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ORIGINAL RESEARCH

First-year Preservice Teachers' Understanding of Digital Technologies and Their Digital Literacy, Efficacy, Attitude, and Online Learning Engagement: Implication for Course Design

Seyum Getenet[1] · **Carole Haeusler**[1] · **Petrea Redmond**[1] · **Robert Cantle**[1] · **Vanessa Crouch**[1]

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Abstract
Ensuring quality education for all students requires teachers to possess knowledge and skills in utilising digital technologies effectively for teaching and learning. This study explored how pre-service teachers (PSTs) perceive their digital attitude, efficacy, literacy, engagement, and understanding of digital technologies in an online learning environment. The study employed a mixed-methods research approach. A survey comprising Likert Scale questions and demographic information was administered to 110 PSTs from a regional university. Descriptive statistics were employed to investigate the relationship between PSTs' understanding of digital technologies and their attitude, literacy, self-efficacy, and learning engagement in online learning. To illustrate the frequently used words in participants' definitions of digital technologies, a 'word cloud' representation was utilised, accompanied by quantitative weightings of key terms. The study revealed significant connections between PST self-efficacy and their attitudes toward digital technologies, digital literacies, and learner engagement. Notably, most of the PSTs exhibited narrower definitions of digital technologies than anticipated. The implications of these findings for course design are discussed, emphasising the need to address PSTs' perceptions of digital technologies, foster their self-efficacy, and enhance their digital literacy and engagement in online learning environments. Understanding these factors can lead to more effective integration of digital technologies in teacher education program courses, ultimately preparing future teachers for digital-age classrooms.

Keywords Engagement · Digital Technology · Digital Literacy · Self-efficacy · Online Learning · Pre-service Teachers · Regional University

✉ Seyum Getenet
Seyum.Getenet@usq.edu.au

[1] University of Southern Queensland, Springfield Education City 37 Sinnathamby Blvd Springfield Central, Toowoomba, QLD 4300, Australia

1 Introduction

The widespread adoption of digital technologies in education has sparked expectations that these technologies can enhance problem-solving, real-world connections, collaboration, and engagement for students with innovative tools and concepts (e.g., Falloon, 2020; Paetsch & Drechsel, 2021; Peled, 2021). Consequently, teacher education programs face the pressing task of ensuring that pre-service teachers (PSTs) possess strong digital technology understanding and skills to effectively educate for the present and future educational landscape. The COVID-19 pandemic accelerated technology integration in higher education, leading to a notable shift in how teachers utilise technology for online learning and teaching (Lindfors et al., 2021). Consequently, numerous higher education courses are now offered online with the support of various technologies.

Successful transitions to online learning are influenced by the intention to use technology for learning (Anastasakis et al., 2021; Kemp et al., 2019). However, learners' intention to pursue further online courses is influenced by various factors, necessitating a thorough examination of inhibitors to successful online learning environments and interventions to enhance learning outcomes (Anastasakis et al., 2021; Aguilera-Hermida, 2020; Heckel & Ringeisen, 2019; Cavanaugh et al., 2022; Zhu et al., 2020). Notably, Aguilera-Hermida's (2020) study revealed the significance of students' attitudes, efficacy, and motivation in technology-integrated online learning, with students' attitudes towards digital technology directly impacting their online learning process, as demonstrated by Ali (2020). Studies (e.g., Hsu & Lin, 2020; Lim, 2023) also emphasise the importance of understanding PSTs' digital technology literacy, attitude, efficacy, and engagement in the design of courses in teacher education institutions. These studies contribute valuable insights into the development of comprehensive and effective teacher education programs that prepare educators to navigate the digital landscape and enhance student learning experiences in diverse educational settings.

The primary focus of this study was on PSTs who were in their first year and first semester of their program at a regional university. The objective was to gain a comprehensive understanding of their digital technology usage and their attitudes, literacy, self-efficacy, and online engagement levels at the onset of their undergraduate degree. By examining these aspects at the early stage of their program, the study aimed to provide valuable insights to education course and program designers for continuous improvement of online course design and content. The authors intend to approach participants again at the end of their degree in a follow-up-up study on the effectiveness of course improvement on PSTs' online engagement.

This study is situated in a regional university where PST education is primarily delivered online, necessitating positive dispositions towards digital technology knowledge and skills. Given the increasing momentum towards digital technology adoption in education, this paper addresses the need for further research into the factors influencing PSTs' use of technology and online engagement, such as digital technology attitude and efficacy. This study is particularly important and urgent as the recent global issue of COVID-19 increased the use of online learning, forcing educational institutes to shift their face-to-face delivery mode to an online delivery method (Ngah et al., 2022) which requires students' positive dispositions towards digital technology knowledge, attitude, and skills. Thus, by extending the approach that Prior et al. (2016) employed in their examination of postgraduate busi-

ness students, the present study aims to explore PSTs' digital technology, digital literacy, self-efficacy, and engagement. This investigation involves validating and confirming these metrics within the realm of teacher education. By introducing novel insights and validated measures to the domain, this research strives to provide fellow researchers investigating the integration of digital technology among PSTs in higher education with enhanced tools and knowledge.

