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# Needs assessment and comparison of digital competence among pre-service teachers

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## Abstract

This survey study aimed to assess the priority needs for enhancing pre-service teachers' self-perceived digital competence and to compare their self-perceived digital competence across different background characteristics. Data were collected from 658 undergraduate pre-service teachers at the University of Phayao, Thailand. Participants completed a questionnaire based on the five competence areas of DigComp 2.2 and rated their current and desired levels of digital competence. Development priorities were determined using the Modified Priority Needs Index ($PNI_{modified}$), calculated from participants' current and desired ratings. Descriptive statistics were used to summarize the data, while independent-samples t-tests and MANOVA were used to examine differences across disciplinary fields and year levels, respectively. The findings indicated that (1) the three highest-priority areas for development were Digital Content Creation, Problem Solving, and Safety, respectively; and (2) differences in self-perceived digital competence were observed between disciplinary groups and across year levels. Pre-service teachers in the humanities group reported significantly higher Digital Content Creation scores than those in the science group. Significant year-level differences were found across all five competence areas. Pairwise comparisons showed lower scores for Year 1 than for Years 2–4 and for Year 2 than for Years 3–4. Years 3 and 4 were statistically comparable. These findings can inform the design of targeted learning activities and curriculum development to strengthen priority areas of digital competence in pre-service teacher education.

**Keywords:** Digital competence, Needs assessment, Pre-service teachers, Teacher education, Thailand.

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**Contribution of this paper to the literature**

This study integrates priority needs assessment with cross-sectional comparisons across disciplinary groups and year levels among pre-service teachers. Using DigComp 2.2 and $PNI_{modified}$, it identifies priority areas and group-specific patterns, providing empirical evidence to support targeted curriculum planning and the development of digital competence effectively in teacher education programs.

## 1. Introduction

The expanding use of digital technologies and artificial intelligence is reshaping how teachers design learning, develop resources, assess students, and perform professional responsibilities. Consequently, teacher preparation must develop the capacity to make appropriate, effective, safe, and responsible decisions about technology use (OECD, 2023). Digital competence among pre-service teachers encompasses professional engagement, the selection and development of digital resources, the design and facilitation of learning, the use of digital tools, assessment, support for learners with diverse needs, and the development of students' digital competence (Economou, 2023). Such competence is therefore essential for preparing pre-service teachers for teaching practicum experiences in schools and for their future professional practice.

Teacher education therefore needs to provide opportunities for students to work with digital information and content, integrate technology with pedagogy and disciplinary knowledge, support interaction, and address privacy and digital-risk issues (Tomczyk, 2024). Developing these competencies can strengthen pre-service teachers' capacity to design and develop instructional media and learning innovations aligned with intended learning outcomes, subject content, individual learner differences, and learning contexts, thereby supporting the knowledge, skills, competencies, and attributes required of learners in digitally mediated educational environments.

Teacher education institutions have established standards, revised curricula, and introduced courses on digital technologies to prepare pre-service teachers for school-based teaching practicums. However, challenges remain in aligning these standards with curriculum content and opportunities for authentic practice. Fewer than half of lower secondary teachers reported feeling well prepared to use information and communication technologies for teaching upon completion of their initial teacher education (OECD, 2023). Similarly, final-year pre-service teachers reported only moderate readiness to integrate technology into their teaching, despite having completed one to three technology-related courses, with digital Safety emerging as their lowest-scoring area of competence (Alnasib, 2023). Pre-service teachers have also reported that their teacher education programs do not adequately prepare them to develop their own digital competence (Dolezal, Motschnig, & Ambros, 2025). In authentic teaching-practicum contexts, most pre-service teachers demonstrated a developing level of technology integration competence and continued to experience limitations in digital skills and in facilitating student–technology interaction (Saraiwang & Pitukwong, 2026).

Evidence from studies of specific dimensions of digital competence further indicates persistent areas for development. Galindo-Domínguez and Bezanilla (2021) found that pre-service teachers demonstrated an overall moderate level of digital competence, with Digital Content Creation receiving the lowest mean score, followed by Problem Solving, Information and Data Literacy, Communication and Collaboration, and Safety. Çebi and Reisoğlu (2020) similarly identified relatively low competence in Digital Content Creation, particularly in modifying existing digital content and creating videos, images, and animations. A Thai study also reported that pre-service teachers obtained their lowest mean score in the use of digital or educational technologies (Watcharothai, Pattayanon, & Inchan, 2024). In addition, pre-service teachers have demonstrated limited competence in searching for, filtering, evaluating the credibility of, storing, and managing digital information and data (Yuvita et al., 2023). Collectively, these findings suggest that participation in technology-related coursework alone may not ensure sufficiently developed digital competence across the range of competencies required for professional teaching practice.

Previous research indicates that the digital competence challenges experienced by pre-service teachers extend beyond access to and operational use of digital devices. These challenges also involve their capacity to analyze information, make informed decisions, create digital content, and apply digital technologies in complex professional contexts. Evidence across the five dimensions of digital competence can be summarized as follows: (1) Information and Data Literacy: pre-service teachers have demonstrated limitations in verifying the accuracy and credibility of information, comparing evidence across multiple sources, and identifying misinformation or fake news. Such limitations may affect how they select and disseminate information for teaching and learning. Pre-service teachers therefore need opportunities to practice information verification and to use digital tools to evaluate source credibility before incorporating or sharing information (Sudjitjoon, 2024). (2) Communication and Collaboration: Pre-service teachers have shown limitations in selecting appropriate communication channels and language for different groups of students, sharing information responsibly, developing professional networks, and collaboratively creating outputs through digital platforms (Phornprasert et al., 2025). (3) Digital Content Creation: Pre-service teachers have encountered difficulties in designing and producing complex digital content, adapting existing content, integrating information from multiple sources, and using copyrighted materials appropriately. Challenges have also been reported in information synthesis, citation practices, and academic ethics (Phornprasert et al., 2025). Similarly, Ambarwati, Utami, Dewi, Alqoyyumi, and Rahma (2025) reported limitations in pre-service teachers' ability to modify and further develop digital content. (4) Safety: Pre-service teachers have demonstrated limitations in protecting personal data, responding to cybersecurity threats, managing digital identities, and regulating technology use appropriately (Phornprasert et al., 2025). They have also reported limited confidence in protecting themselves from the psychological and physical effects associated with technology use (Saraiwang & Pitukwong, 2026). Further challenges have been identified in personal data management, online reputation, data protection regulations, and responses to online threats. These findings point to the need for broader development of digital Safety, ethics, and well-being competencies applicable to both everyday technology use and future professional teaching practice (Ambarwati et al., 2025; Torres-Hernández & Gallego-Arrufat, 2024). (5) Problem Solving: Pre-service teachers have shown limitations in analyzing technical problems, selecting digital tools appropriate to particular tasks,



