

## Article

# Teacher Educators' Digital Proficiency and Sustainable Pedagogical Technology Use: An Integrated Model of Competence and Implementation

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## Abstract

This study proposes an integrated model examining the relationship between teacher educators' digital proficiency and the frequency of their pedagogical use of digital tools. By promoting long-term capacity-building in digital competence, the model contributes to sustainable development goals in education, particularly in ensuring inclusive, equitable, and high-quality learning environments. The study involved 156 faculty members from five teacher-training colleges in Israel. Digital proficiency was measured using a validated self-assessment questionnaire adapted from the SELFIE framework (Self-Reflection on Effective Learning by Fostering the Use of Innovative Educational Technologies). The questionnaire assessed perceived competence across three dimensions: (1) filtering and enhancing digital resources, (2) assessment, feedback, communication, and active learning, and (3) adaptive and creative learning. A second questionnaire examined how frequently educators used specific digital tools across four categories: collaboration, diversity and special needs, active and creative learning, and distance and hybrid learning. Data were analyzed using Item Response Theory (IRT) to generate proficiency scores and Structural Equation Modeling (SEM) to test associations. Results indicated moderate overall digital proficiency, with stronger competence in collaboration and communication and lower use of tools related to personalization and creativity. Significant positive associations were found between digital proficiency and all categories of tool use, especially creative and student-centered learning. Use also varied by gender, seniority, and professional role. The study underscores the importance of pedagogically informed professional development to support meaningful and inclusive digital integration.

**Keywords:** digital proficiency; technology integration; educational technology; personalized learning; techno-pedagogical competence; digital tool usage; sustainability in education

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## 1. Introduction

The COVID-19 pandemic significantly accelerated the adoption of digital technologies in higher education [1]. In Israel, many colleges of education responded by establishing dedicated units to support the pedagogical integration of digital tools into teaching and learning. These initiatives included professional development workshops and ongoing support services designed to strengthen faculty members' techno-pedagogical

competencies. Such competencies involve the intersection of technological proficiency and pedagogical expertise, enabling educators to leverage digital tools to enhance instruction, promote student engagement, and adapt teaching strategies [2].

These efforts not only address immediate instructional needs but also support long-term educational sustainability by fostering digital resilience, equitable access, and the capacity to adapt teaching to evolving societal and technological demands [1,3,4].

In recent years, the emergence of generative AI tools has prompted renewed attention to the potential of digital technologies in teacher education. While initial reactions ranged from concern over plagiarism to fears of automation replacing educators, scholars have increasingly emphasized the pedagogical affordances of AI [3]. One of the most promising developments is the use of AI to support personalized pedagogy—adapting instruction, content, and pacing to individual learner needs [4]. In this context, teacher educators are central figures: their AI readiness and pedagogical framing will shape how future teachers adopt and integrate AI tools into their professional practice [5].

Sancar et al. [6] emphasizes the importance of continuously monitoring and examining educators' practices as they navigate shifting technological environments and seek to apply them meaningfully in educational settings. The present study investigates college educators' digital proficiency in relation to their actual frequency of digital tool usage for a range of instructional purposes. Using a self-assessment questionnaire, the study examines how educators perceive their capabilities and how these perceptions correspond to their classroom practices.

This research contributes to a deeper understanding of the alignment between perceived digital competence and pedagogical implementation, offering insights that can inform professional development and institutional strategies aimed at advancing effective digital integration in teacher education.

## 2. Digital Competence and Tool Utilization

In teacher education and higher education contexts, digital competence is particularly important because teacher educators are expected not only to use digital tools in their own teaching, but also to model meaningful pedagogical integration for future teachers [7,8].

The use of a wide range of digital tools in teaching and the corresponding exposure and guidance provided to students requires educators to possess advanced techno-pedagogical competencies. These competencies integrate technological skills with pedagogical knowledge, enabling teachers to leverage digital technologies to support student-centered learning and adapt instructional strategies accordingly [2,9]. Given the multifaceted nature of techno-pedagogical competence, comprehensive approaches are needed to assess both the frequency of digital tool usage and educators' capacity to engage students effectively through these tools.

Recent developments in AI-based educational tools further highlight the importance of pedagogical digital competence. AI tools may support personalization, feedback, and creative learning, but their meaningful use depends on educators' ability to connect technological affordances with pedagogical aims [10]. This is especially relevant in teacher education, where faculty members model digital practices for future teachers.

Studies have demonstrated a strong link between the frequency of digital tool usage and the development of digital competencies. Regular exposure to various digital technologies enhances educators' confidence and proficiency in incorporating them into their teaching [11,12]. Despite the widespread availability of digital tools, their integration within higher education remains inconsistent. For instance, Mercader and Gairín [13] noted that digital tools are still marginally employed in university contexts, and Henderson et al. [14] found that such tools, while recognized for their potential benefits, have not

yet led to substantial changes in teaching and learning practices. Moreover, teacher educators often use digital technologies more for administrative tasks than for pedagogical purposes, highlighting the need for targeted professional development [15,16].