Two research questions guide the study:

1. How do PSTs define digital technologies and perceive their digital attitude, efficacy, literacy, and engagement in online learning?
2. What are the implications of PSTs' understanding of digital technologies and their perception of digital attitude, literacy, self-efficacy, and engagement in online learning?

These research questions hold significant importance, particularly in the challenging context of engaging PSTs online for university teachers. The successful transition to the new digital learning environment requires many PSTs, who may only be familiar with face-to-face learning or lack digital technology familiarity, to develop an understanding of digital technology, digital literacy, positive attitudes towards digital technology, and high self-efficacy. Addressing these factors is crucial to fostering meaningful online engagement among learners and optimising their learning experiences. In addition, by addressing these factors in designing teacher education courses, institutions can foster a new generation of tech-savvy educators capable of facilitating meaningful online engagement and optimising the learning experiences of their students (Hsu & Lin, 2020; Lim, 2023). Educators' experiences of emergency remote teaching have highlighted the significance of teachers, including PSTs, positive attitudes, and strong understandings and skills related to teaching with digital technologies and student engagement. Hence, as the next generation of teachers, an examination of PSTs' viewpoints offers readers a distinct vantage point, considering that PSTs fulfil dual roles as both learners and future teachers. This inquiry aids readers in contemplating technology-enhanced learning and teaching, a necessity that will likely arise anew due to significant climate events or health epidemics.

2 Background

This research study is grounded in a comprehensive conceptual framework comprising interrelated concepts of digital technologies, digital technology attitude, digital literacies, digital self-efficacy, online engagement, and their implication for course design. Each of these concepts plays a crucial role in understanding the dynamics of technology integration in education and PSTs' engagement in online learning and possesses the potential to guide the ongoing enhancement process of online course design and content for education course designers.

2.1 Digital Technologies

Digital technologies have become pervasive in educational contexts over the last two decades, redefining the landscape of learning (Buckingham, 2020; Tilton & Hartnett, 2016).

These technologies encompass computer and mobile device systems that empower users to create, manage, and utilise information, including software that operates these devices (Castro, 2019). By providing opportunities to access information, collaborate with others, and solve problems, digital technologies significantly enhance teaching and learning experiences. Recent research emphasises the importance of preparing PSTs to use new and emerging technologies in their future classrooms (e.g., Falloon, 2020; Paetsch & Drechsel, 2021). This includes using digital technologies for educational purposes, finding and managing digital information, engaging in online communication, and critically evaluating digital resources (Falloon, 2020). The rapid transformation of teaching and learning due to the COVID-19 pandemic has further highlighted the need for PSTs to develop digital competencies to ensure effective online instruction (Paetsch & Drechsel, 2021). The outbreak of the pandemic led to widespread school closures and the sudden shift to online and remote instruction. This accelerated the demand for effective online teaching methods, making digital competencies necessary for PSTs to ensure successful online instruction.

The cited studies (e.g., Falloon, 2020; Paetsch & Drechsel, 2021) collectively underscore the transformative influence of digital technologies on education. They stress the importance of equipping future teachers with digital competencies to enhance teaching and learning experiences, both in traditional and online settings, in response to the changing educational landscape shaped by digital innovations and the challenges posed by the COVID-19 pandemic.

2.2 Digital Technology Attitude

The term "digital technology attitude" refers to the overall evaluation that individuals have towards digital technology, ranging from negative to positive (Paetsch & Drechsel, 2021). It represents a relatively enduring and general stance shaped by their beliefs, emotions, and past experiences with digital technology (Paetsch & Drechsel, 2021). The attitude towards digital technology can vary among PSTs. For example, some younger PSTs, like school leavers, may naturally possess a positive attitude and feel comfortable with technology as they have grown up in a digital world. On the other hand, mature-age students, who may not have had as much exposure to digital technologies throughout their lives, might lack immersive experiences and feel less confident in using them (Smith et al., 2020). Research has identified comfort with technology as a critical factor impacting attitudes towards its use (Pongsakdi et al., 2021), and the attitudes of PSTs and in-service teachers significantly influence technology integration in teaching practices (Tondeur et al., 2022). A positive digital attitude is essential for embracing digital technology as a valuable tool for teaching and learning. Embracing technology with a positive outlook allows PSTs to explore the full potential of digital resources, engage students effectively, and create innovative and dynamic learning environments. Studies such as Falloon (2020) and Paetsch and Drechsel (2021) emphasised the importance of building PSTs' confidence and positive attitudes towards using digital resources in their classrooms. The COVID-19 pandemic has presented challenges in transitioning to online teaching, highlighting the need for PSTs to develop a positive attitude towards using digital technology effectively in diverse and digitally mediated environments (Paetsch & Drechsel, 2021). Hence, it is crucial to comprehend and cultivate the digital technology attitude among PSTs.