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troubleshooting technical difficulties, and applying digital technologies to address problems arising in authentic teaching situations (Surinwattanakul, Pichayapirut, & Yamkasikorn, 2025).

This study adopted the European Digital Competence Framework for Citizens (DigComp 2.2) as the conceptual framework for defining and organizing digital competence. DigComp 2.2 conceptualizes digital competence as the confident, critical, safe, and responsible use of and engagement with digital technologies for learning, work, and participation in society and comprises 21 individual competences organized into five areas: (1) Information and Data Literacy, (2) Communication and Collaboration, (3) Digital Content Creation, (4) Safety, and (5) Problem Solving (Vuorikari, Kluzer, & Punie, 2022).

DigComp 2.2 was selected because it provides a comprehensive structure encompassing digital competencies relevant to pre-service teachers as learners, digital citizens, and future teaching professionals. These competencies include searching for and evaluating information, communicating and collaborating with others, creating and adapting digital content, using digital technologies safely and responsibly, and selecting appropriate technologies to address problems. The framework also provides clearly defined competence areas that can be operationalized into indicators and questionnaire items for assessing current and desired levels of digital competence. This structure enables developmental needs to be identified and prioritized across competence areas and allows digital competence to be compared among pre-service teachers with different backgrounds using a common conceptual framework. Its applicability across different populations and educational contexts further supports its use as a reference framework for systematically identifying areas requiring development and establishing priorities for strengthening pre-service teachers' digital competence.

Although previous studies have identified specific areas of digital competence that require further development among pre-service teachers, the literature reviewed above provides limited evidence that combines priority needs assessment with comparisons across disciplinary fields and year levels within the same teacher-education context. Addressing this gap, the present study integrates $PNI_{modified}$-based needs assessment with cross-sectional comparisons by disciplinary field and year level using DigComp 2.2 as a common framework.

Accordingly, this study aimed to assess the priority needs for developing pre-service teachers' digital competence and to compare levels of digital competence among pre-service teachers with different backgrounds. The findings can inform the design and improvement of curricula, courses, learning activities, and extracurricular initiatives intended to strengthen digital competence in pre-service teacher education.

### *1.1. Research Objectives*

This study aimed to:

1. Assess the priority needs for enhancing pre-service teachers' self-perceived digital competence.
2. Compare pre-service teachers' self-perceived digital competence across disciplinary fields and year levels.

## 2. Methods

This study employed a quantitative survey design to examine pre-service teachers' current levels of self-perceived digital competence, identify priority areas for development, and compare self-perceived digital competence across participant groups. The study was granted an exemption from ethical review by the University of Phayao Human Research Ethics Committee under Project No. HREC-UP-HSS 2.2/096/68. The research procedures were as follows:

### *2.1. Population and Sample*

The target population comprised undergraduate pre-service teachers enrolled in teacher education programs in Upper Northern Thailand. The accessible population comprised pre-service teachers enrolled at the University of Phayao in the 2025 academic year. The final sample consisted of 658 pre-service teachers from this accessible population. The required sample size was calculated using G*Power (Cohen, 2013) with an effect size (f) of 0.25, an alpha error probability ($\alpha$ err prob) of 0.05, a statistical power ($1 - \beta$ err prob) of 0.95, and four groups. The analysis indicated a minimum required sample of 400 participants. To compensate for potentially incomplete questionnaire responses, the sample size was increased by 20%, resulting in a minimum target of 480 participants. Data were ultimately collected from 658 participants. Participants were selected through a two-stage sampling procedure. In the first stage, stratified sampling was employed to classify participants into two disciplinary groups: (1) the science group, comprising biology, physics, chemistry, mathematics, and exercise and sport science; and (2) the humanities group, comprising English, Thai, Chinese, social studies, and music and dance. In the second stage, convenience sampling was employed, with quotas established to ensure coverage across year levels and disciplinary groups. Because all participants were recruited from a single university and convenience sampling was used, the findings should not be statistically generalized to all pre-service teachers in Upper Northern Thailand.

### *2.2. Research Instrument*

The study used a two-section questionnaire to assess pre-service teachers' self-perceived digital competence. Section 1 collected respondents' demographic information using a checklist format and included three items: gender, year level, and academic major. Section 2 consisted of 40 items assessing pre-service teachers' digital competence using a five-point rating scale, ranging from the lowest to the highest level of competence. Each competence item required separate ratings of the respondent's current and desired competence on a five-point scale. Five experts evaluated content validity, producing indices ranging from 0.600 to 1.000 (M = 0.895). The linguistic appropriateness of the instrument was assessed through face validity testing with five pre-service teachers whose characteristics were similar to those of the research sample. The face validity indices ranged from 0.600 to 1.000, with an overall mean of 0.958. The questionnaire was subsequently pilot-tested with 30 pre-service teachers who had characteristics similar to those of the research sample. Its reliability was examined using Cronbach's alpha coefficient, yielding an overall reliability coefficient of 0.967.