Interestingly, Muhonen et al. [17] found that while pedagogical training enhanced teachers' learning-oriented approaches and expanded their use of digital tools, specific training in digital technologies was not significantly associated with their actual implementation. Similarly, a study by Martin et al. [18] found that pre-service teachers often lack a deep understanding of the pedagogical dimensions of digital tool integration. A recent systematic literature review on technology integration during teaching practice among pre-service teachers highlighted the need for future studies to conduct in-depth research by developing new models that combine various theoretical frameworks across diverse educational contexts [19].

One of the most common applications of digital technology in higher education is through learning management systems (LMS) such as Blackboard and Moodle, which support course organization, communication, and assessment [18]. The use of video conferencing tools like Zoom, Microsoft Teams, and Google Meet surged during the COVID-19 pandemic, enabling synchronous instruction and collaborative interaction. Raes et al. [20] highlight videoconferencing as a key tool for facilitating communication and engagement in higher education.

Additional digital technologies used in higher education include assessment and feedback tools, such as digital quizzes and Q&A sessions. While LMS platforms are widely used for these purposes, more specialized tools for assessment and feedback remain less common [18]. Faculty members also tend to rate social media and adaptive learning technologies as less important and report lower levels of competence in using them.

Collaborative tools such as Google Docs and Padlet enable real-time cooperation, allowing students and faculty to co-create content, share resources, and engage in group problem-solving. However, the frequency of their use is influenced by course content and instructors' familiarity and comfort with such tools. While some educators use collaborative tools to promote active learning, others hesitate due to perceived complexity or lack of confidence [15].

In recent years, educators have also begun experimenting with AI-based tools such as generative text assistants and adaptive tutoring systems. While these tools are still emerging in teacher education contexts, they represent a new category of digital technologies with the potential to support personalization and automate feedback [3,4].

The factors shaping educators' adoption of digital tools are multifaceted. Technological competence, access to infrastructure, and technical support are foundational [21–23]. Additionally, educators' pedagogical approaches, teaching experience, and perceptions of digital tools' effectiveness in achieving learning goals significantly influence their implementation [24,25].

Barriers to adopting digital technologies are equally varied and context dependent. Mercader and Gairín [13] identified personal, professional, institutional, and contextual challenges, with professional constraints being particularly salient. Notably, educators' attitudes toward technology often have a greater impact on adoption than their technical abilities [26,27]. Furthermore, beliefs about the role of technology in education can either support or impede its integration, particularly in the context of assessment [28].

### 3. Research Questions

The aim of this study was to examine the level of teachers' digital proficiency, the connections between digital proficiency and the frequency of using digital tools for various pedagogical purposes, and the connections between the frequency of use and teachers' background characteristics. Specifically, the study addressed the following questions:

1. What is the level of teachers' digital proficiency in using and engaging students with digital technologies, and what is the frequency with which they use various digital tools to enhance teaching and learning?
2. What are the connections between the frequency of using different digital tools and the level of teachers' digital proficiency in integrating and involving students with digital technologies?
3. What are the connections between the frequency of digital tool usage and teachers' background characteristics (e.g., age, gender, teaching experience)?

Based on the reviewed literature, the following analytical assumptions guided the relational analyses. First, higher levels of teachers' digital proficiency were expected to be positively associated with more frequent pedagogical use of digital tools across the four dimensions examined in the study: collaboration, diversity and special needs, active and creative learning, and distance and hybrid learning. Second, the frequency of digital tool use was expected to vary according to selected background characteristics, including gender, seniority, teaching workload, and additional academic roles.

### 4. Methodology

#### 4.1. Research Population

The study comprised 156 educators from diverse academic disciplines across five Israeli teacher-training colleges. These institutions represented varied demographic and cultural contexts: two were sectarian, serving exclusively Jewish students; two were secular, accommodating both Jewish and Arab students; and one catered solely to Arab students. Most participants possessed substantial teaching experience, exceeding six years in the profession, and were responsible for instructing at least five courses annually. Table 1 provides a detailed breakdown of participants' demographic and professional characteristics, including age, gender, education level, academic rank, years of teaching experience, and additional academic roles such as department chair, dean, or program director.