2.3 Digital Literacy

Digital literacy, often referred to as "literacy in the digital age," is a well-established term in educational discourse (Secker, 2018, p. 4). Despite its early recognition, defining digital literacy remains challenging due to its broad and constantly evolving nature (Glister, 1997; Secker, 2018). Digital literacy is a multifaceted concept that requires understanding practices, attitudes, and behaviours relevant to specific digital environments (Secker, 2018). In other words, it is context-specific and can differ based on the technological landscape and digital tools being used (Aslan, 2021). In Australian education, digital literacy encompasses the knowledge and skills that enable students to create, manage, communicate, investigate data, and collaborate effectively (ACARA, 2021). This definition reflects the diverse abilities required to navigate and utilise digital technologies in various aspects of education and beyond. The multifaceted nature of digital literacy necessitates that PSTs adapt to evolving technologies continuously (Liza & Andriyanti, 2020). In the rapidly changing digital world, PSTs must stay updated with the latest tools and systems to use and engage with information and communication technologies effectively. Digital literacy also involves critically identifying and using digital devices and systems while ensuring one's safety in digital environments (ACARA, 2021). This aspect highlights the importance of responsible and ethical digital practices to safeguard oneself and others while using technology in teaching and learning. Recent research suggests that digital literacy is crucial not only for using technology in teaching but also for acquiring other key competencies necessary for active participation in modern society and the economy (Peled, 2021). Digital literacy has become essential to everyday life as technology permeates various domains, such as communication, employment, research, and information access. Developing digital literacy skills equips individuals with the ability to navigate the digital landscape effectively and take advantage of the opportunities it offers.

2.4 Digital Self-efficacy

Digital self-efficacy refers to individuals' perception of their capacity to use digital technology for educational purposes (Bandura, 1997). In other words, it is the belief that one can effectively utilise digital tools and resources to achieve specific educational goals. PSTs' success in various contexts, including the digital realm, relies on high levels of self-efficacy (Berg & Smith, 2016). Graduates with high self-efficacy are better equipped to overcome challenges, develop effective teaching strategies, and display self-motivated approaches to independent study (Prior et al., 2016; Zimmerman, 2000). It is a crucial factor influencing PSTs' decisions to integrate technology into their teaching practices (Paetsch & Drechsel, 2021). High digital self-efficacy is crucial for PSTs' decisions to integrate technology into their teaching practices (Paetsch & Drechsel, 2021). When PSTs believe in their ability to use digital technology effectively, they are more likely to be motivated to incorporate it into their instructional methods. This positive attitude towards technology can significantly influence their future teaching careers, as it promotes a willingness to explore innovative teaching approaches and embrace the potential of digital learning materials. Paetsch and Drechsel (2021) further emphasise the significance of digital self-efficacy in determining PSTs' intentions to use digital learning materials and technology in their future teaching careers. The level of digital self-efficacy directly influences PSTs' confidence in integrat-

ing technology into their instructional practices and how effectively they utilise digital resources to enhance learning experiences for their future students (Meekaew & Jongnimitsataporn, 2023). Hence, by empowering PSTs with high digital self-efficacy, teacher education programs can better prepare them to embrace technology in their classrooms and create meaningful and engaging learning experiences for their students.

2.5 Conceptual Framework: Online Engagement

Online engagement is a multifaceted concept encompassing various activities, such as commenting, sharing, liking, and contributing user-generated content, aimed at fostering meaningful interactions and exchanges of information in the digital realm (Farrell & Brunton, 2020; Redmond et al., 2018). Online engagement elements have been introduced, encompassing indicators related to student beliefs, attitudes, and behaviours, thereby aiding researchers and educators in assessing online courses' efficacy in engaging students (Author, 2018). It has also been highlighted that successful online engagement is influenced by psychosocial and structural factors, emphasising the role of peer community, teacher engagement, workload, and course design (Farrell & Brunton, 2020). The term' engagement' is challenging to define in educational technology and online learning, but it is recognised as involving effort, commitment, active learning, and supportive environments (Kahn et al., 2017; Kennedy, 2020).

Understanding online engagement is a recent field of research, and a few frameworks exist to measure online student engagement. In 2004, Fredricks et al. found that students' behavioural, cognitive, and emotional engagement in an online learning environment resulted in them developing a deeper understanding of subject content. In their 2016 paper, Prior et al. proposed a model linking digital literacy, attitude, and efficacy but modified it to include online engagement. However, their definition of online engagement was limited as it only included social interaction and academic (cognitive) interactions. Redmond et al., (2018) broadened the definition of online engagement for the higher education environment to include three additional constructs: behavioural engagement, collaborative engagement, and emotional engagement. The categorises of the engagement dimensions and their corresponding indicators shown in Table 1 offer a comprehensive framework that captures the multifaceted nature of engagement in online learning contexts.

According to Redmond et al. (2018), social engagement is enhanced when students cultivate meaningful and reliable connections with others. Cognitive engagement, denoting the dynamic learning process, is highlighted as "the active process of learning" (p. 191). Similar to the points made by Acosta-Gonzaga and Ramirez-Arellano (2022), behavioural engagement encompasses the display of positive learning behaviours and attitudes. As Redmond et al. (2018) and Kong and Lai (2023) described, collaborative engagement fosters various relationships and networks that facilitate learning, spanning interactions with peers, educators, industry professionals, and the educational institution itself. Lastly, emotional engagement pertains to the emotional disposition and attitudes that students hold towards the act of learning (Redmond et al., 2018; Shin & Hickey, 2021). Redmond et al. (2018) further identified unique indicators for each of their five proposed constructs of online engagement. They recommended that these indicators be used as an "audit tool or point of reference" for research in online higher education (p. 196). These five constructs form the basis of their

Table 1 Online learning engagement framework (Redmond et al., 2018)

Engagement	Illustrative indicator
Social	Building community, creating a sense of belonging, developing relationships, and establishing trust
Cognitive	Thinking critically, activating metacognition, integrating ideas, justifying decisions, developing deep discipline understandings, and distributing expertise
Behavioural	Developing academic skills, identifying opportunities and challenges, developing multidisciplinary skills, developing agency, upholding online learning norms, supporting and encouraging peers
Collaborative	Learning with peers, relating to faculty members, connecting to institutional opportunities, and developing professional networks
Emotional	Managing expectations, articulating assumptions, recognising motivations, and committing to learning

online learning engagement framework and are adopted as this paper's conceptual framework for online engagement.