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### 2.3. Data Collection

The researcher contacted the pre-service teachers selected as the research sample to explain the questionnaire administration procedures and subsequently distributed the online questionnaire to them. Before responding to the online questionnaire, participants received information about the study and provided their informed consent electronically by selecting the agreement option.

### 2.4. Data Analysis

Data were analyzed using descriptive and inferential statistics. Frequencies, percentages, means, and standard deviations were used to summarize participant characteristics and self-perceived digital competence scores. Priority needs were identified using the Modified Priority Needs Index ($PNI_{modified}$), calculated as (D-C)/C, where D is the mean desired-condition score and C is the mean current-condition score reported by participants. Higher $PNI_{modified}$ values indicate larger discrepancies relative to the current condition and therefore higher development priorities. Values were ranked in descending order, with $PNI_{modified}$ values of .30 or above classified as urgent developmental needs (Wongwanich, 2015). Group differences in self-perceived digital competence were examined using independent-samples t-tests and multivariate analysis of variance (MANOVA).

Where significant year-level differences were identified, Bonferroni-adjusted pairwise comparisons were conducted to examine differences between specific year-level groups.

## 3. Results

The results are presented in three sections: (1) demographic characteristics of the respondents, (2) results of the needs assessment for developing pre-service teachers' digital competence, and (3) results of comparisons in digital competence among pre-service teachers with different background characteristics.

1. Demographic Characteristics of the Respondents

Among the 658 pre-service teachers who completed the questionnaire, 462 were female and 196 were male. By year level, second-year pre-service teachers constituted the largest group, with 257 participants. By field of study, Thai language education had the largest number of participants, with 178 pre-service teachers. Further details are presented in Table 1.

**Table 1.** Demographic characteristics of the respondents (N = 658).

| Demographic Characteristics | Male (n = 196) | | Female (n = 462) | | Total | |
|---|---|---|---|---|---|---|
| | n | % | n | % | n | % |
| Year of study | | | | | | |
| 1. Year 1 | 69 | 35.20 | 160 | 34.63 | 229 | 34.80 |
| 2. Year 2 | 80 | 40.82 | 177 | 38.31 | 257 | 39.06 |
| 3. Year 3 | 35 | 17.86 | 92 | 19.91 | 127 | 19.30 |
| 4. Year 4 | 12 | 6.12 | 33 | 7.14 | 45 | 6.84 |
| Total | 196 | 100.0 | 462 | 100.0 | 658 | 100.0 |
| Field of Study | | | | | | |
| 1. Thai Language | 27 | 13.78 | 151 | 32.68 | 178 | 27.05 |
| 2. English | 38 | 19.39 | 105 | 22.73 | 143 | 21.73 |
| 3. Mathematics | 32 | 16.33 | 68 | 14.72 | 100 | 15.20 |
| 4. Sport Science and Technology | 56 | 28.57 | 13 | 2.81 | 69 | 10.49 |
| 5. Social Studies | 17 | 8.67 | 43 | 9.31 | 60 | 9.12 |
| 6. Chinese | 5 | 2.55 | 33 | 7.14 | 38 | 5.78 |
| 7. Biology | 6 | 3.06 | 23 | 4.98 | 29 | 4.41 |
| 8. Chemistry | 7 | 3.57 | 14 | 3.03 | 21 | 3.19 |
| 9. Physics | 5 | 2.55 | 6 | 1.30 | 11 | 1.67 |
| 10. Music and Dance | 3 | 1.53 | 6 | 1.30 | 9 | 1.37 |
| Total | 196 | 100.0 | 462 | 100.0 | 658 | 100.0 |
| Disciplinary field | | | | | | |
| 1. Science | 106 | 54.08 | 124 | 26.84 | 230 | 34.95 |
| 2. Humanities | 90 | 45.92 | 338 | 73.16 | 428 | 65.05 |
| Total | 196 | 100.00 | 462 | 100.00 | 658 | 100.00 |

2. Priority Needs for Developing Pre-Service Teachers' Digital Competence

The overall analysis of the needs for enhancing the digital competence of pre-service teachers at the University of Phayao revealed an overall needs index of 0.344, indicating an urgent need. At the component level, the needs index values ranged from 0.289 to 0.431. The three highest-ranked components were digital content creation (0.431), problem-solving through digital technologies (0.383), and digital safety management (0.328). All three components were classified as urgent needs.

For Communication and Collaboration, $PNI_{modified}$ values ranged from 0.292 to 0.305. The three highest-priority competences were Engaging in Citizenship through Digital Technologies (0.305), Interacting through Digital Technologies (0.303), and Sharing Information and Digital Content Responsibly (0.299), respectively. The first two competences met the criterion for urgent developmental needs, whereas the remaining competences had PNI values below 0.30.

For Digital Content Creation, $PNI_{modified}$ values ranged from 0.425 to 0.437. The three highest-priority competences were Developing Digital Content (0.437), Copyright and Licences (0.433), and Integrating and Re-Elaborating Digital Content (0.429), respectively. All competences within this area exceeded the 0.30 criterion and were therefore classified as urgent developmental needs.

For Safety, $PNI_{modified}$ values ranged from 0.322 to 0.334. The three highest-priority competences were Protecting Personal Data and Privacy (0.334), Protecting Devices, Accounts, and Digital Data (0.330), and Managing



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Digital Technology Use to Promote Well-Being (0.326), respectively. All competences within this area were classified as urgent developmental needs.

For Problem Solving, $PNI_{modified}$ values ranged from 0.377 to 0.389. The three highest-priority competences were Evaluating and Developing One's Own and Learners' Digital Competence (0.389), Identifying and Solving Technical Problems Related to Digital Devices and Systems (0.385), and Identifying Needs and Selecting and Adapting Digital Technologies (0.381), respectively. All competences within this area exceeded the 0.30 criterion and were therefore classified as urgent developmental needs.