**Table 1.** Characteristics of the study participants ( $N = 156$ ).

| Characteristic                        | Count          | %    |
|---------------------------------------|----------------|------|
| Gender                                | 96 females     | 61.7 |
|                                       | 60 males       | 38.3 |
| Age                                   | 31–40: 19      | 12.2 |
|                                       | 41–50: 44      | 28.2 |
|                                       | 51–60: 56      | 35.9 |
|                                       | 61–70: 31      | 20.0 |
|                                       | 71+: 6         | 3.9  |
| Education                             | MA: 42         | 26.9 |
|                                       | PhD: 114       | 73.0 |
| Teaching discipline                   | Education: 61  | 43.0 |
|                                       | Humanities: 43 | 30.2 |
|                                       | Sciences: 38   | 26.8 |
| Seniority in teacher training (years) | 1–3 years: 11  | 7.1  |
|                                       | 4–6 years: 19  | 12.2 |

|                                            |                                   |      |
|--------------------------------------------|-----------------------------------|------|
|                                            | 7–10 years: 31                    | 19.9 |
|                                            | 11+ years: 95                     | 60.9 |
| Working hours (number of courses per year) | 1–2 courses: 26                   | 16.7 |
|                                            | 3–4 courses: 24                   | 15.4 |
|                                            | 5–6 courses: 46                   | 29.5 |
|                                            | 7+ courses: 60                    | 38.5 |
| Academic rank                              | Without an academic rank: 60      | 39.0 |
|                                            | Lecturer rank: 54                 | 35.1 |
|                                            | Senior lecturer and Professor: 40 | 26.1 |
| Additional academic role                   | No: 79                            | 53.7 |
|                                            | Yes: 68                           | 46.3 |

#### 4.2. Research Tool

The research instrument consisted of a questionnaire with two sections:

A. Digital technology proficiency: This section consisted of an 18-item questionnaire designed to enable educators to self-assess their familiarity with and utilization of digital technologies across various professional contexts. The questionnaire was based on the Self-reflection on Effective Learning by Fostering the use of Innovative Educational technologies (SELFIE) framework, developed by the European Commission's Joint Research Centre [29]. The adaptations made to the questionnaire, validated in a prior study [30], demonstrated high reliability, with consistency exceeding 0.8. The questionnaire addressed topics such as creating and modifying digital resources, leveraging digital technologies for feedback and reflection, and fostering collaboration among learners. Each item offered five response options, ranging from non-use to use and to active student engagement in employing digital technologies [30].

The processing and validation of the questionnaire were conducted using a combination of Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). Principal Axis Factoring (PAF) was employed, as it is suitable for cases where the distribution of results is not necessarily normal [31]. To clearly define which items belonged to each dimension, Promax rotation was applied. Unlike orthogonal approaches, Promax allows for some correlation between the identified dimensions. This process resulted in the identification of three statistically distinct dimensions of teachers' digital proficiency: (1). Filtering and enhancing digital resources. (2). Assessment, feedback, communication, and active learning. (3). Adjusted and creative learning.

Although other instruments and frameworks (such as DigCompEdu Check-In and the HeDiCoM framework) are highly relevant for assessing digital competence among higher education teachers, the present study used an adapted SELFIE-based questionnaire because it had been previously validated and was closely aligned with the study's focus on the relationship between perceived digital proficiency, pedagogical use of digital tools, and student engagement with these tools.

B. Frequency of digital tool usage in teaching: This section aimed to examine the frequency with which educators employ various digital tools in their teaching practices. It included 18 questions, each pertaining to a specific digital tool or group of tools, with five possible responses ranging from "do not use at all" to "use more than six times during the course" (the questionnaire is attached as an Appendix A). A factor analysis yielded four main dimensions of digital tools: (1). Tools encouraging collaboration: such as forums and collaborative boards. (2). Tools supporting diversity and special needs: including digital diaries for setting learning goals. (3). Tools promoting active and creative learning: such as online quizzes and digital games. (4). Tools for distance and hybrid learning: for example, Zoom. The reliability of these sub-factors ranged between 0.60 and 0.83.

The two sections of the questionnaire were distributed via email to approximately 500 educators, with 156 completing the survey, yielding a response rate of around 30%.

#### 4.3. Data Analysis

We employed the Item Response Theory (IRT) framework [32] to generate a unique score measuring teachers' proficiency in using digital resources and engaging students. The 18-item digital technology proficiency questionnaire was recoded into a binary format: 1 (I use, I use and engage students with digital tech) and 0 (not using, aware of it, or attempted to use it). This classification ensured that the recoded items effectively captured both teachers' use of digital resources and students' engagement with them. The binary recoding was chosen because the aim of the IRT analysis was to estimate teachers' overall tendency to move beyond awareness or initial experimentation toward actual pedagogical use of digital technologies, including use that involves students. Thus, the distinction between non-use, awareness, or attempted use and actual implementation was conceptually aligned with the study's focus on pedagogical enactment. Although a polytomous IRT model could preserve finer distinctions among the original response categories, the binary approach provided a more parsimonious proficiency score for the present analysis and was consistent with the study's focus on actual implementation rather than awareness alone.

The three dimensions of the questionnaire were then modeled using IRT, generating proficiency scores (theta scores). The three dimensions exhibited relatively high correlations (F1 with F2:  $r = 0.651$ ,  $p < 0.001$ ; F1 with F3:  $r = 0.741$ ,  $p < 0.001$ ; F2 with F3:  $r = 0.542$ ,  $p < 0.001$ ), though not excessively high. However, when tested within the confirmatory model, the correlations increased, suggesting the presence of a potential second-order overall factor.

