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Assessing and bridging the digital competence gap: a comparative study of lebanese student teachers and in-service teachers using the DigCompEdu framework

Levon Momdjian[1] · Marni Manegre[2] · Mar Gutiérrez-Colón[2]

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Abstract
This study investigates the digital competence levels of Lebanese student teachers and in-service teachers using the DigCompEdu framework. The study employs a cross-sectional descriptive survey design, analyzing data from 170 in-service teachers with varying years of experience and 399 student teachers across five academic years. Results indicate that in-service teachers consistently outperform student teachers in all six areas of digital competence, with the most substantial gap in Digital Resources. However, significant improvements in digital competence were observed among student teachers from the first to the third academic year. The study highlights the necessity for enhanced digital competence training in teacher education programs and continuous professional development for in-service teachers. Recommendations include embedding digital tools into curricula, providing hands-on training, fostering collaborative cultures, and regularly monitoring competence development. These findings emphasize the importance of preparing teachers to meet the digital demands of modern classrooms.

Keywords DigCompEdu · Digital competence · Teacher education · Digital education · Teacher training · Student teachers · In-service teachers

1 Introduction

Equipping teachers with the necessary digital competence needed for the modern classroom should be a well-planned process that begins at the teacher education programs and continues throughout their career [68]. Comprehensive and versatile frameworks, such as DigCompEdu, serve as valuable tools to define and promote teachers' digital competence [19]. Most teacher education programs acknowledge the fact that digital knowledge and skills cannot be acquired only through direct instruction. Strategies proposed for promoting digital competence include field experience [9], Guillén-Gámez et al. [29], problem-based learning [32, 57], self-reflection, and authentic learning activities, and observation [37, 50, 56]. These approaches guarantee ample time for student teachers to experiment with digital tools and resources before they start their careers and allows them to refine their digital skills for pedagogical purposes.

Despite the continuous efforts of teacher training programs to close the gap, there are several challenges in the effective implementation of digital competencies that preservice teachers face when transitioning to their teaching careers

✉ Marni Manegre, Marnilynne.manegre@urv.cat; Levon Momdjian, levon.momdjian@liu.edu.lb; Mar Gutiérrez-Colón, Mar.gutierrezcolon@urv.cat | [1]School of Education, Lebanese International University, Beirut, Lebanon. [2]Department of English and German Studies, Universitat Rovira I Virgili, Tarragona, Spain.

[26, 48, 71, 78]. Although there are not many recent studies in the Lebanese context, the few existing studies [4, 11, 13, 18, 53] confirm that preservice teachers in Lebanon face similar challenges.

This study aims to fill the gap in research by investigating and comparing the digital competence levels of Lebanese student teachers and in-service teachers. It attempts to shed light on the development of student teachers' digital competence over five academic years and in-service teachers' digital competence over years of experience. As a result, this study aims to contribute valuable insights into the extent to which teacher education programs in Lebanon are preparing future teachers to meet both the current and future demands of Lebanese classrooms in terms of digital competence.

2 Literature review

2.1 The Lebanese education system

In Lebanon, the Ministry of Education and Higher Education (MEHE) oversees and regulates both public and private education sectors. Education is mandatory until the age of eleven, and public schools are free [21]. However, private schools dominate in terms of educational quality and remain the primary option, with 60% of Lebanon's 2.15 million students attending private institutions despite the ongoing financial crisis [77].

MEHE governs both public and private schools through licensing requirements, standards, and monitoring processes. Since 1995, it has implemented various reforms to revitalize the education sector following the civil war, including a significant 1997 reform that introduced technology and computer skills instruction. Additionally, the ministry mandates national exams for all students, ensuring that private schools adhere to the national curriculum [21].

To modernize Lebanon's curriculum and align with global educational reforms, the ministry launched Lebanon's Education Reform Strategy and Action Plan (LERSAP) in October 2011, followed by the National Educational Technology Strategic Plan in 2012 [51]. These initiatives aimed to integrate information and communications technology (ICT) into schools, with a focus on providing ongoing professional development for educators to enhance their use of digital tools.

Several studies have evaluated the progress of these initiatives. Burns [11], in a comparative study of Lebanon, Jordan, the UK, and the USA, concluded that Lebanon's efforts to integrate technology in schools are still in the early stages, facing challenges such as limited digital professional development, exclusion of digital skills from national exams, and inadequate technology infrastructure. Awada and Diab [2] reviewed the ministry's efforts after the end of the LERSAP in 2015 and recognized the need for continued action. They highlighted the significance of the reforms but also acknowledged that there was still a huge discrepancy in teachers' digital competence. Other studies pointed out issues like the lack of national standards for teachers' digital competence, insufficient funding, low teacher compensation, and inadequate training in digital skills [15, 21, 65]. There have nojkt been any significant attempts by the Ministry of Education to promote the digital skills of teachers since the 2012 National Educational Technology Strategic Plan, and recently the MEHE [52] acknowledged the challenges and set the improvement of digital learning environments as a priority area for future plans. The World Bank [77] also warned of a significant decline in Lebanon's education system, urging immediate reforms. There have been no recent publications to evaluate the impact of the reform and only a few assessing the digital competence levels of teachers [53, 54]. Therefore, this study plays a significant role in providing an analysis of the current situation and a stepping stone for future studies on the topic.

2.2 Teacher education programs in Lebanon

According to BouJaoude and Baddour [8] and Naccache [55], teacher preparation programs in Lebanon are offered through various higher education institutions, including the only public university and other private institutions. These programs typically follow one of three major models: (1) The model aligned with the European Credit Transfer and Accumulation System (ECTS), (2) The American-style Bachelor's Degree (BA) model, and (3) The Teaching Diploma (TD).

The first two models are similar in that they require three years for an undergraduate degree (Licence or Bachelor) and two additional years for a graduate degree (Master). The third model, the Teaching Diploma (TD) is normally a one-year post-bachelor's qualification designed for those who already hold a bachelor's degree in any major and wish to gain a teaching credential. In other words, students pursuing a teaching diploma may come from a non-educational background with no prior knowledge in teaching methods.

Research on Lebanese teacher education found discrepancies in structure among the various programs. For example, studies report major differences in the fieldwork experience in terms of the number of hours required, mentoring approaches, and evaluation criteria [14, 55, 66]. These discrepancies can significantly impact the student teachers' development of digital competence, along with other teaching skills.

This study looks into the five academic years of teacher preparation. The first three years refer to undergraduate preservice teachers. The fourth year could include student teachers pursuing their first year of a Master's degree with prior training in education and teaching or student teachers enrolled in the TD program with some or no previous teacher training experience. The fifth year refers to those enrolled in the second year of a Master's degree program. It is worth noting that most fourth- and fifth-year student teachers have some in-service teaching experience.

2.3 Digital competence in education

The concept of digital competency has become the focus of research and practice in education, especially in the wake of the COVID-19 pandemic. The lack of adequate training in digital competence and technology for teachers has led to significant learning losses during and after the pandemic [73]. This pressing necessity of digital skills for educators has led to an increased interest in research and publications about digital competence [76]. This heightened interest has led to various studies that examine teachers' digital proficiency and identify areas for improvement [20, 49, 80].

Teacher education programs all over the world have acknowledged the critical need to address the digital competence of preservice teachers [16, 37, 38, 72]. Similarly, in Lebanon, student teachers are required to develop digital competence during their initial training in teacher education programs. This development is vital for preparing them to use digital tools effectively in their future teaching careers [8, 13, 54]. Studies indicate that student teachers everywhere exhibit varying levels of digital competence at the entry to the programs, and these tend to improve as they progress through their academic years [33, 44].

Vásquez Peñafiel et al. [74] found that the availability of resources and educational policies cause a variability in student teachers' levels of digital competence in different countries. This shows that there is a need for common standards and frameworks. In Indonesia, Sumarni, et al. [69] found that student teachers have relatively low proficiency in using digital technology, specifically in reflective practices and analyzing assessment results. Similarly, García-Vandewalle García et al. [24] examined the digital competence of student teachers in Melilla, Spain, and found major gaps in digital security. Also, Haşlaman et al. [30] investigated student teachers' digital competence in Turkey, where they identified areas for improvement and recommended a blended training approach. A study by Marimon-Martí et al. [46] evaluated 3029 student teachers' self-perceptions of their digital competence in Catalonia and Andorra. The results showed high self-perceived digital competence among student teachers, but this was contrasted by the results of their focus groups. They recommended aligning digital skills with educational standards. Velasco [75] examined the role of an educational program and practicum courses at a Catalonian university in enhancing student teachers' digital teaching skills. The findings showed that student teachers were highly confident in using digital technologies but not for teaching practices.

