidentiality.

Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.

Competing Interests: The authors declare that they have no competing interests.

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