The proficiency score was computed as a combined factor score for each of the three dimensions, following a continuous, normally distributed scale ( $M = 0$ ,  $SD = 1$ ). Higher IRT-derived proficiency scores indicate a higher estimated likelihood that teachers not only use digital tools but also engage students in working with these tools. A key limitation of applying the separate dimensions within the IRT model was the high correlations among the tested factors, some exceeding 0.80. Therefore, the three dimensions were not entered into the SEM as separate predictors. Instead, overall digital proficiency was modeled as a single latent factor in the subsequent hypothesis testing. This approach was used to reduce redundancy among highly correlated proficiency dimensions and to avoid instability that could result from treating them as independent predictors. Since the SEM did not include the three proficiency dimensions as simultaneously observed predictors, standard collinearity diagnostics such as VIF were not directly applicable to the structural paths reported.

To examine the relationship between teachers' digital proficiency and the frequency of digital tool use in their teaching, we constructed a Structural Equation Model (SEM), treating proficiency as a latent variable. In addition, to explore the correlations between digital tool usage frequency and teachers' background characteristics, we conducted Spearman or Pearson correlation tests, depending on measurement level of the variables.

During the preparation of this manuscript, the following AI tools were used: Elicit basic version (to identify relevant academic sources), Notebook LM standard (to organize articles by subtopics and generate summaries), and ChatGPT 4.0 free version (to assist in formulating initial ideas).

## 5. Results

### 5.1. Teachers' Digital Proficiency and the Frequency of Digital Usage

Table 2 presents the three dimensions of teachers' digital proficiency. The factor loadings indicate that the items were meaningfully associated with their respective dimensions, supporting the use of the three-dimensional structure of digital proficiency in the subsequent analyses. A notable use of digital tools was observed in the dimension related to communication and collaboration among learners (Dimension 2—F2;  $M = 3.34$ ). However, within this same dimension, a relatively low percentage of teachers reported using digital tools for summative or formative assessment and feedback.

**Table 2.** Dimensions of digital technology proficiency.

| Dimension                                                   | Questions Included in Dimension * (% of Teachers Using & Engaging Students with Digital Tech) | Mean | SD   | Standardized Loading (CFA) ** |
|-------------------------------------------------------------|-----------------------------------------------------------------------------------------------|------|------|-------------------------------|
| F1. Filtering and enhancing digital resources               | Q2: Creating digital resources (71.0)                                                         | 3.17 | 0.90 | 0.62                          |
|                                                             | Q3: Modification and adaptation of digital resources (58.4)                                   |      |      | 0.76                          |
|                                                             | Q4: Store and share information with teachers (66.9)                                          |      |      | 0.85                          |
|                                                             | Q5: Feedback on the teaching (64.3)                                                           |      |      | 0.72                          |
|                                                             | Q6: Collaboration between learners (65.8)                                                     |      |      | 0.72                          |
| F2. Assessment, feedback, communication and active learning | Q7: Learning planning and management (49.7)                                                   | 3.34 | 0.95 | 0.76                          |
|                                                             | Q8: Summative and formative assessment (44.2)                                                 |      |      | 0.75                          |
|                                                             | Q10: Feedback for learners (40.0)                                                             |      |      | 0.60                          |
|                                                             | Q14: Distance learning and hybrid learning (64.5)                                             |      |      | 0.57                          |
|                                                             | Q15: Management and information evaluation by learners (45.8)                                 |      |      | 0.67                          |
|                                                             | Q16: Communication between learners (76.1)                                                    |      |      | 0.54                          |
|                                                             | Q17: Expression and content creation by the learners (66.0)                                   |      |      | 0.67                          |
|                                                             | Q9: Analysis and collection of learning outcomes (49.3)                                       |      |      | 0.70                          |
| F3. Adjusted and creative learning                          | Q11: Access to digital resources for special needs (25.5)                                     | 2.66 | 1.09 | 0.68                          |
|                                                             | Q12: Respond to differences between learners (25.0)                                           |      |      | 0.71                          |
|                                                             | Q13: creative learning (45.5)                                                                 |      |      | 0.83                          |
| $\chi^2, df, p$                                             |                                                                                               |      |      | 159.29, 97, <0.001            |

\* Q1 and Q18 were excluded due to poor loadings. \*\* The values reported in the last column are standardized factor loadings obtained from the confirmatory factor analysis.

Another dimension in which a relatively high percentage of teachers reported using digital tools was the creation and adaptation of digital resources for instructional purposes (Dimension 1—F1;  $M = 3.17$ ). This included tasks such as editing texts, digital images, and presentations, as well as using cloud-based storage solutions to share materials with colleagues. In contrast, only a small percentage of teachers reported using digital tools to support personalized learning, address learner diversity, or promote creative learning (Dimension 3—F3;  $M = 2.66$ ).