When classified by disciplinary group, the humanities group had an overall needs index of .339, with component-level index values ranging from 0.270 to 0.430. The three highest-priority components were digital content creation (0.430), problem-solving through digital technologies (0.375), and digital safety management (0.354). All three components were classified as urgent needs.

The science group had an overall needs index of 0.353, with competence-area index values ranging from .282 to 0.431. The three highest-priority competence areas were Digital Content Creation (0.431), Digital Problem Solving (0.397), and Communication and Collaboration (0.354), respectively. All three areas met the criterion for urgent developmental needs.

When classified by year level, first-year pre-service teachers had the highest overall needs index (0.415), followed by second-year (0.356), third-year (0.268), and fourth-year pre-service teachers (0.188), respectively. These findings indicate that the level of need tended to decrease across year levels.

First-year pre-service teachers exhibited component-level index values ranging from 0.330 to 0.520. The components were ranked in descending order as follows: digital content creation (0.520), digital safety management (0.450), and problem-solving through digital technologies (0.420), respectively. All components were classified as urgent developmental needs.

Second-year pre-service teachers exhibited component-level index values ranging from 0.290 to 0.450. The three highest-priority components were digital content creation (0.450), problem-solving through digital technologies (0.430), and digital safety management (0.320), respectively. All three components were classified as urgent developmental needs.

Third-year pre-service teachers exhibited component-level index values ranging from 0.200 to 0.330. The components were ranked in descending order as follows: digital content creation (0.330), problem-solving through digital technologies (0.300), and communication and collaboration (0.280).

Fourth-year pre-service teachers exhibited component-level index values ranging from 0.140 to 0.230. The components were ranked in descending order as follows: digital content creation (0.230), problem-solving through digital technologies (0.210), and communication and collaboration (0.190). As all component-level index values were below 0.30, none of the components were classified as an urgent developmental need. Further details are presented in Table 2.



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**Table 2.** Priority needs for pre-service teachers' digital competence by field of study and year level (N = 658).

| Priority Needs for Developing Pre-Service Teachers' Digital Competence | Humanities (n = 428) | | Science (n = 230) | | Year 1 (n = 229) | | Year 2 (n = 257) | | Year 3 (n = 127) | | Year 4 (n = 45) | | Overall (n = 658) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PNI | Rank | PNI | Rank | PNI | Rank | PNI | Rank | PNI | Rank | PNI | Rank | PNI | Rank |
| Competence Area 1: Information and Data Literacy | 0.283 | 4 | 0.300 | 4 | 0.380 | 4 | 0.290 | 5 | 0.200 | 5 | 0.140 | 5 | 0.289 | 5 |
| Indicator 1: Searching for and Filtering Digital Information and Data | 0.283 | (2) | 0.300 | (2) | 0.380 | (2) | 0.290 | (2) | 0.200 | (2) | 0.140 | (2) | 0.289 | (2) |
| Indicator 2: Evaluating Digital Information and Data | 0.286 | (1) | 0.303 | (1) | 0.383 | (1) | 0.293 | (1) | 0.203 | (1) | 0.143 | (1) | 0.292 | (1) |
| Indicator 3: Managing Digital Information and Data | 0.280 | (3) | 0.297 | (3) | 0.377 | (3) | 0.287 | (3) | 0.197 | (3) | 0.137 | (3) | 0.286 | (3) |
| Competence Area 2: Communication and Collaboration | 0.270 | 5 | 0.354 | 3 | 0.330 | 5 | 0.300 | 4 | 0.280 | 3 | 0.190 | 3 | 0.298 | 4 |
| Indicator 1: Communicating and Interacting through Digital Technologies | 0.275 | (2) | 0.359 | (2) | 0.335 | (2) | 0.305 | (2) | 0.285 | (2) | 0.195 | (2) | 0.303 | (2) |
| Indicator 2: Sharing Information and Digital Content Responsibly through Digital Technologies | 0.271 | (3) | 0.355 | (3) | 0.331 | (3) | 0.301 | (3) | 0.281 | (3) | 0.191 | (3) | 0.299 | (3) |
| Indicator 3: Collaborating and Co-Creating through Digital Technologies | 0.269 | (4) | 0.353 | (4) | 0.329 | (4) | 0.299 | (4) | 0.279 | (4) | 0.189 | (4) | 0.297 | (4) |
| Indicator 4: Using Appropriate Language and Behavior in Digital Communication | 0.265 | (5) | 0.349 | (5) | 0.325 | (5) | 0.295 | (5) | 0.275 | (5) | 0.185 | (5) | 0.293 | (5) |
| Indicator 5: Engaging in Participation through Digital Technologies | 0.277 | (1) | 0.361 | (1) | 0.337 | (1) | 0.307 | (1) | 0.287 | (1) | 0.197 | (1) | 0.305 | (1) |
| Indicator 6: Managing Privacy and Digital Identity | 0.264 | (6) | 0.348 | (6) | 0.324 | (6) | 0.294 | (6) | 0.274 | (6) | 0.184 | (6) | 0.292 | (6) |
| Competence Area 3: Digital Content Creation | 0.430 | 1 | 0.431 | 1 | 0.520 | 1 | 0.450 | 1 | 0.330 | 1 | 0.230 | 1 | 0.431 | 1 |
| Indicator 1: Designing and Developing Digital Content | 0.436 | (1) | 0.437 | (1) | 0.526 | (1) | 0.456 | (1) | 0.336 | (1) | 0.236 | (1) | 0.437 | (1) |
| Indicator 2: Modifying, Integrating, and Improving Digital Content | 0.428 | (3) | 0.429 | (3) | 0.518 | (3) | 0.448 | (3) | 0.328 | (3) | 0.228 | (3) | 0.429 | (3) |
| Indicator 3: Using Digital Content in Accordance with Copyright and Licenses | 0.432 | (2) | 0.433 | (2) | 0.522 | (2) | 0.452 | (2) | 0.332 | (2) | 0.232 | (2) | 0.433 | (2) |
| Indicator 4: Creating, Testing, and Debugging Instructions for Digital Systems | 0.424 | (4) | 0.425 | (4) | 0.514 | (4) | 0.444 | (4) | 0.324 | (4) | 0.224 | (4) | 0.425 | (4) |
| Competence Area 4: Digital Safety | 0.354 | 3 | 0.282 | 5 | 0.450 | 2 | 0.320 | 3 | 0.220 | 4 | 0.160 | 4 | 0.328 | 3 |
| Indicator 1: Protecting Digital Devices, Accounts, and Data | 0.356 | (2) | 0.284 | (2) | 0.452 | (2) | 0.322 | (2) | 0.222 | (2) | 0.162 | (2) | 0.330 | (2) |
| Indicator 2: Protecting Personal Data and Privacy in Digital Environments | 0.360 | (1) | 0.288 | (1) | 0.456 | (1) | 0.326 | (1) | 0.226 | (1) | 0.166 | (1) | 0.334 | (1) |
| Indicator 3: Managing Digital Technology Use to Promote Well-Being | 0.352 | (3) | 0.280 | (3) | 0.448 | (3) | 0.318 | (3) | 0.218 | (3) | 0.158 | (3) | 0.326 | (3) |
| Indicator 4: Reducing the Environmental Impact of Digital Technology Use | 0.348 | (4) | 0.276 | (4) | 0.444 | (4) | 0.314 | (4) | 0.214 | (4) | 0.154 | (4) | 0.322 | (4) |
| Competence Area 5: Digital Problem Solving | 0.375 | 2 | 0.397 | 2 | 0.420 | 3 | 0.430 | 2 | 0.300 | 2 | 0.210 | 2 | 0.383 | 2 |
| Indicator 1: Identifying and Solving Technical Problems Related to Digital Devices and Systems | 0.377 | (2) | 0.399 | (2) | 0.422 | (2) | 0.432 | (2) | 0.302 | (2) | 0.212 | (2) | 0.385 | (2) |
| Indicator 2: Assessing Needs and Selecting and Adapting Digital Technologies | 0.373 | (3) | 0.395 | (3) | 0.418 | (3) | 0.428 | (3) | 0.298 | (3) | 0.208 | (3) | 0.381 | (3) |
| Indicator 3: Using Digital Technologies Creatively to Develop Instructional Innovations | 0.369 | (4) | 0.391 | (4) | 0.414 | (4) | 0.424 | (4) | 0.294 | (4) | 0.204 | (4) | 0.377 | (4) |
| Indicator 4: Assessing and Developing One's Own and Learners' Digital Competence | 0.381 | (1) | 0.403 | (1) | 0.426 | (1) | 0.436 | (1) | 0.306 | (1) | 0.216 | (1) | 0.389 | (1) |