Therefore, initial teacher training alone is not enough to maintain high digital competence. As digital tools and resources evolve, continuous professional development (CPD) becomes increasingly essential. Reisoğlu and Çebi [64] found that training in communication, collaboration, digital content creation, and safety issues is vital for developing digital competence. In Finland, Pongsakdi et al. [62] found that digital pedagogy training created positive attitudes and increased confidence in in-service teachers. Lucas, Dorotea, and Piedade [42, 43] tested continuous professional development sessions for Portuguese teachers and reported that teachers experienced great improvement after the training. A qualitative study by Brynildsen et al. [10] examined Norwegian teachers' experiences with professional development events and found that these events were instrumental in enhancing their digital competence and transformative digital agency.

Comparative studies suggest that school teachers' digital competence levels vary across countries and educational levels. For example, Diz-Otero et al. [17] reported that secondary school teachers in Spain had low levels of digital competence, specifically in digital content creation. On the other hand, Arslan [1] found that primary and secondary school teachers in Turkey had high levels of digital competence, varying according to their years of teaching experience. Other studies in Spain and Malaysia reported varying levels of digital competence among teachers across different dimensions [5, 12, 58].

Teachers' digital competence is influenced by various personal and contextual factors. Kaya [38] found a positive correlation between teachers' self-efficacy in technology integration and their digital competence. Guillén-Gámez et al. [29] emphasized that when teachers perceive technology as useful, they are more likely to develop in their digital skills. Research on gender differences in digital competence presents mixed results. Lucas, Bem-Haja, et al. [42, 43] reported that male teachers generally have higher digital competence than female teachers, especially in younger age groups. However, other studies contradict these findings. For example, Zakharov et al. [79] used the DigComp framework and found that Russian teachers showed no significant gender differences in overall digital competence.

Research found that age and teaching experience, which are highly relevant to this study, are significant predictors of digital competence. Younger teachers, who have grown up with digital technologies, often show higher digital skills compared to their older counterparts. For example, Gudmundsdottir and Hatlevik [27] found that novice teachers tend to have higher digital competence, which might be due to their familiarity with digital tools from a young age. However, Hinojo-Lucena et al. [31] found that teachers with fewer years of teaching experience exhibited lower digital competence due to limited teaching practice.

Finally, Lebanese teacher training programs face a similar challenge of effectively integrating technology into their curricula and practices. The Ministry of Education and Higher Education published the National Educational Technology Strategic Plan in 2012, emphasizing the necessity of prioritizing initial teacher training in digital competence [51]. However, challenges, such as the lack of adequate digital resources and insufficient training in digital skills, persisted [8, 13, 15, 21, 65]. Chaaban and Moloney [13] investigated seven Lebanese teacher training programs and identified both barriers and facilitators in developing preservice teachers' digital competence. They recommended adopting effective instructional design, emphasizing digital pedagogical application, and continuous professional development opportunities for teacher educators. In a more recent study, Daccache and Ibrahim [16] examined the preparedness of student teachers and novice teachers in using technology. One discouraging finding was that only one student teacher had the opportunity to observe the use of technology during internship.

2.4 Studies comparing in-service teachers' and student teachers' digital competence

Numerous studies have explored the digital competence of pre-service and in-service teachers separately, but fewer have compared both groups or examined the gap between them. Some research shows little to no difference between pre-service and in-service teachers in terms of digital skills. For example, Polly et al. [61] assessed both groups' readiness to use digital technologies and found that while both valued collaboration tools and learning management systems, they were less enthusiastic about mobile apps and social media. Similarly, Aygun and İlhan [3] found that both pre-service and in-service social studies teachers considered themselves proficient in digital skills but lacked critical thinking and collaboration in online environments.

On the other hand, some studies report significant differences, with in-service teachers showing greater digital competence in specific areas. Teo [71] examined the factors influencing technology acceptance between the two groups and found that in-service teachers perceived more favorable conditions for technology use and faced fewer technological challenges. Gonscherowski and Rott [26] also noted that in-service mathematics teachers demonstrated broader digital competencies and better decision-making skills compared to pre-service teachers. This finding underscores the need for improved digital resource training for pre-service teachers. Yang et al. [78] conducted a survey of pre-service and in-service teachers in Anhui, China, finding that while both groups saw themselves as digitally competent, in-service teachers demonstrated higher levels of competence due to factors like age, education, and years of teaching experience.

The findings in a couple of studies discordantly show pre-service teachers to be more digitally competent. Quast et al. [63] reported that pre-service teachers had higher digital competence beliefs than their in-service counterparts, suggesting the success of current teacher education programs in developing digital skills. In another study, Bertram et al. [6] examined the impact of reverse mentoring on digital competence and proposed that pre-service teachers can mentor in-service teachers effectively in digital skills.

Against this backdrop of conflicting results regarding the difference in digital competence between pre-service and in-service teachers, it is important to investigate the situation in the Lebanese context to find out if there are any differences between digital competence levels of student teachers and in-service teachers. Also, the study aims to explore whether the years of teaching experience positively affect in-service teachers' digital competence as found by Yang et al. [78] or whether student teachers and novice teachers as digital natives could be more advanced in digital skills than in-service teachers as found by Quast et al. [63]. Moreover, no studies have yet explored this comparison within the Lebanese context. Therefore, the present research aims to fill this gap by investigating potential differences or similarities in digital competence between Lebanese pre-service and in-service teachers.

3 Purpose statement, research questions, and hypothesis statements

This research aims to investigate the levels of digital competence among Lebanese student teachers and in-service teachers based on the DigCompEdu framework. It aims to explore the gap between the two groups based on student teachers' academic year level and in-service teachers' years of experience. Therefore, the study not only sheds light on the gap between the two groups, but it also investigates whether student teachers show any progress in digital competence through the five academic years and whether in-service teachers' digital proficiency varies according to their teaching experience. In doing so, the study attempts to compare the levels of digital competence between student teachers at their graduation and novice in-service teachers with little teaching experience. This could provide insight into the extent to which teachers acquire digital proficiency during their education as compared to their career experience.

The study attempts to answer the following research questions:

1. How do the levels of in-service teachers' digital competence compare to those of student teachers?
2. How does the level of experience affect student teachers' competence and in-service teachers' competence in each area of the DigCompEdu framework?

The study aims to test the hypothesis statements:

H_0 There is no statistically significant relationship between student teachers' total digital competence over five academic years and in-service teachers' total digital competence according to their teaching experience.

H_1 There is a statistically significant relationship between student teachers' total digital competence over five academic years and in-service teachers' total digital competence according to their teaching experience.

4 Methods

This section describes the design of the study, the participants, and the instruments used for data collection.

4.1 Study design

The aim of the study is to describe the gap between student teachers in five academic years and in-service teachers according to their years of experience. Since the study aims to describe an existing phenomenon or relationship between two groups without establishing causality, it is considered *descriptive* [7]. The instrument used for both groups is a *survey* questionnaire based on the European Framework for the Digital Competence of Educators (DigCompEdu). Moreover, there was a single episode of data collection; thus, it is a *cross-sectional* study [7]. Therefore, this study follows a *cross-sectional descriptive survey* design.

4.2 Participants

The sample includes two distinct groups: (1) 170 Lebanese in-service teachers and (2) 399 student teachers from 14 out of 15 active Lebanese teacher training programs. The specialties of both groups cover a range from childhood education to teaching math, sciences, humanities, and languages. Table 1 presents a breakdown of in-service teachers according to their years of experience and of student teachers according to their academic year. The student teachers include undergraduate pre-service teachers (first three academic years), who mostly have no teaching experience, and graduate student teachers, some of whom might be teachers at schools.