The frequencies of teachers' use of various digital tools, categorized into four types of usage, are presented in Table 3. Teachers reported the highest frequency of use for tools that promote student collaboration (Dimension Y1;  $M = 3.01$ ). Notably, the most frequently used tools included Zoom breakout rooms for group work and collaborative documents. Tools used for distance and hybrid learning (Dimension Y4;  $M = 2.55$ ) were also employed relatively frequently, with Zoom standing out as the most prominent platform for remote instruction. However, other tools within this dimension—such as virtual laboratories and platforms like Pearltrees, Pinterest, and Wakelet, were used much less frequently.

**Table 3.** Dimensions of frequency of digital tool use.

| Dimension (Y) and Tools Included (Question No.)                                               | Mean | SD   | $\alpha$ |
|-----------------------------------------------------------------------------------------------|------|------|----------|
| Y1. Encouraging collaboration                                                                 | 3.01 | 1.06 | 0.75     |
| 1. Zoom breakout rooms for group work                                                         | 3.26 | 1.40 |          |
| 3. Collaborative documents                                                                    | 3.31 | 1.40 |          |
| 5. Collaborative boards (e.g., Padlet)                                                        | 2.55 | 1.30 |          |
| 7. Forums                                                                                     | 2.84 | 1.42 |          |
| Y2. Diversity and special needs                                                               | 2.12 | 0.98 | 0.65     |
| 9. Digital dairies for setting learning goals and tracking progress                           | 1.73 | 1.19 |          |
| 11. Providing digital alternatives (e.g., listening to a podcast instead of watching a video) | 2.03 | 1.19 |          |
| 13. Online forms or similar tools with personalized feedback                                  | 2.55 | 1.35 |          |
| Y3. Active and creative learning                                                              | 2.10 | 0.84 | 0.83     |
| 15. Interactive presentations (e.g., H5P or Genially)                                         | 2.31 | 1.39 |          |
| 17. Tools for discussions around learning content (e.g., Perusall or Annoto)                  | 1.64 | 1.02 |          |
| 2. Digital games                                                                              | 2.26 | 1.24 |          |
| 4. Online quizzes                                                                             | 2.51 | 1.33 |          |
| 6. Surveys                                                                                    | 2.25 | 1.24 |          |
| 8. Applications (apps)                                                                        | 2.23 | 1.36 |          |
| 10. Interactive videos                                                                        | 1.98 | 1.25 |          |
| 12. Simulators                                                                                | 1.49 | 0.87 |          |
| Y4. Distance and hybrid learning                                                              | 2.56 | 0.84 | 0.61     |
| 14. Online meetings (e.g., Zoom)                                                              | 4.07 | 1.04 |          |
| 16. Virtual labs or virtual worlds                                                            | 2.65 | 1.13 |          |
| 18. “Information curation” tools (e.g., shared cloud folder, Pearltrees, Pinterest, Wakelet)  | 1.83 | 1.18 |          |

Another category examined was the use of digital tools to address learner diversity and special needs. The use of tools that provide personalized feedback or digital dairies for setting learning goals and tracking progress was relatively low (Dimension Y2;  $M = 2.12$ ). The lowest frequencies of use were reported for digital tools aimed at promoting active and creative learning (Dimension Y3;  $M = 2.10$ ). Teachers rarely used tools such as digital surveys, educational games, or interactive presentations for these purposes.

### 5.2. Teachers’ Digital Proficiency and the Frequency of Digital Tool Usage

Table 4 presents the structural relationships between teachers’ overall digital proficiency, represented as a latent variable (as explained in the Section 4.3), and the frequency of digital tool usage across the four dimensions. The results indicate statistically significant and positive relationships between digital proficiency and all four dimensions of digital tool use ( $p < 0.001$  for all paths). The standardized regression coefficients ( $\beta$ ) were used to compare the relative strength of the associations across the four tool-use dimensions. These coefficients show that higher levels of digital proficiency are strongly associated with more frequent use of digital tools, with the strongest association found for active and creative learning and the weakest, though still significant, for distance and hybrid learning.

**Table 4.** Structural relationships between the frequency of digital tool usage and teachers' overall digital competence.

|                    | Encouraging Col-<br>laboration (Y1) | Diversity and<br>Special Needs<br>(Y2) | Active and Crea-<br>tive Learning<br>(Y3) | Distance and<br>Hybrid Learn-<br>ing (Y4) |
|--------------------|-------------------------------------|----------------------------------------|-------------------------------------------|-------------------------------------------|
|                    | $b, p; \beta$                       | $b, p; \beta$                          | $b, p; \beta$                             | $b, p; \beta$                             |
| Proficiency Factor | 0.66<br><0.001; 0.624               | 0.61<br><0.001; 0.624                  | 0.56<br><0.001; 0.669                     | 0.41<br>< 0.001; 0.496                    |
| $R^2$              | 0.390                               | 0.390                                  | 0.448                                     | 0.245                                     |

$b$  = unstandardized coefficient;  $\beta$  = standardized coefficient;  $R^2$  = proportion of explained variance. Both unstandardized and standardized coefficients are reported:  $b$  indicates the estimated association in the original metric, whereas  $\beta$  enables comparison of the relative strength of the associations across the four dimensions of digital tool use.