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Section 3. Comparison of Digital Competence across Pre-Service Teachers with Different Background Characteristics

Digital competence was compared across pre-service teachers according to two background characteristics: year level and field of study. Year level comprised four groups: (1) Year 1, (2) Year 2, (3) Year 3, and (4) Year 4. Differences in digital competence across year levels were analyzed using multivariate analysis of variance (MANOVA). The field of study comprised two groups: (1) humanities and (2) science. Differences in digital competence between these two groups were examined using an independent-samples t-test. The results are presented below.

### *3.1. Comparison of Pre-Service Teachers' Digital Competence by Field of Study*

The comparison of pre-service teachers' digital competence by field of study showed that, for Information and Data Literacy, the humanities group had a mean score of 3.357 (SD = 0.513), compared with 3.278 (SD = 0.534) for the science group. For Communication and Collaboration, the mean scores were 3.473 (SD = 0.459) for the humanities group and 3.407 (SD = 0.513) for the science group. For Digital Content Creation, the humanities group had a mean score of 3.140 (SD = 0.511), whereas the science group had a mean score of 3.026 (SD = 0.513). For Safety, the corresponding mean scores were 3.227 (SD = 0.505) and 3.149 (SD = 0.535), respectively. For Problem Solving, the humanities group had a mean score of 3.049 (SD = 0.531), compared with 2.966 (SD = 0.534) for the science group.

The independent-samples t-test indicated that pre-service teachers in the humanities group reported significantly higher Digital Content Creation scores than those in the science group, $t(656) = 2.714$, $p = 0.007$, Cohen's $d = 0.22$. The humanities group also reported significantly higher overall self-perceived digital competence, $t(656) = 2.179$, $p = 0.030$, Cohen's $d = 0.18$. Both differences were small in magnitude. No statistically significant differences between the two groups were observed for Information and Data Literacy, Communication and Collaboration, Safety, or Problem Solving. Detailed results are presented in Table 3.