A non-probabilistic convenience sampling approach was used for practical reasons. From the beginning of this study, education in Lebanon has been going through several disruptions caused by a catastrophic economic crisis and political instability. As a result, a significant number of teachers resigned or deserted their teaching roles, and many schools and universities closed their doors for extended periods of time due to ongoing strikes, limited resources, or security risks [35, 39, 45]. All these factors hindered the possibility of using a more representative and generalizable sampling approach. The convenience sampling method limits the generalizability of the findings. However, as proposed by Kanaki and Kalogiannakis [36], a larger sample in survey studies reduces the potential error of sampling. One of the methods

Table 1 Breakdown of participants

Years (experience/academic)	Number
In-service teachers	
1–3 years	20
4–5 years	18
6–9 years	32
10–14 years	37
15–19 years	28
20+years	32
Prefer not to say	3
Total	**170**
Student teachers	
Academic year 1	68
Academic year 2	47
Academic year 3	79
Academic year 4	89
Academic year 5	116
Total	**399**

for determining the sample size with an acceptable error margin of less than 5% is the Cochran formula. Applying this formula to the sample in this study yields a 4.5% margin of error.

4.3 Instruments

To evaluate the digital competence of teachers, this study utilized the DigCompEdu framework [19]. Both student teachers and in-service teachers participated in a survey based on the DigCompEdu Check-In self-reflection questionnaire. Before its launch, the survey was piloted and reviewed by a group of 11 experienced educators to ensure its validity within the Lebanese context. Following their feedback, minor adjustments were made before launching the survey for data collection.

The DigCompEdu Check-In self-reflection tool [25] was used to assess participants' digital competence across six areas: professional engagement, digital resources, teaching and learning, assessment, empowering learners, and facilitating learners' digital competence. These areas are further divided into 22 competencies, each represented by a survey item (See Table 2). Participants rated each item on a 5-point scale, measuring the complexity of each task, which reflects their proficiency level in that specific competence.

The designers of the questionnaire confirmed its validity using the Mann–Whitney U test and Spearman rank correlation. The results showed significant differences between identified groups and acceptable validity scores [25]. The Cronbach's alpha reliability test showed excellent internal consistency across the 22 items and acceptable consistency within each competence area. Several subsequent studies (e.g., [23, 28, 41, 47]) have also supported the instrument's validity and reliability in a variety of contexts. For this study likewise, Cronbach's alpha was used to ensure the reliability of the results, revealing a high reliability score of 0.91 for the total test.

4.4 Data analysis

The collected data were analyzed using JASP software. Descriptive statistics (means and standard deviations) were calculated for both student teachers and in-service teachers in each dimension of the DigCompEdu framework. As for the inferential analyses, the tests that were conducted are:

- One-way ANOVA is a statistical measure used with categorical variables when comparing the means of two or more groups to see if there is a statistically significant difference among them. In this study, the one-way ANOVA was used to test the significance of the difference among all teacher groups—student teachers of each academic level and in-service teachers of each teaching experience bracket—for each competence area. A p-value < 0.05 indicates statistically significant

Table 2 DigCompEdu competence areas and competences

Competence area	Competence
Educators' professional competences	
Professional engagement	Organizational communication
	Professional collaboration
	Reflective practice
	Digital continuous professional development
Educators' pedagogic competences	
Digital resources	Selecting
	Creating & modifying
	Managing, protecting, sharing
Teaching & learning	Teaching
	Guidance
	Collaborative learning
	Self-regulated learning
Assessment	Assessment strategies
	Analyzing evidence
	Feedback & planning
Empowering learners	Accessibility & inclusion
	Differentiation & personalization
	Actively engaging learners
Learners' competences	
Facilitating learners' digital competence	Information & media literacy
	Communication
	Content creation
	Responsible use
	Problem solving

differences between group means. The eta-squared (η^2) was calculated to measure the effect size. An effect size $\eta^2 < 0.01$ is negligible, $0.01 \leq \eta^2 < 0.06$ is small, $0.06 \leq \eta^2 < 0.14$ is medium, and $\eta^2 \geq 0.14$ is large.

- Tukey Post Hoc tests with 95% Confidence Intervals were conducted to further explore significant differences between specific pairs of groups.

4.5 Ethical considerations

In the questionnaire, a disclaimer was included to inform participants about the purpose of the study and their rights as participants. Before answering questions, they were assured that participation was entirely voluntary and that they could withdraw from the study at any point without any negative consequences. To ensure participants' privacy and confidentiality, data were collected anonymously, securely stored, and made accessible only to the research team.

Throughout the different phases of this study, there were no factors that could harm the scientific enterprise or the relation between science and society. All research conducted in this study is free from any research misconduct, such as individual impurity, institutional failure, and structural crisis [60].

Ethical approval was obtained from the Ethics Research Committee of the Rovira i Virgili University in accordance with the principles and requirements of the European Charter for Researchers.

5 Results

This section presents the descriptive and inferential analyses of the data collected. The aim of the study was to investigate the digital competence levels of both student teachers and in-service teachers and to examine the gap between the two groups in each competence area of the DigCompEdu framework. The results go further, providing insight into the gap between each academic year for student teachers and each bracket of teaching experience for in-service teachers.

5.1 In-service and student teachers' digital competence levels

The descriptive analyses in Table 3 show that in-service teachers scored higher than student teachers across all competence areas.

For Professional Engagement, in-service teachers scored higher (M = 13.971, SD = 3.507) than student teachers (M = 12.504, SD = 3.270). Both groups demonstrated a moderate to high proficiency level, knowing that the highest possible score is 20 for this area.

In the Digital Resources area, with a highest possible score of 15, in-service teachers demonstrated a high level of proficiency (M = 12.194, SD = 2.116) compared to a moderate to high proficiency level for student teachers (M = 9.078, SD = 2.745).

In Teaching and Learning, in-service teachers (M = 14.388, SD = 3.072) and student teachers (M = 13.596, SD = 3.460) both had a moderate to high proficiency level, knowing that the highest possible score for this area is 20, but again, the in-service teachers scored higher.

For Assessment, the results were similar with in-service teachers (M = 10.700, SD = 2.693) scoring higher than student teachers (M = 9.734, SD = 2.616). However, both groups were in the moderate to high levels of proficiency, knowing that the highest possible score is 15.

In the Empowering Learners area, in-service teachers scored 11.118 (SD = 2.451) and student teachers scored 10.266 (SD = 2.850) out of 15, which means they both had moderate to high levels of proficiency, with in-service teachers outperforming student teachers.

In the Facilitating Learners' Digital Competence area, in-service teachers scored 17.429 (SD = 4.479) compared to 16.361 (SD = 4.564) for student teachers out of 25. Both groups had a moderate to high proficiency level.

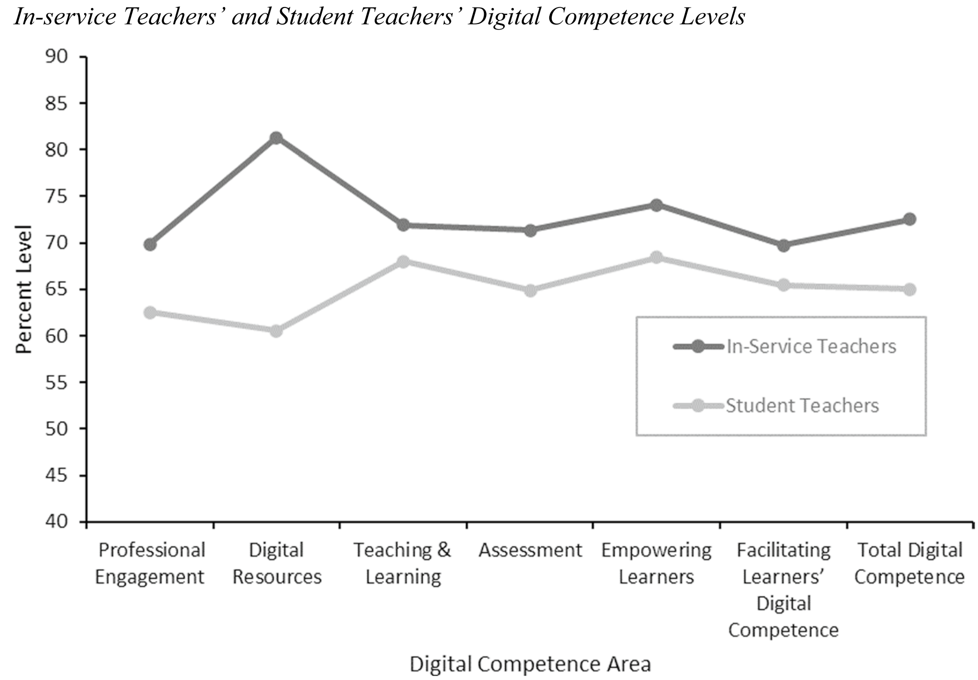
Finally, the total digital competence score for in-service teachers was 79.800 (SD = 14.290) and for student teachers was 71.539 (SD = 16.350) out of a possible 110 points. These results indicate that both groups demonstrated a moderate to high level of overall digital competence, with in-service teachers consistently scoring higher across all areas.