The  $R^2$  values indicate that teachers with higher digital competence are more likely to make extensive use of digital tools, particularly in ways that support innovative, student-centered instructional practices. The relatively lower  $R^2$  value for distance and hybrid learning suggests that other factors, such as institutional policies or infrastructure, may also influence the frequency of tool usage in this context.

### 5.3. Teachers' Background Variables and the Frequency of Digital Tool Usage

Table 5 presents the correlations between teachers' background characteristics and the dimensions of frequency of digital tool usage. Significant positive correlations emerged between gender and the frequency of digital tool usage for collaboration, as well as for active and creative learning. Teachers with additional roles reported higher frequencies of use across three dimensions: collaboration, diversity and special needs, and active and creative learning. Seniority was positively associated with the frequency of use for both collaboration and distance or hybrid learning, while a weak negative correlation was observed between academic degree and the frequency of use for collaboration, indicating slightly lower reported use among PhD holders than among MA holders. Working hours were also positively correlated with the frequency of use for distance and hybrid learning. No significant correlations were found between age or education level and any of the usage frequency dimensions. As teaching discipline is a categorical variable, an analysis of variance (ANOVA) was conducted for each dimension separately; no significant differences were found across disciplines.

**Table 5.** Pearson's and Spearman's correlation coefficients between dimensions of frequency of digital Tool usage and teachers' background variables.

|                 | Encouraging<br>Collaboration | Diversity and<br>Special Needs | Active and Crea-<br>tive Learning | Distance and<br>Hybrid Learning |
|-----------------|------------------------------|--------------------------------|-----------------------------------|---------------------------------|
| Gender          | 0.22 **                      | 0.12                           | 0.22 **                           | −0.13                           |
| Age             | 0.04                         | 0.04                           | −0.06                             | 0.04                            |
| Education       | −0.07                        | −0.06                          | −0.09                             | −0.03                           |
| Degree          | −0.16 *                      | −0.003                         | −0.05                             | 0.12                            |
| Seniority       | 0.19 *                       | 0.08                           | 0.07                              | 0.16 *                          |
| Working hours   | 0.13                         | 0.13                           | 0.13                              | 0.19 *                          |
| Additional Role | 0.24 **                      | 0.23 **                        | 0.23 **                           | 0.10                            |

Pearson correlations were used for continuous or ordinal background variables, and Spearman correlations were used for binary variables such as gender, education, and additional academic role. \*\*  $p < 0.01$ , \*  $p < 0.05$ . Academic degree was coded as MA = 1 and PhD = 2.

## 6. Discussion

The findings of this study provide insights into teachers' digital proficiency and their patterns of digital tool usage for pedagogical purposes. Overall, the results reinforce existing research emphasizing the pivotal role of digital competence in facilitating meaningful technology integration in teaching [7,8].

Teachers in this study exhibited moderate digital proficiency, particularly in communication, collaboration, and the creation and adaptation of instructional materials. However, lower proficiency was evident in personalized learning, addressing learner diversity, and fostering creative instructional practices. These findings align with prior research showing that educators tend to feel more confident using digital tools for administrative or organizational tasks than for complex, student-centered applications [15,18]. This underutilization may stem from gaps in techno-pedagogical training or limited institutional support [14].

Frequency data supports this pattern. While collaboration tools such as breakout rooms and shared documents were commonly used, tools supporting personalization, diversity, and creativity, like virtual labs or educational games, were less frequently employed. This limited use may reflect perceived complexity, lack of confidence, or insufficient familiarity [13,27].

Importantly, a strong positive association was found between digital proficiency and all four dimensions of pedagogical tool use. That is, teachers with higher levels of digital proficiency also tended to use a broader range of digital tools more frequently and for a variety of pedagogical purposes. This finding affirms theoretical claims that digital competence predicts effective and frequent technology use in educational practice [11,12].

### 6.1. Teachers' Technological Proficiency and Frequency of Use: Model Insights

The integrated model presented in Figure 1 conceptualizes digital proficiency as a key predictor of the frequency of digital tool usage across four pedagogical domains: collaboration, personalization, active and creative engagement, and distance/hybrid learning. Grounded in the empirical results, the model reflects the multifaceted nature of digital competence and illustrates how proficiency translates into concrete teaching behaviors.