**Table 3.** Comparison of pre-service teachers' digital competence by field of study (N = 658).

| Component / Disciplinary Group | n | M | SD | Levene's Test for Equality of Variances | | t | Sig. 2 tailed | Cohen's d | Results of the Comparison |
|---|---|---|---|---|---|---|---|---|---|
| | | | | F | p | | | | |
| | Competence Area 1: Information and Data Literacy | | | | | | | | |
| | Field of Study | | | | | | | | |
| 1. Humanities | 428 | 3.357 | 0.513 | 0.802 | 0.371 | 1.852 | 0.064 | 0.15 | Not Significant |
| 2. Science | 230 | 3.278 | 0.534 | df = 656 | | | | | |
| Total | 658 | | | | | | | | |
| | Competence Area 2: Communication and Collaboration | | | | | | | | |
| | Field of Study | | | | | | | | |
| 1. Humanities | 428 | 3.473 | 0.459 | 2.341 | 0.127 | 1.708 | 0.088 | 0.14 | Not Significant |
| 2. Science | 230 | 3.407 | 0.513 | df = 656 | | | | | |
| Total | 658 | | | | | | | | |
| | Competence Area 3: Digital Content Creation | | | | | | | | |
| | Field of Study | | | | | | | | |
| 1. Humanities | 428 | 3.140 | 0.511 | 0.249 | 0.618 | 2.714 | 0.007* | 0.22 | Significant |
| 2. Science | 230 | 3.026 | 0.513 | df = 656 | | | | | |
| Total | 658 | | | | | | | | |
| | Competence Area 4: Safety | | | | | | | | |
| | Field of Study | | | | | | | | |
| 1. Humanities | 428 | 3.227 | 0.505 | 0.850 | 0.357 | 1.842 | 0.066 | 0.15 | Not Significant |
| 2. Science | 230 | 3.149 | 0.535 | df = 656 | | | | | |
| Total | 658 | | | | | | | | |
| | Competence Area 5: Problem Solving | | | | | | | | |
| | Field of Study | | | | | | | | |
| 1. Humanities | 428 | 3.049 | 0.531 | 0.301 | 0.583 | 1.922 | 0.055 | 0.16 | Not Significant |
| 2. Science | 230 | 2.966 | 0.534 | df = 656 | | | | | |
| Total | 658 | | | | | | | | |
| Overall Digital Competence | | | | | | | | | |
| 1. Humanities | 428 | 3.255 | 0.460 | 0.125 | 0.724 | 2.179 | 0.030* | 0.18 | Significant |
| 2. Science | 230 | 3.172 | 0.484 | df = 656 | | | | | |

**Note:** *$p < 0.05$, Cohen's d was calculated using the pooled standard deviation.

### *3.2. Multivariate Analysis of Pre-Service Teachers' Digital Competence by Year Level*

Students in higher year-level groups reported higher mean levels of self-perceived digital competence. The mean scores for Years 1–4 were 3.04, 3.23, 3.43, and 3.58, respectively. Box's M test was statistically significant, indicating heterogeneity of the variance–covariance matrices across year-level groups, Box's $M = 70.134$, $F(45, 102265.319) = 1.523$, $p = 0.013$. Therefore, Pillai's Trace, which is relatively robust to violations of covariance homogeneity, was used as the primary multivariate test statistic. Levene's tests were nonsignificant for all five competence areas ($p = 0.165$–$0.965$).

The multivariate analysis showed statistically significant differences in self-perceived digital competence across year-level groups, Pillai's Trace = 0.138, $F(15, 1956) = 6.286$, $p < 0.001$, $\eta p^2 = 0.046$. Further details are presented in Table 4.



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**Table 4.** Descriptive statistics for pre-service teachers' self-perceived digital competence by year level (N = 658).

| Digital Competence | Year 1 (n = 229) M (SD) | Year 2 (n = 257) M (SD) | Year 3 (n = 127) M (SD) | Year 4 (n = 45) M (SD) |
|---|---|---|---|---|
| 1. Information and Data Literacy | 3.167 (0.507) | 3.322 (0.501) | 3.526 (0.468) | 3.648 (0.532) |
| 2. Communication and Collaboration | 3.262 (0.469) | 3.457 (0.441) | 3.652 (0.455) | 3.796 (0.377) |
| 3. Digital Content Creation | 2.922 (0.457) | 3.098 (0.498) | 3.300 (0.514) | 3.447 (0.506) |
| 4. Safety | 3.012 (0.487) | 3.206 (0.483) | 3.402 (0.509) | 3.547 (0.487) |
| 5. Problem Solving | 2.823 (0.477) | 3.016 (0.508) | 3.238 (0.517) | 3.431 (0.535) |
| Overall | 3.042 (0.432) | 3.227 (0.439) | 3.430 (0.452) | 3.581 (0.449) |

**Note:** Box's M = 70.134, F(45, 102,265.319) = 1.523, p = 0.013. Levene's tests: Information and Data Literacy, F = 0.804, p = 0.492; Communication and Collaboration, F = 1.705, p = 0.165; Digital Content Creation, F = 0.956, p = 0.413; Safety, F = 0.092, p = 0.965; and Problem Solving, F = 0.378, p = 0.769. Pillai's Trace = 0.138, F(15, 1956) = 6.286, p < 0.001, $\eta p^2 = 0.046$.

The analysis of variance indicated statistically significant differences in pre-service teachers' self-perceived digital competence across year levels. Bonferroni-adjusted post hoc comparisons showed that first-year pre-service teachers reported significantly lower digital competence scores than those in Years 2–4, while second-year pre-service teachers reported significantly lower scores than those in Years 3 and 4. No statistically significant difference was observed between third- and fourth-year pre-service teachers. Overall, students in higher year-level groups reported higher mean levels of self-perceived digital competence, with no statistically significant difference between Years 3 and 4. Detailed results are presented in Table 5.

**Table 5.** Between-group analysis of variance in pre-service teachers' digital competence by year level.

| Competence Area | Type III Sum of Squares | df | MS | F | p | Comparison Results |
|---|---|---|---|---|---|---|
| Competence Area 1: Information and Data Literacy | 15.573 | 3 | 5.191 | 20.813 | < 0.001 | 1 < 2 < (3, 4) |
| Competence Area 2: Communication and Collaboration | 18.660 | 3 | 6.220 | 30.742 | < 0.001 | 1 < 2 < (3, 4) |
| Competence Area 3: Digital Content Creation | 17.732 | 3 | 5.911 | 24.802 | < 0.001 | 1 < 2 < (3, 4) |
| Competence Area 4: Safety | 18.687 | 3 | 6.229 | 25.972 | < 0.001 | 1 < 2 < (3, 4) |
| Competence Area 5: Problem Solving | 22.509 | 3 | 7.503 | 29.869 | < 0.001 | 1 < 2 < (3, 4) |

**Note:** 1 = Year 1; 2 = Year 2; 3 = Year 3; and 4 = Year 4. Numbers in parentheses indicate groups that did not differ significantly from each other. Pairwise comparisons were conducted using the Bonferroni adjustment.