As shown in Fig. 1, the in-service teachers outperform student teachers in all competence areas, and the largest gap between the two groups is in the Digital Resources competence area. Figure 1 also reveals that the highest proficiency level for in-service teachers is in Digital Resources and the lowest is in Facilitating Learners' Competence Levels. As for student teachers, the highest is in Empowering Learners and the lowest is in Digital Resources.

Table 3 Means and standard deviations per competence area

Competence area	In-service teachers		Student teachers	
	Mean	SD	Mean	SD
Educators' professional competences				
Professional engagement	13.971	3.507	12.504	3.270
Educators' pedagogic competences				
Digital resources	12.194	2.116	9.078	2.745
Teaching & learning	14.388	3.072	13.596	3.460
Assessment	10.700	2.693	9.734	2.616
Empowering learners	11.118	2.451	10.266	2.850
Learners' competences				
Facilitating learners' digital competence	17.429	4.479	16.361	4.564
Total digital competence	79.800	14.290	71.539	16.350

Fig. 1 In-service teachers' and student teachers' digital competence levels



5.2 Effect of experience levels of in-service teachers and student teachers per competence area

The descriptive statistics in Table 4 present the means and standard deviations in Professional Engagement for both in-service teachers and student teachers across different experience and academic levels.

In regard to in-service teachers, the mean scores for professional engagement varied across different experience levels. Specifically, in-service teachers with 1–3 years of teaching experience had a mean score of M = 14.200 (SD = 3.592, SE = 0.803, CV = 0.253), while those with 4–5 years of experience had a slightly lower mean score of M = 14.056 (SD = 3.077, SE = 0.725, CV = 0.219). The mean scores remained relatively stable for teachers with 6–9 years (M = 14.188, SD = 3.702, SE = 0.654, CV = 0.261) and 10–14 years (M = 14.378, SD = 3.419, SE = 0.562, CV = 0.238) of teaching experience. However, there was a slight decrease in mean score for teachers with 15–19 years of experience (M = 13.429, SD = 3.469, SE = 0.656, CV = 0.258), and further decrease for those with 20 or more years of experience (M = 13.219, SD = 3.617, SE = 0.639,

Table 4 Descriptives for professional competence according to experience level

Experience level	N	Mean	SD	SE	Coefficient of variation
In-service teachers' years of teaching					
1–3 years	20	14.200	3.592	0.803	0.253
4–5 years	18	14.056	3.077	0.725	0.219
6–9 years	32	14.188	3.702	0.654	0.261
10–14 years	37	14.378	3.419	0.562	0.238
15–19 years	28	13.429	3.469	0.656	0.258
20 + years	32	13.219	3.617	0.639	0.274
Prefer not to say	3	17.667	3.215	1.856	0.182
Student teachers' academic levels					
First year	68	10.588	2.835	0.344	0.268
Second year	47	11.426	3.235	0.472	0.283
Third year	79	12.367	2.518	0.283	0.204
Fourth year	89	13.258	3.626	0.384	0.273
Fifth year	116	13.578	3.085	0.286	0.227

Table 5 One-way ANOVA for professional engagement

Cases	Sum of squares	df	Mean square	F	p	η^2
Experience levels	822.699	11	74.791	7.222	< 0.001	0.125
Residuals	5768.387	557	10.356			

Type III sum of squares

Table 6 Descriptives for digital resources according to experience level

Experience level	N	Mean	SD	SE	Coefficient of variation
In-service teachers' years of teaching					
1–3 years	20	12.500	2.373	0.531	0.190
4–5 years	18	12.444	1.542	0.364	0.124
6–9 years	32	12.031	1.875	0.331	0.156
10–14 years	37	12.351	2.176	0.358	0.176
15–19 years	28	12.321	2.144	0.405	0.174
20 + YEARS	32	11.719	2.466	0.436	0.210
Prefer not to say	3	12.333	1.528	0.882	0.124
Student teachers' academic levels					
First year	68	7.765	2.845	0.345	0.366
Second year	47	8.511	2.742	0.400	0.322
Third year	79	9.127	2.334	0.263	0.256
Fourth year	89	9.854	2.570	0.272	0.261
Fifth year	116	9.448	2.802	0.260	0.297

CV = 0.274). Three participants preferred not to share their years of teaching experience. The results for these participants here and in other competence areas will not be discussed since they do not present any meaningful or significant implications to the aim of this article.

As for student teachers, the mean scores for professional competence increased with each academic year. In the undergraduate levels, First-year student teachers had the lowest mean score of M = 10.588 (SD = 2.835, SE = 0.344, CV = 0.268), followed by second-year student teachers with a mean score of M = 11.426 (SD = 3.235, SE = 0.472, CV = 0.283), and third-year student teachers with a higher mean score of M = 12.367 (SD = 2.518, SE = 0.283, CV = 0.204). For the graduate level, fourth-year student teachers had a further increase in mean score to M = 13.258 (SD = 3.626, SE = 0.384, CV = 0.273), and fifth-year student teachers had the highest mean score of M = 13.578 (SD = 3.085, SE = 0.286, CV = 0.227).

A one-way ANOVA was conducted to compare the effect of experience level on professional engagement in both groups of participants. The results in Table 5 report a statistically significant effect, $F(11, 557) = 7.22$, $p < 0.001$, $\eta^2 = 0.125$. This indicates that the level of professional engagement significantly varies according to the participants' experience levels with a moderate to large effect size.

Table 6 provides descriptive statistics for the Digital Resources competence. For in-service teachers, there seems to be a steady decrease in the competence levels in the first ten years of teaching experience, from 1 to 3 years scoring a mean score of M = 12.500 (SD = 2.373, SE = 0.531, CV = 0.190) to 6–9 years scoring a mean score of M = 12.031 (SD = 1.875, SE = 0.331, CV = 0.156). After a slight increase with 10–14 years of experience (M = 12.351, SD = 2.176, SE = 0.358, CV = 0.176), the competence levels continue to decrease again, with teachers of 20 and more years of experience scoring the lowest mean of M = 11.719 (SD = 2.466, SE = 0.436, CV = 0.210) with the highest variability.

As for student teachers, the competence of handling digital resources notably and consistently increases from first year (M = 7.765, SD = 2.845, SE = 0.345, CV = 0.366) to fourth year (M = 9.854, SD = 2.570, SE = 0.272, CV = 0.261). The fifth-year student teachers show a small drop (M = 9.448, SD = 2.802, SE = 0.260, CV = 0.297) in this competence.

The one-way ANOVA in Table 7 reveals a statistically significant effect of experience levels on the digital resources competence, $F(11, 557) = 19.627$, $p < 0.001$, $\eta^2 = 0.279$. The large effect size suggests that experience levels account for a substantial proportion of the variance in competence levels.

The results in Table 8 show slight changes in the Teaching and Learning competence levels among experience levels. To begin with the in-service teachers, the mean scores are relatively similar across the different brackets of teaching

Table 7 One-way ANOVA for digital resources

Cases	Sum of Squares	df	Mean Square	F	p	η^2
Experience levels	1372.363	11	124.760	19.627	< 0.001	0.279
Residuals	3540.593	557	6.357			

Type III sum of squares

Table 8 Descriptives for teaching and learning according to experience level

Experience Level	N	Mean	SD	SE	Coefficient of variation
In-service teachers' years of teaching					
1–3 years	20	14.400	3.817	0.853	0.265
4–5 years	18	14.111	2.805	0.661	0.199
6–9 years	32	14.563	3.473	0.614	0.238
10–14 years	37	13.865	2.668	0.439	0.192
15–19 years	28	14.857	2.940	0.556	0.198
20 + years	32	14.469	2.951	0.522	0.204
Prefer not to say	3	15.333	3.786	2.186	0.247
Student teachers' academic levels					
First year	68	12.676	3.500	0.424	0.276
Second year	47	12.957	3.283	0.479	0.253
Third year	79	14.139	3.185	0.358	0.225
Fourth year	89	13.933	3.457	0.366	0.248
Fifth year	116	13.767	3.600	0.334	0.262

Table 9 One-way ANOVA for teaching and learning

Cases	Sum of squares	df	Mean square	F	p	η^2
Experience levels	209.721	11	19.066	1.706	0.068	0.033
Residuals	6223.418	557	11.173			

Type III sum of squares

experience, ranging from M = 13.865 (SD = 2.668, SE = 0.439, CV = 0.192) for 10–14 years of experience to M = 14.857 (SD = 2.940, SE = 0.556, CV = 0.198) for 15–19 years of experience. The levels vary irregularly across the years of experience.