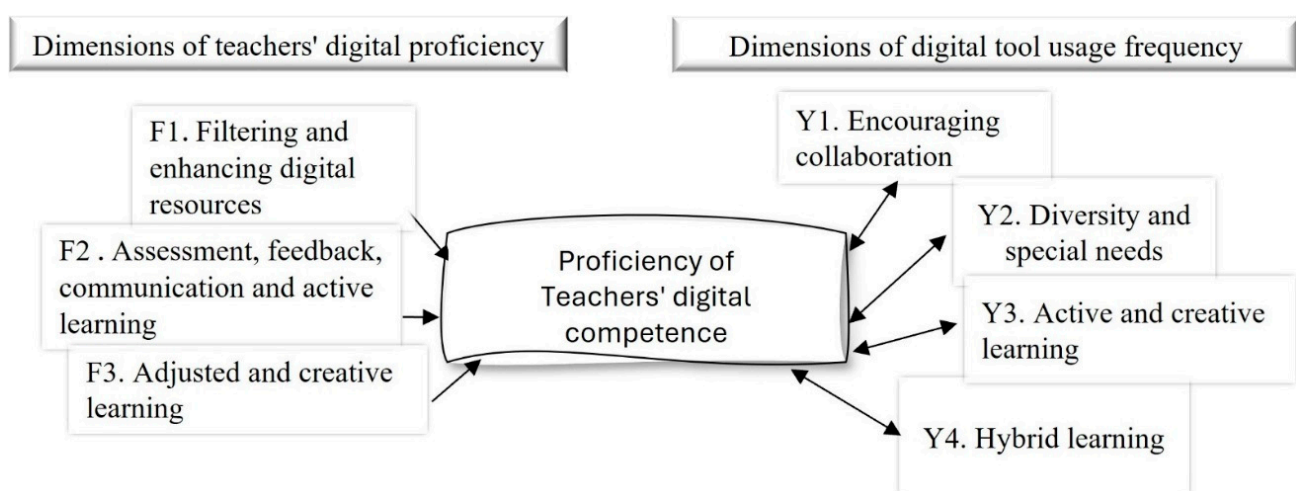
The strongest associations were observed between digital proficiency and the use of tools for active and creative learning, which was also the domain with the lowest overall usage. This apparent discrepancy between the strong association and the low overall frequency of use should not be interpreted as a contradiction. Rather, it suggests that active and creative digital practices may represent a more advanced form of pedagogical technology integration. While these tools were not widely used across the full sample, their use appears to be more strongly concentrated among teachers with higher levels of digital proficiency. In this sense, digital proficiency may function as an important enabling condition for adopting more complex, student-centered practices, but it may not be sufficient on its own to ensure broad implementation.

The low mean frequency of use also suggests that additional barriers, such as limited familiarity, perceived complexity, time constraints, lack of institutional support, or insufficient pedagogical training, may restrict the wider adoption of these tools. In contrast, the weaker association with distance and hybrid learning implies that external factors, such as institutional infrastructure or policy, may limit the translation of proficiency into practice [22,23].

Although AI-based tools were not included in the original model or measurement instruments, the findings may provide a useful basis for future research on AI integration in teacher education. In particular, the lower use of tools related to personalization, feedback, and creative learning suggests that these pedagogical domains may require further professional development as new AI-based tools become more common. This cautious

interpretation is consistent with recent discussions of generative AI in teacher education, which emphasize its potential contribution to lesson planning, assessment, personalization, and pedagogical innovation, while also highlighting the need for educators to develop appropriate pedagogical understanding of such tools [3]. However, the present study does not provide direct evidence regarding the use of AI tools. Rather, it offers a broader framework for examining how digital proficiency may be connected to different forms of pedagogical tool use, including those that future studies may examine in relation to AI.

The proposed model may contribute to the existing literature by offering a practical framework that can inform future research and guide the design of professional development initiatives. The findings suggest the potential value of complementing tool-centered training with pedagogically grounded approaches that may better support teachers in meaningfully integrating technology into their practice [17,19].



**Figure 1.** An integrated model for teachers' technological proficiency and frequency of digital tool usage. (One-directional arrows represent dimensions of teachers' digital proficiency, whereas bidirectional arrows represent reciprocal relationships between digital tool-use frequency and digital proficiency).

### 6.2. Teachers' Background Variables and Tool Usage

Analysis of background characteristics revealed nuanced patterns. Female teachers and those holding additional professional roles reported higher frequencies of tool use across several pedagogical domains. This may reflect findings in the literature suggesting that women are more inclined toward student-centered approaches [33,34] and may be more proactive in experimenting with educational technologies [35,36].

Seniority was positively associated with collaboration and distance/hybrid learning, possibly indicating that experienced teachers are more comfortable incorporating tools in well-established formats. However, no significant correlations were found for age or education level, and a weak negative correlation emerged between academic degree and collaboration tool use. These findings echo previous research emphasizing the importance of beliefs, attitudes, and institutional culture over demographic variables [26,28].

Interestingly, no significant differences were observed across teaching disciplines. This contradicts earlier findings that subject area can influence technology integration [37,38] but aligns with studies highlighting that professional experience and systemic support are more predictive of digital engagement [8,39]. These findings support calls for cross-disciplinary professional development programs focused on pedagogical rather than primarily technical integration [17,19,40].