## 4. Discussion

1. Based on the results of the needs assessment for enhancing pre-service teachers' digital competence, several key findings warrant further discussion, as follows:

Pre-service teachers demonstrated the greatest need for enhancing their digital competence in the area of digital content creation. This finding may be attributed to the increasing need for pre-service teachers to create diverse forms of digital content and instructional media to address the varied learning needs of contemporary students. The use of a single mode of content representation may not adequately accommodate all learners, as students differ in how they perceive, process, and engage with information. Providing multiple forms of representation can therefore support learners in accessing and engaging with instructional content in ways that are responsive to their individual learning needs (CAST, 2024). Meaningful learning is further facilitated when learners select relevant information, organize it into coherent mental representations, regulate the pace of their learning, and integrate new information with their prior knowledge through appropriately designed multimedia resources (Mayer, 2024). In addition, the rapid and continuous advancement of digital technologies and artificial intelligence, together with the growing adoption of online and blended learning, has increased the demand for diverse and pedagogically appropriate digital learning materials. Pre-service teachers therefore need continued opportunities to develop their digital content creation competence, particularly in designing, developing, and adapting instructional materials for different teaching and learning contexts.

Pre-service teachers in both the science and humanities disciplines demonstrated the greatest need for developing competence in digital content creation. For pre-service teachers in science-related disciplines, this finding may be explained by the extensive use of digital media to represent phenomena, processes, and relationships that are difficult to observe directly. Such media include animations, three-dimensional models, simulations, virtual laboratories, experimental demonstration videos, graphs, and data visualizations (Hansen & Richland, 2020; Kulgemeyer & Wittwer, 2023). Consequently, pre-service science teachers need to be able to select, adapt, and create digital instructional materials that are scientifically accurate and appropriately aligned with intended learning outcomes, instructional approaches, and learners' levels of prior knowledge. Developing such competence requires the integration of technological, content, and pedagogical knowledge in the design and use of digital learning materials (Kartal & Dilek, 2021).

Pre-service teachers in humanities-related disciplines are required to transform content in areas such as language, literature, history, society, culture, the arts, and communication into multimodal learning materials, including digital storytelling, podcasts, videos, and infographics (Nuroh, Retnaningdyah, & Munir, 2025; Yu & Wang, 2025). The development of such materials requires careful attention to the preservation of meaning, sociocultural context, the credibility of supporting evidence, and the appropriateness of language. Pre-service teachers must also consider copyright issues related to images, audio, text, and cultural works, as well as critically evaluate digital content and materials generated by artificial intelligence.

The effective use of digital resources requires pre-service teachers to design and adapt such resources to specific disciplinary content, instructional activities, and learning contexts (OECD, 2025).

Pre-service teachers across Years 1–4 demonstrated the greatest need for developing competence in digital content creation. This finding may be associated with the progressive structure of teacher education curricula.



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During the early stages of their programs, pre-service teachers typically create digital content primarily for learning activities and academic presentations. As they progress into professional education and subject-specific courses, they are increasingly required to transform disciplinary knowledge into instructional materials and learning activities that are appropriate for their learners. However, opportunities to develop digital content creation skills through course-based activities may remain fragmented or insufficiently connected to authentic teaching practice and professional field experiences (Bothe, 2023). Rapid developments in digital technologies and artificial intelligence may further contribute to pre-service teachers' recognition of the need to strengthen this area of competence. Pre-service teachers can use generative AI to create a range of learning materials, including text, images, audio, video, exercises, and assessment tasks. Using these materials in teaching requires them to check accuracy, evaluate sources, consider language use, and address copyright and privacy issues. These expectations are consistent with the UNESCO AI Competency Framework for Teachers, which emphasizes pedagogical use, critical evaluation of AI outputs, human-centred learning design, and responsible AI practice (Miao & Cukurova, 2024). Digital content creation should therefore be developed alongside instructional design and teaching practice throughout teacher preparation.

Pre-service teachers showed the greatest development need in evaluating digital information and data within the Information and Data Literacy area. They encounter information from a wide range of sources, including websites, social media, academic databases, AI systems, videos, blogs, news outlets, and learning platforms. The reliability of this information can vary, and some content may be inaccurate, outdated, unsupported by verifiable references, or generated by AI without transparent evidence. Pre-service teachers therefore need to verify information using original or authoritative sources and assess the quality and credibility of evidence before using digital content in their own learning or teaching practice (Miao & Holmes, 2023). Developing these practices would help them make more informed decisions about which digital information is appropriate for academic and instructional use.

Pre-service teachers showed the greatest development need in promoting participation through digital technologies within the Communication and Collaboration area. Promoting participation involves more than routine online communication among students, parents, teachers, and community members. Pre-service teachers may already use digital tools for messaging, sharing content, joining online groups, and attending virtual meetings, but meaningful participation requires them to plan how people will take part and interact. They need to determine the purpose of participation, identify relevant participants, select suitable communication channels, prepare questions or activities, encourage discussion, manage different viewpoints, and use the information generated from the interaction (Ata & Yıldırım, 2019; Vuorikari et al., 2022). This requires pre-service teachers to consider how digital tools are used to organize and support learning interactions. A group chat, shared post, or online meeting does not by itself guarantee active engagement or collaboration. Pre-service teachers need to create learning situations in which students work toward common goals, contribute to group tasks, exchange ideas, make decisions together, take responsibility for their work, and construct knowledge collaboratively (Ohle-Peters, Ludewig, & McElvany, 2024). These practices can help pre-service teachers use digital communication more effectively to support participation and collaborative learning.