2.6 Optimising Course Design in Online Learning

Integrating digital technologies, digital technology attitude, digital literacies, digital self-efficacy, and online engagement into course design is imperative for creating effective and engaging learning experiences in the digital era (Hsu & Lin, 2020; Lim, 2023; Prior et al., 2016). Previous studies have consistently demonstrated that these factors contribute to students' positive disposition towards digital technology, influencing their learning behaviours, attitudes, engagement, and overall academic outcomes. The works of Hsu and Lin (2020), Lim (2023), and Prior et al. (2016) provide valuable insights into the significance of considering digital technology attitude, digital literacies, digital self-efficacy, and online engagement in course design. Notably, where course content and delivery lend themselves to fostering positive attitudes towards digital technology and enhancing digital literacies and self-efficacy, students tend to exhibit more meaningful and successful learning outcomes and behavioural engagement (Acosta-Gonzaga & Ramirez-Arellano, 2022; Roman et al., 2022). As highlighted by Prior et al. (2016), students' digital literacy forms the foundation of effective course design, emphasising the need to integrate digital competencies into educational programs. By recognising the impact of these variables on students' learning experiences, course designers can optimise the learning journey of PSTs and support their academic success.

It is important to underscore the critical need to integrate digital elements in educational course design, reflecting insights from Hsu and Lin (2020), Lim (2023), and Prior et al. (2016). Emphasising digital technologies, attitudes, literacies, self-efficacy, and online engagement is key to creating engaging and effective learning experiences in the digital age. Such integration enhances interactivity, accessibility, and adaptability in education. It is especially vital in equipping PSTs with the skills and confidence to use digital tools effectively, preparing them for their future roles in a technology-driven educational land-

scape. This comprehensive approach, blending teaching methods with digital innovation, is essential for improving learning outcomes and adapting to the evolving demands of online education.

3 Method

This paper is part of a series. The first paper centres on conducting a Confirmatory Factor Analysis (CFA) to determine the reliability and validity of the measurement approach. The second paper focuses on the differences in age, gender, and learning model. Finally, this paper employs descriptive statistics to examine how PSTs' comprehension of digital technologies correlates with their attitude, literacy, self-efficacy, and engagement in online learning course design. To address the research questions, this study employs a mixed-method approach, integrating both quantitative (survey) and qualitative (an open-ended question response from the survey) methods for data collection and analysis. Given the multi-faceted nature of these research questions, we believe that using a mixed-method approach is the most appropriate strategy (Wambugu & Njoroge, 2022). By combining these two approaches, the study aims to comprehensively explore various aspects of online engagement preferred by PSTs, along with their understanding of digital technology, digital literacy, digital technology attitude, and self-efficacy. The decision to use a mixed-method approach is grounded in two primary reasons. Firstly, it allows the study to capitalise on the strengths of both quantitative and qualitative methods while mitigating their individual limitations. Secondly, this approach ensures and enhances the validity of the interpretations derived from the findings (Almeida, 2018).

3.1 Instrument

The survey used validated constructs adapted from existing studies described in the next paragraph. Participants rated items on a five-point Likert Scale (1 = Strong disagree to 5 = Strongly Agree). To identify participants' knowledge and understanding of digital technologies, the survey included one open question: *Describe briefly what you understand by digital technologies.*

The seven items of the *Digital technologies attitude* construct and the nine items used for the *Digital literacy* construct are those initially proposed by Ng (2012) and modified by Prior (2016). The eight items of the *Digital self-efficacy* construct are taken from Shen (2013). Following the recommendation of Prior and colleagues (2016) that all three constructs were reliable (i.e., all α values > 0.7) and could be used with confidence in other contexts, we contextualised individual items for the digital technology and learning context of our study. For example, the *Digital literacy* construct included digital skills for online learning, such as solving technical problems and learning digital technologies. These three constructs and their contextualised items are shown in Table 5 (*Digital technologies attitude, Digital literacy*, and *Digital technology self-efficacy)*, located in the paper's results section.

To quantify participants' online engagement, the five constructs of the *Online Engagement Framework* of Redmond et al. (2018) were adopted in our study. Each construct consists of five items and includes references to the online learning environment where relevant.

The constructs are adapted from the indicators of each engagement dimension described by Redmond et al. (2018).