### 6.3. Practical Implications

Based on the study's findings and the proposed model, several practical implications emerge. First, professional development should prioritize the cultivation of pedagogical digital proficiency over mere technical skills, with an emphasis on student-centered and creative applications. Second, differences in digital tool use by gender and professional role suggest the need for personalized training pathways that consider individual motivation, responsibilities, and experience. Third, the relatively weak connection between digital proficiency and the use of distance learning tools highlights the importance of addressing structural barriers, such as infrastructure, policy constraints, and workload—that may inhibit effective implementation. Finally, the absence of significant differences across teaching disciplines points to the need for system-wide approaches that support digital pedagogy across subject areas, moving beyond discipline-specific interventions.

## 7. Limitations and Future Research

This study has several limitations. First, the data were collected through self-reported surveys, which may be subject to response bias and social desirability effects. Future studies could address this limitation by incorporating complementary methodologies, such as classroom observations, analysis of instructional materials, or assessment of student learning outcomes, to improve the reliability and depth of the findings.

In addition, because the digital proficiency items were recoded into a binary format for the IRT analysis, the model did not capture the full granularity of the original ordinal response scale. Future studies with larger samples could apply polytomous IRT models, such as the Graded Response Model, to examine more nuanced levels of digital proficiency and student engagement.

Furthermore, the variability in course characteristics (e.g., research seminars with individualized guidance versus traditional frontal teaching) may have influenced the results. To address this, follow-up studies are recommended to examine how teachers' technological proficiency is applied across different pedagogical formats and instructional goals. Moreover, future research should explore broader contextual factors that shape digital proficiency, including institutional culture, access to technological infrastructure, and student diversity.

The composition of the sample should also be considered when interpreting the findings. In the present study, 60.9% of the participants reported more than 11 years of seniority in teacher training. Since seniority was positively associated with the use of tools for collaboration and distance/hybrid learning, the findings may partly reflect the practices of more veteran faculty members. Therefore, the generalizability of the proposed model to broader faculty populations, particularly early-career lecturers or less experienced teacher educators, should be interpreted with caution. Future studies should include more balanced samples in terms of seniority to examine whether the relationship between digital proficiency and digital tool use varies across different career stages.

Another limitation concerns the exclusion of AI-based technologies from the original model. Although the study was conducted before the widespread use of AI tools, these technologies are now becoming increasingly common in educational settings. As a result, the model does not directly address recent developments related to generative AI in teacher education. However, it still provides a useful framework for understanding how digital proficiency relates to different types of pedagogical tool use. The structure of the model, linking proficiency to areas such as personalization, creativity, and collaboration, offers a solid basis for examining how AI tools may fit into broader patterns of technology integration. As Prilop et al. [10] emphasize, teacher educators need structured opportunities to develop AI literacy that includes technical, pedagogical, and ethical aspects. Without this preparation, the use of AI to support personalized teaching may remain limited

or inconsistent. Future research should explore how AI-enhanced instruction aligns with digital competence and what institutional conditions are needed to support responsibility and effectiveness.

In conclusion, this study highlights the complexity of digital proficiency in teaching and its central role in determining the frequency and nature of digital tool usage. The integrated model developed from the findings offers a conceptual tool for understanding how digital competence translates into pedagogical practice. While many teachers demonstrate foundational digital skills and primarily apply them in routine teaching tasks and in promoting learner collaboration, significant gaps remain in the adoption of more advanced, creative, and student-centered uses of technology. Building on the proposed model, future research should refine its components and empirically test its applicability across varied educational settings. Such efforts could deepen our understanding of how different dimensions of digital proficiency interact with real-world teaching practices and inform the development of professional learning initiatives that bridge the gap between digital competence and meaningful classroom implementation. Addressing these gaps requires a systemic approach that combines pedagogically informed professional development with institutional commitment to reducing both practical and perceptual barriers to effective technology integration in education.

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## Appendix A. Frequency of Digital Tool Usage Questionnaire

Please indicate how frequently you utilize the following digital tools in your courses:

- Not at all;
- Once during the course;
- 2–3 times during the course;
- 4–6 times during the course;
- More than 6 times during the course.

## Digital Tools:

1. Zoom breakout rooms for group work
2. Digital games
3. Collaborative documents
4. Online quizzes
5. Collaborative boards (e.g., Padlet)
6. Surveys
7. Forums
8. Applications (apps)
9. Digital dairies for setting learning goals and tracking progress
10. Interactive videos
11. Providing digital alternatives (e.g., listening to a podcast instead of watching a video)
12. Simulators
13. Online forms or similar tools with personalized feedback
14. Online meetings (e.g., Zoom)
15. Interactive presentations (e.g., H5P or Genially)
16. Virtual labs or virtual worlds
17. Tools for discussions around learning content (e.g., Perusall or Annoto)
18. “Information curation” tools (e.g., shared cloud folder, Pearltrees, Pinterest, Wakelet)

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