As for student teachers, the teaching and learning competence level seems to increase from the first year (M = 12.676, SD = 3.500, SE = 0.424, CV = 0.276) to the third year (M = 14.139, SD = 3.185, SE = 0.358, CV = 0.225). However, the competence level begins to decrease again to M = 13.933 (SD = 3.457, SE = 0.366, CV = 0.248) in the fourth year and to M = 13.767 (SD = 3.600, SE = 0.334, CV = 0.262) in the fifth year.

The one-way ANOVA in Table 9 shows no statistically significant effect of experience levels on the teaching and learning competence, $F(11, 557) = 1.706$, $p = 0.068$, $\eta^2 = 0.033$.

In the Assessment competence area, Table 10 shows that there is very little difference among the teaching experience brackets for in-service teachers. The highest mean score is for 1–3 years of teaching experience (M = 11.300, SD = 3.358, SE = 0.751, CV = 0.297), and the lowest is for 4–5 years of teaching experience (M = 10.000, SD = 2.765, SE = 0.652, CV = 0.277).

For the student teachers, the results for Assessment are similar to those for Teaching and Learning. The competence levels increase from the lowest score of M = 8.529 (SD = 2.651, SE = 0.322, CV = 0.311) in the 1st year to the highest score of M = 10.291 (SD = 2.338, SE = 0.263, CV = 0.227) in the 3rd year, but the competence level drops slightly in the fourth year (M = 10.011, SD = 2.386, SE = 0.253, CV = 0.238) and then in the 5th year (M = 9.948, SD = 2.855, SE = 0.265, CV = 0.287).

The one-way ANOVA in Table 11 shows that experience levels of in-service teachers and student teachers have a significant effect on using digital assessment methods and tools, $F(11, 557) = 4.017$, $p < 0.001$, $\eta^2 = 0.073$, with a small to medium effect size.

Table 10 Descriptives for assessment according to experience level

Experience Level	N	Mean	SD	SE	Coefficient of variation
In-service teachers' years of teaching					
1–3 years	20	11.300	3.358	0.751	0.297
4–5 years	18	10.000	2.765	0.652	0.277
6–9 years	32	10.969	2.584	0.457	0.236
10–14 years	37	10.108	2.664	0.438	0.264
15–19 years	28	10.964	2.472	0.467	0.225
20 + years	32	10.688	2.481	0.439	0.232
Prefer not to say	3	13.000	2.646	1.528	0.204
Student teachers' academic levels					
First year	68	8.529	2.651	0.322	0.311
Second year	47	9.489	2.330	0.340	0.246
Third year	79	10.291	2.338	0.263	0.227
Fourth year	89	10.011	2.386	0.253	0.238
Fifth year	116	9.948	2.855	0.265	0.287

Table 11 One-way ANOVA for assessment

Cases	Sum of squares	df	Mean square	F	p	η^2
Experience levels	298.459	11	27.133	4.017	< 0.001	0.073
Residuals	3762.244	557	6.754			

Type III sum of squares

Table 12 Descriptives for empowering learners according to experience level

Experience level	N	Mean	SD	SE	Coefficient of variation
In-service teachers' years of teaching					
1–3 years	20	11.550	2.800	0.626	0.242
4–5 years	18	11.056	2.235	0.527	0.202
6–9 years	32	11.219	2.075	0.367	0.185
10–14 years	37	10.730	2.557	0.420	0.238
15–19 years	28	11.214	2.455	0.464	0.219
20 + years	32	11.125	2.406	0.425	0.216
Prefer not to say	3	11.333	5.508	3.180	0.486
Student teachers' academic levels					
First year	68	9.088	2.991	0.363	0.329
Second year	47	9.894	2.425	0.354	0.245
Third year	79	10.861	2.556	0.288	0.235
Fourth year	89	10.404	2.907	0.308	0.279
Fifth year	116	10.595	2.901	0.269	0.274

Table 12 presents the descriptives for both groups in the Empowering Learners competence area. In-service teachers with 1–3 years of teaching experience display the highest mean score (M = 11.550, SD = 2.800, SE = 0.626, CV = 0.242) whereas those with 10–14 years of experience have the lowest mean score (M = 10.730, SD = 2.557, SE = 0.420, CV = 0.238). The variability of mean scores within the in-service teachers' group is small, which means they have relatively consistent levels in empowering learners.

The student teachers likewise exhibit consistency among the different academic levels. The trend follows the same pattern of increasing from the lowest mean score in the 1st year (M = 9.088, SD = 2.991, SE = 0.363, CV = 0.329) to the highest in the third year (M = 10.861, SD = 2.556, SE = 0.288, CV = 0.235). Then the scores decrease with the fourth and fifth years (M = 10.404, SD = 2.907 and M = 10.595, SD = 2.901 respectively).

The one-way ANOVA in Table 13 reveals a statistically significant effect of experience levels on empowering learners competence, $F(11, 557) = 2.963$, $p < 0.001$, $\eta^2 = 0.055$, with a small effect size.

The results in Table 14 indicate that in-service teachers with 1–3 years of teaching experience report the highest mean score (M = 17.900, SD = 5.119, SE = 1.145, CV = 0.286) for Facilitating Learners' Digital Competence. Again, the variability within the group is small, the lowest mean score being for in-service teachers with 4–5 years of experience (M = 17.111, SD = 4.651, SE = 1.096, CV = 0.272).

In the area of Facilitating Learner's Digital Competence, like most other competence areas, student teachers follow an increasing trend from the first year (M = 14.544, SD = 4.730, SE = 0.574, CV = 0.325) to the third year (M = 17.152, SD = 4.154, SE = 0.467, CV = 0.242). After this rise for third-year student teachers once again comes a slight decrease for the fourth year (M = 16.820, SD = 4.847, SE = 0.514, CV = 0.288) and the fifth year (M = 16.845, SD = 4.424, SE = 0.411, CV = 0.263).

The one-way ANOVA in Table 15 reveals that there are statistically significant differences among experience levels for facilitating learners' digital competence, $F(11, 557) = 2.269$, $p = 0.010$, $\eta^2 = 0.043$, with a small effect size.

5.3 Effect of experience levels on total digital competence for in-service teachers and student teachers

Table 16 presents the descriptive statistics for the total digital competence of in-service teachers and student teachers across experience levels. For in-service teachers, no regular trend can be observed. The mean scores start with the highest M = 81.850 (SD = 17.688, SE = 3.955, CV = 0.216) for 1–3 years of experience. They drop to M = 78.778 (SD = 12.398, SE = 2.922, CV = 0.157) for 4–5 years. They then go up to M = 80.750 (SD = 15.707, SE = 2.777, CV = 0.195) for 6–9 years and down again to M = 78.595

Table 13 One-way ANOVA for empowering learners

Cases	Sum of squares	df	Mean square	F	p	η^2
Experience levels	239.674	11	21.789	2.963	< 0.001	0.055
Residuals	4096.344	557	7.354			

Type III sum of squares

Table 14 Descriptives for facilitating learners' digital competence according to experience level

Experience Level	N	Mean	SD	SE	Coefficient of variation
In-service teachers' years of teaching					
1–3 years	20	17.900	5.119	1.145	0.286
4–5 years	18	17.111	4.651	1.096	0.272
6–9 years	32	17.781	5.185	0.917	0.292
10–14 years	37	17.162	3.693	0.607	0.215
15–19 years	28	17.429	3.910	0.739	0.224
20 + years	32	17.125	4.612	0.815	0.269
Prefer not to say	3	19.000	7.211	4.163	0.380
Student teachers' academic levels					
First year	68	14.544	4.730	0.574	0.325
Second year	47	15.596	4.116	0.600	0.264
Third year	79	17.152	4.154	0.467	0.242
Fourth year	89	16.820	4.847	0.514	0.288
Fifth year	116	16.845	4.424	0.411	0.263

Table 15 One-way ANOVA for facilitating learners' digital competence

Cases	Sum of Squares	df	Mean Square	F	p	η^2
Experience Levels	506.660	11	46.060	2.269	0.010	0.043
Residuals	11,309.125	557	20.304			