3.2 Participants

The participants in this study were 110 PSTs in their first year and first semester of their program at a regional university. After ethics approval, an invitation to participate in the online survey was emailed to 515 undergraduate PSTs during the third week of their initial semester, including the link to the online survey. Table 2 shows the demographic information of the study participants. The survey response from the sample comprises 88 female participants, representing 79.3% of the total, while 18 are male, accounting for 16.2%. Additionally, 4 participants chose not to disclose their gender, comprising 3.6% of the sample. In terms of age, 48 participants (43.2%) fall within the 15–25 years range, 29 (26.1%) are between 26 and 35 years, 21 (18.9%) are aged 36–45 years, and 12 (10.8%) are 46 years and above. All participants did not answer some of the questions- study status (N = 108), program enrolment (N = 107), and mode of study (N = 109).

Regarding study status, 49 participants (44.5%) are full-time PSTs taking four courses per semester, and 59 (53.6%) are part-time PSTs with fewer than four courses per semester. The programs enrolled include Bachelor of Early Childhood (1.8%), Bachelor of Education (Early Childhood) (15.5%), Bachelor of Education (Primary) (51.8%), and Bachelor of Education (Secondary) (28.2%). Moreover, 15 participants (13.5%) predominantly follow

Table 2 Demographic information of the participants (n = 110)

Demographic variables		n	%
Gender	Female	88	79.3
	Male	18	16.2
	N/A	4	3.6
	Total	110	99.1
Age	15–25 Years	48	43.2
	26–35 Years	29	26.1
	36–45 Years	21	18.9
	46 and above	12	10.8
	Total	110	99.1
Study Status	Full time (4 courses per semester)	49	44.5
	Part-time (fewer than four courses per semester)	59	53.6
	Total	108	98.2
Program enrolled	Bachelor of Early Childhood	2	1.8
	Bachelor of Education (Early Childhood)	17	15.5
	Bachelor of Education (Primary)	57	51.8
	Bachelor of Education (Secondary)	31	28.2
	Total	107	97.3
Current mode of study	Mainly on-campus (all but one course is face-to-face)	15	13.5
	Mixture of on-campus and online (about 50:50)	11	9.9
	Mainly online (all but one course is online)	2	1.8
	Online (all courses are online)	81	73.0
	Total	109	98.2

on-campus courses with only one online, 11 (9.9%) have an equal mix of on-campus and online courses, 2 (1.8%) have mainly online courses with one on-campus, and the majority, 81 participants (73.0%), have all courses online.

3.3 Data Analysis

PSTs' written responses to the question '*Describe briefly what you understand by the term 'digital technologies'* were analysed in two steps. Firstly, the frequency of keywords used by PSTs in their definition was quantified using Monkey Learn (https://monkeylearn.com/word-cloud/result) and represented visually (Doyle, 2011). The word cloud visually emphasises the PSTs' definition of digital technologies, directly related to addressing research Question 1. The size of a word in the visualisation is proportional to the number of times the word appears in the input text. These words were a starting point to assist in thematic analysis applied to PSTs' written responses. Codes were assigned to each identified concept and given a numerical value. This allowed the numerically coded responses to be scaled on a spreadsheet using a Guttman scaling process (Guttman, 1944). This process reveals groups of PSTs responses containing similar concepts and allows these PSTs groups to be ranked or ordered according to the level of conceptual complexity,

Descriptive statistical analysis was applied to each item of the attitude, literacy, self-efficacy, and online learning engagement constructs, and means and standard deviations were calculated. Within each construct, items were ranked in order of decreasing means to highlight the relative degree of positivity or negativity of PSTs' evaluation of the items. The authors thoroughly inspected each response to address the issue of missing data, ensuring that it did not unduly impact the study results. It is important to note that no missing data had any effect on the current study results. Furthermore, outliers were examined to identify any influential or erroneous data points. Whenever necessary, outliers were addressed through the analysis of standard deviations and the normality test was conducted by assessing a normal distribution of the data set. In addition, before conducting data analysis, the reliability of each construct was confirmed by calculating Cronbach's alpha. All constructs were found to be reliable with $a \geq 0.7$.

4 Results

4.1 Thematic Analysis Results

The thematic analysis results are directed at addressing a portion of Research Question 1, which queries how PSTs articulate their understanding of digital technologies. These results carry significant implications for course design (Research Question 2). One hundred and two PSTs (92.7%) of the participants provided written responses to the question '*Describe briefly what you understand by the term digital technologies'.* The 'wordcloud' representation of the keywords (Fig. 1) shows that the most frequent words are synonyms or examples of digital technology hardware (e.g., computer, phone device, tools), electronic systems or software (e.g., internet), and the function or uses of digital technology (e.g., social media, process data, information).

Fig. 1 'wordcloud' frequency representation of keywords in PSTs' definitions of digital technologies

The thematic analysis provided more detailed information about the types of words PSTs used. Most PSTs used multiple examples in lengthy responses. Using the broad groups of words highlighted in the 'wordcloud', we defined two major categories of words: Digital tools and Digital Function concepts. Both concepts contained two or more sub-concepts, as shown in Table 3. How responses were classified and counted (N) is illustrated. This example response, "*All things digital; laptops, iPads, phones, smartboards, etc."* contained a reference to hardware devices and was counted as one instance in the Hardware sub-concept of Digital tools. The following example, "*It is technology in which data and information are stored as binary file"*, was counted as one instance in the Information sub-concept of Digital function as it described the function of digital technology. Some responses contained instances of more than one sub-concept. For example, the response, '*Devices such as computers, iPads/Tablets, mobile phones used for everyday learning, collaboration with others and data collection'*, was counted as one instance in each of Hardware, Information, Communication and Education. The column, % of PSTs, refers to the number of PSTs with at least one instance of sub-concept of a major concept.