Pre-service teachers showed the greatest development need in using digital content in accordance with copyright and licensing requirements within the Digital Content Creation area. This is closely related to teachers' professional roles as users, creators, and distributors of digital materials. They need to recognize licensing symbols, understand the conditions attached to different licences, determine whether materials may be modified or used commercially, and record information about creators and original sources accurately (Kapitzke, Dezuanni, & Iyer, 2011). In Thailand, these skills are especially relevant because copyright law protects the rights of copyright owners to reproduce, adapt, and communicate their works to the public. Educational use of copyrighted materials must therefore remain within the conditions permitted by relevant legal exceptions (Copyright Act B.E. 2537 [1994], as amended through 2022). Pre-service teachers are also expected to model lawful and ethical use of digital tools and content. This includes respecting intellectual property, protecting personal data and learner privacy (International Society for Technology in Education, 2024). The growing use of artificial intelligence adds another layer of responsibility, as pre-service teachers must consider copyright, privacy, and legal requirements when selecting or using AI-generated content and AI-enabled tools (Miao & Cukurova, 2024). Copyright and licensing knowledge should therefore be included as a regular part of teacher preparation, digital content creation, and teaching practice.

Pre-service teachers showed a high need for further development in protecting digital devices, accounts, and data. During teaching practicum, they may have access to sensitive student information, including names, academic results, assignments, assessment records, learning behaviours, photographs, videos, and other personally identifiable information.

The loss of a device, the accidental transmission of files to an unintended recipient, the public sharing of documents through inappropriate access settings, or the compromise of a digital account may consequently infringe upon students' rights and privacy (Department for Education, 2026). The growing use of artificial intelligence also raises significant concerns regarding data protection. Pre-service teachers may upload instructional documents, assessment instruments, student work, or personal information to AI systems without adequately reviewing the platforms' privacy policies, purposes of data processing, data retention periods, or conditions governing subsequent use of the submitted information. Pre-service teachers should therefore use AI technologies safely and responsibly, respect data privacy, and protect both their own information and that of their students throughout the entire data lifecycle, including data collection, use, sharing, storage, and deletion (Miao & Cukurova, 2024). These responsibilities indicate that teacher education programmes should provide systematic preparation in account security, device protection, access control, secure data management, privacy risk assessment, and the responsible use of AI-enabled technologies.

Pre-service teachers demonstrated the greatest need for development in assessing and enhancing their own and their learners' digital competence within the area of digital problem-solving. This finding may be attributed to the complexity of evaluating digital competence across learners with diverse characteristics, including differences in age, prior knowledge, experience with technology, access to digital devices, learning preferences, and disciplinary contexts. Pre-service teachers need to be able to formulate digital learning outcomes, design authentic tasks that elicit observable evidence of competence, develop appropriate assessment criteria, analyse learners' performance,



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provide constructive feedback, and implement developmental activities that respond to the needs and constraints of different learner groups (Pastore, 2023; Redecker, 2017). These responsibilities require the integration of assessment literacy, digital technology knowledge, and pedagogical knowledge to ensure that digital competence is evaluated accurately and developed systematically (Pastore, 2023). Strengthening these capabilities would enable pre-service teachers to identify digital competence gaps, plan targeted interventions, monitor learners' progress, and continuously improve both their own digital practices and those of their learners.

2. Comparison of Digital Competence among Pre-Service Teachers with Different Background Characteristics

Pre-service teachers in humanities-related disciplines reported higher overall self-perceived digital competence and greater competence in digital content creation than those in science-related disciplines. This finding may be attributed to the greater opportunities available to humanities pre-service teachers to produce and present digital artefacts through course-based learning activities and assignments. The nature of humanities-related coursework frequently involves the development of presentation slides, videos, instructional materials, infographics, digital stories, podcasts, and content for dissemination through online platforms. These experiences correspond directly to competencies in creating and editing digital content and integrating text, images, audio, and video into coherent digital products (Buckley-Marudas & Martin, 2020; Sancar-Tokmak & Yanpar-Yelken, 2015; Yu & Wang, 2025). By contrast, pre-service teachers in science-related disciplines may use digital technologies primarily for discipline-specific content and processes of scientific inquiry. Such applications include computational and graphing software, dynamic geometry tools, algebraic manipulation programs, geometric construction, data analysis, simulations, virtual laboratories, and digital systems for collecting and recording experimental data (Özgün-Koca, Meagher, & Edwards, 2010). They may also employ programming to develop scientific models and simulations for experimentation and lesson design (Vasconcelos & Kim, 2022).

Higher year-level groups reported higher levels of self-perceived digital competence. First-year pre-service teachers reported lower scores than those in Years 2–4, while second-year students reported lower scores than those in Years 3 and 4. The third- and fourth-year groups did not differ significantly. Because this study compared different year-level cohorts at a single point in time, these findings should not be interpreted as evidence that individual students' digital competence increased as they progressed through the teacher education program.

The higher scores reported by later-year students may reflect differences in the learning experiences available at different stages of teacher preparation. Students in later years may have greater exposure to coursework and practicum activities involving lesson planning, instructional material development, assessment, information management, communication, and problem solving with digital technologies. Such experiences may be associated with higher self-perceived digital competence; however, the cross-sectional design does not permit causal or developmental conclusions.

Third- and fourth-year students reported comparable levels of self-perceived digital competence in this sample. Similar year-level differences have been reported in previous studies of pre-service teachers (Galindo-Domínguez & Bezanilla, 2021; Momdjian, Manegre, & Gutiérrez-Colón, 2024). Opportunities to apply digital competence during school-based experiences may also vary according to digital infrastructure, school technological readiness, and support from mentor teachers (McCoy & Lynam, 2022).

## 5. Conclusion

1. Digital Content Creation was the highest-priority competence area, with Designing and Developing Digital Content identified as the highest-priority indicator.
2. Pre-service teachers in the humanities group reported significantly higher overall self-perceived digital competence and Digital Content Creation scores than those in the science group. No significant differences were found in the other four competence areas. Significant year-level differences were observed across all five areas. First-year pre-service teachers reported significantly lower self-perceived digital competence scores than those in Years 2–4, while second-year pre-service teachers reported significantly lower scores than those in Years 3 and 4.

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