Type III sum of squares

Table 16 Descriptives for total digital competence according to experience level

Experience Level	N	Mean	SD	SE	Coefficient of variation
In-service teachers' years of teaching					
1–3 years	20	81.850	17.688	3.955	0.216
4–5 years	18	78.778	12.398	2.922	0.157
6–9 years	32	80.750	15.707	2.777	0.195
10–14 years	37	78.595	13.232	2.175	0.168
15–19 years	28	80.214	12.239	2.313	0.153
20 + years	32	78.344	14.437	2.552	0.184
Prefer not to say	3	88.667	22.368	12.914	0.252
Student teachers' academic levels					
First year	68	63.191	15.115	1.833	0.239
Second year	47	67.872	15.015	2.190	0.221
Third year	79	73.937	13.748	1.547	0.186
Fourth year	89	74.281	17.072	1.810	0.230
Fifth year	116	74.181	16.946	1.573	0.228

(SD = 13.232, SE = 2.175, CV = 0.168) for 10–14 years. Next, the mean score increases to M = 80.214 (SD = 12.239, SE = 2.313, CV = 0.153) for 15–19 years of experience, only to drop to the lowest score M = 78.344 (SD = 14.437, SE = 2.552, CV = 0.184) for in-service teachers with 20 years of experience and more. Although the changes in total digital competence levels across years of experience are not regular, it is worth noting that teachers with the least experience have the highest score and those with the most experience have the lowest score.

As for student teachers, the total digital competence shows a steady increase from the first year (M = 63.191, SD = 15.115, SE = 1.833, CV = 0.239) to the 4th year (M = 74.281, SD = 17.072, SE = 1.810, CV = 0.230), with a very slight drop in the fifth year (M = 74.181, SD = 16.946, SE = 1.573, CV = 0.228).

The one-way ANOVA in Table 17 shows that there are statistically significant differences in total digital competence among the different experience levels, $F(11, 557) = 6.061$, $p < 0.001$, $\eta^2 = 0.107$, with a medium to large effect size.

A post-hoc test is needed to add insight into the significance of the difference among various teaching experience brackets for in-service teachers (see Table 18), among the different academic levels of student teachers (see Table 19), and between the two groups (see Table 20).

5.4 Comparing in-service teachers with different years of teaching experience

Table 16 revealed that in-service teachers with 1–3 years of experience have the highest level of digital competence, but the digital proficiency fluctuated as the years of experience increased, as also illustrated in Fig. 2.

A post hoc analysis using the Tukey HSD test was conducted to check whether there is a statistically significant difference between each pair of teaching experience brackets. The pairwise mean differences, along with their 95% confidence intervals, standard errors, t-values, and adjusted p-values, are reported in Table 18. The results show that adjusted p-values for all pairwise comparisons are equal to 1.000, so there are no statistically significant differences in total digital competence scores among the different levels of teaching experience.

Therefore, the significant effect of experience level on total digital competence yielded in the one-way ANOVA in Table 17 is not likely to be the result of in-service teachers' teaching experience. The post hoc comparison reported in Table 19 below should further shed light into whether student teachers' academic levels have a significant effect on the difference.

Table 17 One-way ANOVA for total digital competence

Cases	Sum of squares	df	Mean square	F	p	η^2
Experience levels	15,933.184	11	1448.471	6.061	< 0.001	0.107
Residuals	133,108.788	557	238.974			

Type III sum of squares

Table 18 Post hoc comparisons—in-service teachers' teaching experience

		Mean difference	95% CI for mean difference		SE	t	Ptukey
			Lower	Upper			
1–3 years	4–5 years	3.072	– 13.412	19.556	5.022	0.612	1.000
	6–9 years	1.100	– 13.362	15.562	4.406	0.250	1.000
	10–14 years	3.255	– 10.826	17.337	4.290	0.759	1.000
	15–19 Years	1.636	– 13.218	16.490	4.526	0.361	1.000
	20 + years	3.506	– 10.956	17.968	4.406	0.796	1.000
4–5 years	6–9 years	– 1.972	– 16.921	12.976	4.555	– 0.433	1.000
	10–14 years	0.183	– 14.397	14.763	4.442	0.041	1.000
	15–19 years	– 1.437	– 16.764	13.891	4.670	– 0.308	1.000
	20 + years	0.434	– 14.514	15.382	4.555	0.095	1.000
6–9 years	10–14 years	2.155	– 10.093	14.404	3.732	0.578	1.000
	15–19 years	0.536	– 12.594	13.665	4.000	0.134	1.000
	20 + years	2.406	– 10.278	15.090	3.865	0.623	1.000
10–4 years	15–19 years	– 1.620	– 14.328	11.089	3.872	– 0.418	1.000
	20 + years	0.251	– 11.997	12.499	3.732	0.067	1.000
15–19 years	20 + years	1.871	– 11.259	15.000	4.000	0.468	1.000

P-value adjusted for comparing a family of 12

Table 19 Post hoc comparisons—student teachers' academic level

		Mean difference	95% CI for Mean difference		SE	t	Ptukey
			Lower	Upper			
First year	Second year	– 4.681	– 14.305	4.943	2.932	– 1.596	0.910
	Third year	– 10.746	– 19.138	– 2.353	2.557	– 4.202	0.002
	Fourth year	– 11.090	– 19.262	– 2.918	2.490	– 4.454	< 0.001
	Fifth year	– 10.990	– 18.739	– 3.241	2.361	– 4.655	< 0.001
Second year	Third year	– 6.064	– 15.411	3.282	2.848	– 2.130	0.602
	Fourth year	– 6.409	– 15.557	2.740	2.787	– 2.299	0.478
	Fifth year	– 6.309	– 15.081	2.464	2.673	– 2.360	0.435
Third YEAR	Fourth year	– 0.344	– 8.187	7.499	2.390	– 0.144	1.000
	Fifth year	– 0.244	– 7.645	7.157	2.255	– 0.108	1.000
Fourth year	Fifth year	0.100	– 7.050	7.249	2.178	0.046	1.000

P-value adjusted for comparing a family of 12

5.5 Comparing student teachers of different academic levels

The post hoc pairwise comparisons for total digital competence levels of student teachers at different academic levels in Table 19 revealed that there are statistically significant differences between first-year student teachers and student teachers in their third (MD = – 10.746, 95% CI [– 19.138,-2.353], SE = 2.557, t = – 4.202, p = 0.002), fourth (MD = – 11.090, 95% CI [– 19.262, – 2.918], SE = 2.490, t = – 4.454, p < 0.001), and fifth (MD = – 10.990, 95% CI [– 18.739, – 3.241], SE = 2.361, t = – 4.655, p < 0.001), with first-year student teachers scoring lower. All other pairwise comparisons yielded statistically insignificant differences with p-values > 0.05.

Therefore, the only impactful effect of student teachers' academic levels is the difference between first-year students and those in third year and beyond (see Fig. 3). Thus, the post hoc comparison between the two groups' experience levels (see Table 20 below) will bring to light whether the difference between the two groups explains the significant results yielded by the ANOVA test (see Table 17).