A closer inspection of the data identified additional concepts arising from PSTs' definitions. Most PSTs specified digital tools' use and/or purpose in their responses. The example '*Digital technologies are electronic tools and devices that are used to store, gather and generate data for the purpose of communication, entertainment and education.'* identifies

Table 3 Results of thematic analysis of 102 received responses. (N (number of instances) > 102 as many PSTs included multiple examples)

Concept	Sub-concept	Example words	N	(%) of PSTs (n = 102)
Digital tools	Hardware:	Computers, laptops, iPads, mobile phones, devices, whiteboards,	69	93 (91.2%)
	Software/system	Internet, software	34	
Digital function	Information	Data storage/ handling/access, cloud, eBooks,	46	81 (79.4%)
	Communication	Email, social media, zoom, skype, forums	32	
	Education	Learning, classroom, scaffolding	24	
	Life/ work	Banking, work use, everyday research	15	
	Entertainment	Gaming, streaming	11	
Other	Self-efficacy	Confidence, knowing what to do	2	4 (3.8%)
	Cyber issues	Bullying, offenders	1	
	Irrelevant	Anything that needs charging	1	

Table 4 Results of Guttman analysis showing the ordered connection concepts in PSTs' definitions of digital technologies

Ordered connection of concepts in PSTs' responses	No. & %
Digital technology means:	
Using digital tools for a digital function	61 (59.8%)
Using digital tools	6 (5.9%)
Use for a digital function	7 (6.8%)
Digital tools and digital function	13(12.7%)
Digital tools	13(12.7%)
Other	2 (1.9%)
Total	102

three uses or purposes of digital tools. To account for the complexity of PSTs' answers, we expanded the number of concepts to five (see Table 4). Applying the Guttman (1944) scaling process to the instances of recorded responses, allowing them to be ranked in order of increasing complexity and the number of PSTs within each conceptual category counted. The results of this ordered scaling in Table 4 show that almost 60% of the participants could describe the use and purpose of digital technology in some detail.

As shown in Table 4, the most common PSTs response (59.8%) was using digital tools for a digital function. This view is markedly more popular than other definitions, underscoring a dominant understanding of digital technology as an amalgamation of tool and function. Other responses included using digital tools without specifying the function (5.9%), using them for a digital function (6.8%), mentioning both digital tools and functions (12.7%), and mentioning digital tools only (12.7%).

4.2 Quantitative Results

The quantitative analysis findings aim to tackle a segment of Research Question 1, which investigates how PSTs view their digital attitude, efficacy, literacy, engagement in online learning, and relevance to course design (Research Question 2). The means and standard deviations for the items of the constructs, digital literacy, digital technology attitude, and digital technology self-efficacy, are found in Table 5. As the means are calculated using the five five-point Likert scale values, the means will lie between 1 and 5 (where $0<M<1.49$=Strongly disagree, $1.5<M>2.49$=Disagree, $2.5<M<3.49$=Neither agree nor disagree, $3.5<M<4.49$=Agee and $M>4.49$=Strongly agree).

As shown in Table 5, PSTs rated their attitude, efficacy, and literacy towards digital technologies to the scale of agree except in some items where they were neutral in their self-rate. For example, in their digital attitude self-rate, PSTs were neutral (M=3.36) with the statement, "Course leaders should use more digital technologies in their teaching of my classes". A similar rating is observed in their digital literacy rating of the statement 'I know about a lot of different digital technologies" (M=3.38). They found digital technologies helpful for collaboration (M=3.95, SD=0.828) and demonstrating understanding (M=3.93, SD=0.738). While technical problem-solving and keeping up with new technologies were less comfortable (M=3.49, SD=0.906; M=3.42, SD=1.017, respectively), a positive attitude towards using digital technologies for learning was evident (M=4.25, SD=0.641). Their self-efficacy for online learning was high (M=4.06, SD=0.413). Focusing on one notable aspect, the item dl1 stands out with a relatively high mean (M=4.33, SD=0.622. This high level of self-reported familiarity contrasts with other aspects of digital literacy and attitudes towards technology, underscoring PSTs' confidence in navigating the web's ethical and practical challenges.

Similarly, the M and SD of the items of the constructs comprising the online engagement are reported in Table 6.

The PSTs rated their social, cognitive, behavioural, collaborative, and emotional engagement near to agree except for their rate of one item of the emotional engagement. The item "I am comfortable expressing my feelings in an online course" was rated near neutral (M=3.48, SD=0.865). Particularly, PSTs felt a strong sense of belonging (M=4.08, SD=0.706) and valued trust among peers (M=3.95, SD=0.788). They appreciated well-designed courses that connected concepts (M=4.37, SD=0.619) and encouraged regular interactions (M=4.09, SD=0.808). However, expressing feelings was less comfortable (M=3.48, SD=0.865). One item particularly stands out: em1 with highest mean score (M=4.49, SD=0.632), indicating a strong consensus among PSTs on its importance. This high rating underscores the critical role of clear guidance and structured objectives in online courses.