Table 20 Post Hoc comparisons—student teachers' academic level

Student teachers	In-service teachers'	Mean difference	95% CI for Mean Difference		SE	t	Ptukey
			Lower	Upper			
First year	1–3 years	– 18.659	– 31.565	– 5.753	3.932	– 4.745	< 0.001
	4–5 years	– 15.587	– 29.035	– 2.138	4.098	– 3.804	0.009
	6–9 years	– 17.559	– 28.435	– 6.682	3.314	– 5.298	< 0.001
	10–14 years	– 15.403	– 25.768	– 5.039	3.158	– 4.878	< 0.001
	15–19 years	– 17.023	– 28.416	– 5.630	3.471	– 4.904	< 0.001
	20 + years	– 15.153	– 26.029	– 4.276	3.314	– 4.572	< 0.001
Second year	1–3 years	– 13.978	– 27.523	– 0.432	4.127	– 3.387	0.036
	4–5 years	– 10.905	– 24.969	3.158	4.285	– 2.545	0.314
	6–9 years	– 12.878	– 24.506	– 1.250	3.543	– 3.635	0.016
	10–14 years	– 10.722	– 21.873	0.429	3.398	– 3.156	0.073
	15–19 years	– 12.342	– 24.454	-0.230	3.690	– 3.344	0.041
	20 + years	– 10.471	– 22.100	1.157	3.543	– 2.956	0.125
Third year	1–3 years	– 7.913	– 20.613	4.787	3.870	– 2.045	0.662
	4–5 years	– 4.841	– 18.092	8.410	4.037	– 1.199	0.989
	6–9 years	– 6.813	– 17.445	3.818	3.239	– 2.103	0.621
	10–14 years	– 4.658	– 14.765	5.449	3.080	– 1.513	0.937
	15–19 years	– 6.278	– 17.436	4.881	3.400	– 1.846	0.791
	20 + years	– 4.407	– 15.039	6.224	3.239	– 1.360	0.970
Fourth year	1–3 years	– 7.569	– 20.124	4.986	3.825	– 1.979	0.708
	4–5 years	– 4.497	– 17.609	8.616	3.995	– 1.126	0.993
	6–9 years	– 6.469	– 16.927	3.989	3.186	– 2.030	0.673
	10–14 years	– 4.314	– 14.238	5.611	3.024	– 1.427	0.958
	15–19 years	– 5.933	– 16.927	5.060	3.350	– 1.771	0.833
	20 + years	– 4.063	– 14.521	6.395	3.186	– 1.275	0.982
Fifth year	1–3 years	– 7.669	– 19.953	4.615	3.743	– 2.049	0.659
	4–5 years	– 4.597	– 17.450	8.256	3.916	– 1.174	0.991
	6–9 years	– 6.569	– 16.700	3.562	3.087	– 2.218	0.603
	10–14 years	– 4.414	– 13.993	5.166	2.919	– 1.512	0.937
	15–19 years	– 6.033	– 16.716	4.650	3.255	– 1.854	0.787
	20 + years	– 4.163	– 14.294	5.968	3.087	– 1.349	0.972

P-value adjusted for comparing a family of 12

5.6 Comparing student teachers' and in-service teachers' total digital competence

Table 20 reports the results of the post hoc pairwise comparisons between the student teachers of each academic level and the in-service teachers of each teaching experience bracket. The findings show that first-year student teachers scored significantly lower than in-service teachers across all experience levels (all p-values < 0.05) and second-year student teachers scored significantly lower than in-service teachers with 1–3 years (MD = – 13.978, 95% CI [– 27.523, – 0.432], SE = 4.127, t = – 3.387, p = 0.036), 6–9 years (MD = – 12.878, 95% CI [– 24.506, – 1.250], SE = 3.543, t = – 3.635, p = 0.016), and 15–19 years (MD = – 12.342, 95% CI [– 24.454, – 0.230], SE = 3.690, t = – 3.344, p = 0.041) of teaching experience. There were no significant differences in the other pairwise comparisons because they all yielded p-values > 0.05.

The statistically significant results reported by the ANOVA test in Table 17 can be attributed to the highly significant differences between first year student teachers and all in-service teachers and the significant differences between second year student teachers and some of the in-service teachers. However, student teachers in their third, fourth, and fifth academic years show no significant difference in their total digital competence as compared to all in-service teachers (see Fig. 4).

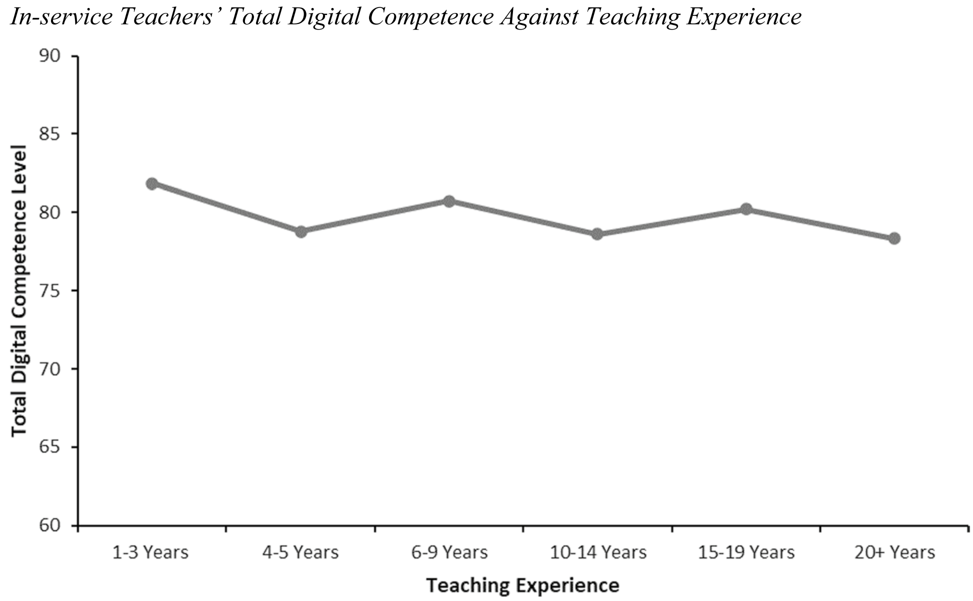


Fig. 2 In-service teachers' total digital competence against teaching experience

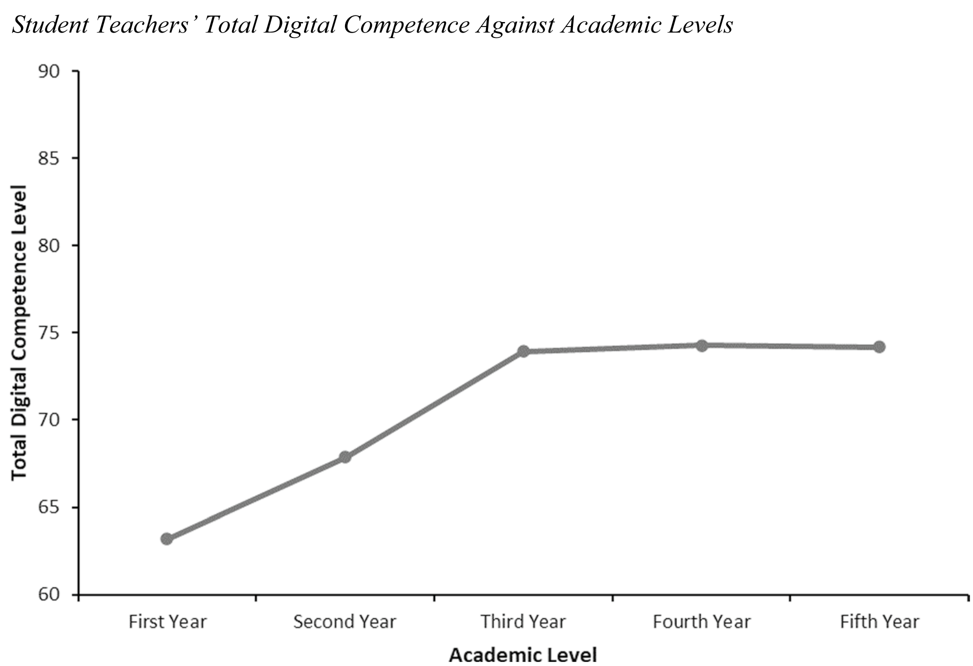


Fig. 3 Student teachers' total digital competence against academic levels

6 Discussion

The study aimed to compare the digital competence levels of preservice and in-service teachers across various competence areas of the DigCompEdu framework. The findings showed that in-service teachers outperformed student teachers in all six competence areas: Professional Engagement, Digital Resources, Teaching and Learning, Assessment, Empowering Learners, and Facilitating Learners' Digital Competence. However, the most substantial gap is in the Digital Resources competence, which includes using, creating, managing, and protecting digital resources. To close this gap, Lebanese teacher education programs need to make digital resources more accessible and take measures to enhance digital competence, which is corroborated by other findings in Lebanon [11, 13, 16, 18]. These measures might involve incorporating authentic activities paired with digital tools into their classes [81], offering hands-on

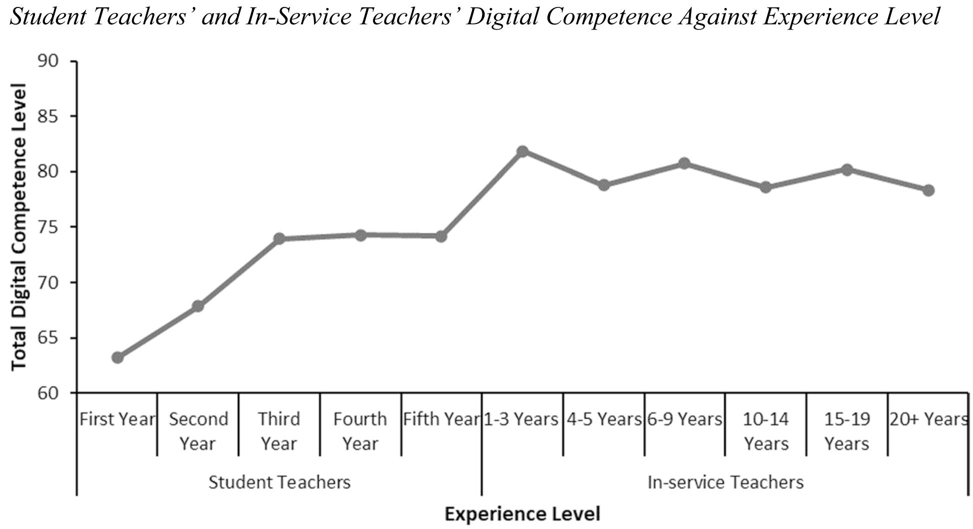


Fig. 4 Student teachers' and in-service teachers' digital competence against experience level

opportunities for student teachers to create their own activities using digital technologies [27, 72, 82], and promoting reflective practices on the proper utilization of digital resources and tools [27, 33, 72].

The results in this study align with Gonscherowski and Rott [26] and Yang et al. [78] who reported that in-service teachers showed higher digital proficiency in their teaching as compared to student teachers. Other studies however contradict this finding, reporting similar digital competence levels between the two groups [3, 61], and in some cases even better performance for student teachers [6, 63].

The better performance of in-service teachers in digital competence as compared to student teachers could be explained by several factors. Researchers agree that practical experience contributes to higher competence levels for in-service teachers [78]. Student teachers, on the other hand, may lack sufficient practical training in using digital tools for teaching and learning and often receive theoretical knowledge without enough practical application [33, 44, 59, 75]. Another factor proposed by research as conducive to in-service teachers' development of digital skills is continuous professional development [10, 12, 34, 64].

Yang et al. [78] reported experience as a factor influencing the levels of digital competence. This corroborates the findings of this study, where experience levels had a significant effect on the total digital competence of both student teachers and in-service teachers. In fact, the study found that student teachers' digital competence significantly improves from the first year to the third year, with insignificant changes in the fourth and fifth years. This aligns with García-Vandewalle García et al. [24] and Galindo-Domínguez and Bezanilla [22], who found that student teachers experience improvement in digital competence levels as they advance in academic years. This means that the majority of digital skills are acquired by student teachers in their undergraduate programs. A finding that calls for a revisit of graduate level curricula and courses in Lebanese teacher education programs.

As for the experience level of in-service teachers, the results show a variability in digital competence levels over the years of experience with no regular pattern. However, a noteworthy finding is that teachers with one to three years of teaching experience performed the best. This aligns with [27], who suggested that novice teachers are usually younger and therefore tend to be more competent in using digital tools due to familiarity [3]. However, Hinojo-Lucena et al. [31] contradict these findings in their study, where they reported that teachers with less experience tend to have lower digital competence levels because they have little practice.

Finally, an important finding is that although in-service teachers outperformed the student teachers as a whole group, there was no significant difference between the in-service teachers and the third-, fourth-, and fifth-year student teachers. The significant difference was evident between all in-service teachers and first-year student teachers and some in-service teachers and second-year student teachers. This suggests that as Lebanese student teachers progress in their education, the gap between them and school teachers narrows down although it is not totally bridged.

7 Limitations and future research implications

While the study provides valuable insights into the field, there are limitations to consider. One limitation is related to the non-probabilistic convenience sampling technique, which limits the generalizability and representativeness of the results. Future studies could employ a probability sampling method, such as random or stratified sampling, with a larger sample and a representative distribution of participants over the experience levels subgroups, to better represent the populations of in-service teachers and student teachers in Lebanon. A replication of this study with a sample that accounts for demographic characteristics could help confirm the generalizability of this study or find discrepancies.

The cross-sectional design of the study with a single episode of data collection limits the ability to observe changes over time and establish causality. Also, the study relies on self-reported data through the DigCompEdu Check-In self-reflection questionnaire. Self-reported measures are always subject to various biases and may not always accurately reflect actual competence levels. Future studies could adopt a longitudinal approach or an experimental design and include both quantitative and qualitative data.

Future research could also add insight by looking into how many of the fourth- and fifth-year student teachers are at the same time school teachers to explore whether their digital proficiency was the result of their initial training or their experience as school teachers.

8 Recommendations

To address the digital competence gap between student teachers, especially in the first and second years, and in-service teachers, several recommendations can be mined from previous literature:

- Enhancing digital competence training in teacher education programs. This could be done by embedding digital tools and resources into all courses so student teachers regularly use and become proficient with them [74], providing more hands-on opportunities and authentic activities in creating, modifying, and managing digital content [27, 37, 56, 57, 72, 81, 82], and increasing the duration and quality of field experience in partnership with schools that have robust digital infrastructures [9, 14], especially for graduate student teachers who showed a slight drop in their digital competence levels.
- Continuous digital professional development for in-service teachers. Organizing regular training sessions focused on the latest digital tools and pedagogical strategies would help maintain and enhance teachers' digital competence across their years of teaching experience [10, 62, 64] and decrease the big variability found in this study. Also, establishing mentorship and reverse-mentorship programs allows more experienced or digitally proficient teachers to guide and support their colleagues [6, 78]. This way, teachers with 1 to 3 years of experience, who were found to have the most advanced levels of digital competence, could share their skills with others.
- Promoting a collaborative culture. Building a collaborative culture within and between schools and teacher education programs can facilitate the sharing of best practices and resources [6, 40, 56]. This could effectively help bridge gaps found between the different subgroups of student teachers and in-service teachers. For example, teachers with 10 + years of experience, who were found to have lower digital competence levels, could collaborate and exchange knowledge and skills with novice teachers, thus benefiting from their digital skills while investing pedagogical and content expertise in them.
- Monitoring and evaluating digital competence development. Regular monitoring and evaluation of digital competence development can help identify gaps and inform necessary adjustments to training programs [27]. This can be achieved through periodic assessments with tools like the DigCompEdu framework to track progress and identify areas needing improvement and through establishing feedback mechanisms where student teachers and in-service teachers can provide input on the effectiveness of digital competence training and suggest improvements [67, 70]. This would regularly alert school leaders about the dropping levels of digital competence found in teachers of 10 + years of experience.

9 Conclusion

This study provides a detailed analysis of the digital competence levels of both Lebanese student teachers and in-service teachers, revealing significant insights and implications for teacher education programs. The findings show that in-service teachers generally outperform student teachers across all areas of the DigCompEdu framework, with the most notable gap in the area of Digital Resources.

The study also indicates that student teachers show significant improvement in digital competence as they progress through their academic years, particularly from the first to the third year. However, the competence levels plateau in the fourth and fifth years, suggesting a need to revisit and potentially revamp the graduate-level curricula to ensure continued growth in digital proficiency.

Among in-service teachers, there is an irregular variability in digital competence levels across different experience. Interestingly, the study found that teachers with 1–3 years of experience performed the best, aligning with the notion that younger, digitally native teachers may be more adept with digital tools.

While the study sheds light on the existing digital competence gap between student teachers and in-service teachers, it also points to the narrowing of this gap as student teachers advance in their education. Nevertheless, there remains room for improvement, particularly in the initial years of teacher education programs.

To further advance our understanding, future research could explore the specific impact of different digital training methodologies, such as blended learning, on both student and in-service teachers. Additionally, longitudinal studies could help trace the development of digital competence over time and across different educational systems.

Future research should also investigate how these digital competences can be applied in other fields, such as vocational education and professional training, broadening the scope of this study's impact beyond traditional educational settings. This approach could provide a holistic view of digital competence development in various professional environments, making it possible to design more adaptive, inclusive, and forward-thinking education policies that align with global educational and technological trends.

These findings could also serve as a basis for educational policy reform, especially in contexts where digital literacy is increasingly vital. Policymakers at local and regional levels could use these insights to update teacher training programs, making digital competence a central focus from the early stages of teacher education.

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Data availability Data is provided within the manuscript and the raw data is available on request.

Declarations

Competing interests The authors declare no competing interests.

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