5 Discussion

The following discussion of the results aims to address the research questions and provide insights into course design and improvement implications. By exploring the PSTs' perspectives on digital technologies and their attitudes toward digital literacy, self-efficacy, and

Table 5 Means (M) and standard deviation (SD) of PSTs digital technology attitude, efficacy, and efficacy constructs

Code	Digital literacy item	M	SD
dl1	I am familiar with issues related to web-based activities (e.g., cyber safety, search issues, plagiarism)	4.33	0.622
dl2	I am confident with my search and evaluation skills for obtaining information from the Web	4.03	0.772
dl3	I have good digital technologies skills	3.97	0.735
dl4	Digital technologies enable me to collaborate better with my peers on project work and other learning activities	3.95	0.828
dl5	I have the technical skills I need to use digital technologies to demonstrate my understanding of what I have learned	3.93	0.738
dl6	I learn new digital technologies easily	3.84	0.819
dl7	I know how to solve my own technical problems with digital technologies	3.49	0.906
dl8	I keep up with important new digital technologies	3.42	1.017
dl9	I know about a lot of different digital technologies	3.38	1.040
Digital technology attitude items			
at1	I like using digital technologies for learning	4.25	0.641
at2	There is a lot of potential in the use of mobile digital technologies for learning	4.17	0.718
at3	Digital technologies enable me to be a self-directed learner	4.15	0.743
at4	Digital technologies make learning more interesting	3.82	0.683
at5	I learn better when using digital technologies	3.55	0.739
at6	I am more motivated to learn when using digital technologies	3.50	0.835
at7	Course leaders should use more digital technologies in their teaching of my classes	3.36	0.800
Digital technologies self-efficacy item			
se1	I am able to succeed with new learning challenges	4.06	0.413
se2	I am able to create a plan to complete the course assignments	4.05	0.633
se3	I am able to complete an online course and achieve a good grade	4.01	0.613
se4	I am able to successfully complete all of the required online activities	3.99	0.684
se5	I am able to adapt my learning styles to meet course expectations	3.95	0.661
se6	I am able to understand the requirements for assignments	3.95	0.612
se7	I am able to understand complex concepts	3.82	0.561
se8	I am able to keep up with a course schedule	3.73	0.777

online engagement, we seek to gain a deeper understanding of their experiences in online learning. Two research questions guide the study:

Table 6 Means (M) and standard deviation (SD) of the online learning engagement construct for PSTs

Code	Social engagement item	M	SD
so1	A good online course is one in which I have a sense of belonging	4.08	0.706
so2	Online courses work best when we are able to trust each other	3.95	0.788
so3	Participants in online courses benefit when they are seen as having lives outside of class	3.95	0.817
so4	I prefer online courses that develop a sense of community among participants	3.79	0.889
so5	I enjoy developing relationships with other participants during an online course	3.61	0.802
	Cognitive engagement item		
co1	A well-designed online course explains how important concepts of the course are connected	4.37	0.619
co2	I appreciate opportunities to check my learning through quizzes and other activities	4.29	0.640
co3	I enjoy online courses that deepen my understanding of discipline content	4.13	0.718
co4	An online course should challenge me to ask questions about what I am learning	4.09	0.711
co5	I learn best when online courses encourage me to think about how I learn	4.01	0.748
Behavioural engagement item			
be1	A structured online course helps me to manage my study along with other commitments	4.35	0.642
be2	Online courses should include support for developing broader academic skills	4.20	0.618
be3	A well-designed online course offers opportunities for regular interaction with other participants	4.09	0.808
be4	Online courses should include information to assist participants with behaving appropriately	3.85	0.740
be5	I make an effort to support and encourage other participants in an online course	3.67	0.814
Collaborative engagement item			
cl1	Interacting with teaching staff in an online course helps me to succeed with learning	4.16	0.723
cl2	I appreciate when an online course alerts me to wider opportunities at the university	4.05	0.776
cl3	Getting to know other students in an online course is an aid to building my professional network	3.87	0.768
cl4	Working on projects with other students in an online course develops important professional skills	3.84	0.873
cl5	Working with other students in an online course helps me to learn more effectively	3.68	0.845
Emotional engagement item			
em1	I learn more effectively when an online course makes it clear what I need to do to succeed	4.49	0.632
em2	I work best when I know clearly what to expect at each stage in an online course	4.45	0.615
em3	Online courses should provide for students with different circumstances and needs	4.37	0.604
em4	It is helpful when the introduction to an online course explains clearly what prior knowledge is assumed	4.33	0.607
em5	I am comfortable expressing my feelings in an online course	3.48	0.865

1. How do PSTs define digital technologies and perceive their digital attitude, efficacy, literacy, and engagement in online learning?
2. What are the implications of PSTs' understanding of digital technologies and their perception of digital attitude, literacy, self-efficacy, and engagement in online learning?

5.1 Digital Technology Understanding

One of the objectives of this study was to address the research question of how PSTs conceptualise digital technologies. The cohort of beginning first-year PSTs participating in this study brings with them a range of understandings about the nature of digital technology. The thematic analysis (Table 3) showed that 91.2% of respondents identified various examples of digital technology hardware and software, and 79.4% identified the practical function/purpose of technology, including who acknowledged that one purpose of digital technology was for learning. The Guttman scaling and ordering process (Table 4) revealed that more than half of respondents claimed that digital technology meant using hardware and software for practical purposes. This example of a typical response, selected from this group, shows that this participant has a wide knowledge of digital tools and digital functions and can explain that digital technology involves using digital tools for specific functions or purposes. *"Digital technology is a term used to describe the**use**of digital resources such as mobile phones, iPads, tablets, computers, computer programs, apps & so on to deliver images, messages, content, information, video, film & more to an audience. These resources can be delivered through* the use of *social media, television, radio & other digital forms."* Of the remaining PSTs, 39 provided less detailed statements, such as lists of hardware devices or not mentioning how people use digital technology. Only 2% offered irrelevant or effective statements. Other studies have also suggested that PSTs' beliefs about digital technologies reflect digital skills or knowing how to use devices, learning through projects or goals and sociocultural perspectives (List, 2019; List et al., 2020).

5.2 Pre-service Teachers' Digital Technologies Attitude, Efficacy, Literacy, and Engagement in Online Learning

The following discussion concerns the research question regarding how PSTs perceive their digital attitude, efficacy, literacy, and engagement in online learning.

5.3 Digital Literacy

Although the data analysis of PSTs' definitions of digital technology discussed above showed that almost all PSTs had some knowledge of aspects of digital technology, the results of PSTs' rating of items related to their digital literacy (see Table 5) add more nuanced information about PSTs' digital capabilities. The high mean for 'I am familiar with issues related to web-based activities (e.g., cyber safety, search issues, plagiarism)' is likely due to the compulsory academic integrity module that all PSTs must complete in their first semester before submitting any assessment. Participants rated highly for their online information research skills, general digital technologies skills, online collaboration skills, and digital skills required to complete the assessment. However, lower means and larger standard deviations for some other items describing more complex tasks, such as solving technical problems, or familiarity with new and varied digital technologies (see Table 5), suggest that the average participant has a degree of hesitation about their digital capabilities in new contexts. The large SD values indicate a spread of individual ratings, and those contributing to the mean with very low ratings may have limited digital literacy. These PSTs may be at risk of

developing low self-efficacy, as an Australian study of postgraduate business students (Prior et al., 2016) showed that positive digital literacy is related to positive digital self-efficacy.

These results align with other studies. For example, digital literacy is defined in the Programme for International Student Assessment (PISA) as an ability to "evaluate information from several sources, assessing the credibility and utility of what is written using self-established criteria as well as the ability to solve tasks that require the reader to locate information, related to an unfamiliar context, in the presence of ambiguity and without explicit directions" (OECD, 2015, p. 50). Aslan (2021) suggested that digital literacy comprises intersecting concepts such as creativity, critical thinking, cultural and social understanding, collaboration, finding and selecting information, communication, E-Safety, and functional skills.

5.4 Digital Technologies Attitude

The PSTs' attitude towards digital technologies (Table 5) was high for items referring to broad statements of attitude, namely 'I like using technologies for learning" digital, 'There is a lot of potential in the use of mobile digital technologies for learning', and 'Digital technologies enable me to be a self-directed learner'. However, it seems that once PSTs are asked to rate whether they learn better using digital technologies, are more motivated to learn when using digital technologies or would like course leaders to use digital more in teaching, positivity decreases. The PSTs' lower mean rating indicates that some PSTs may have or may develop increasingly negative attitudes toward technology. As a relationship exists between attitude and self-efficacy and digital literacy (Prior, 2016), lower attitudes to technology may negatively affect PSTs' success. Further, maintaining highly positive attitudes is important for PSTs because they impact the extent to which they integrate technology in their future classrooms (Bai & Ertmer, 2008).

5.5 Digital Technologies Self-efficacy

Maintaining positive self-efficacy in an online learning environment influences online engagement (Prior, 2016). The results for the self-efficacy items show that in the initial semester of their teacher education degree, PSTs rate their self-efficacy highly, indicating that they believe they can meet new learning challenges and adapt their learning styles, complete online activities, understand and complete course and assignment requirements, and complete the course with a good grade. On the other hand, lower ratings were noted for PSTs' confidence in understanding complex concepts and keeping to the course schedule. These results suggested that care needs to be taken to link these results to PTSs' online learning experience at the beginning of their course. Prior et al. (2016) also found strong links between positive student attitudes, self-efficacy, and digital technologies. In exploring digital competence and academic engagement during COVID-19, authors found "a positive and significant relationship between students' digital competence and their academic engagement" (Heidari et al., 2021, p. 1160).

However, apart from items se3 and se4, which include the word 'online", all other items do not specify the learning context. Therefore, it is unclear whether PSTs' rating for the items reflects their self-efficacy in previous learning contexts (such as school) or their current experience in their first year of university studies. The data for this study was col-

lected in 2022 towards the end of COVID-19 restrictions. In another study conducted during COVID-19 (Heidari et al., 2021), the authors found a significant direct relationship between students' digital competence and academic engagement. It is possible that the younger participants in our study in the age group less than 20 years, who were at school during the COVID-19 restrictions, may have had online learning experiences at school that impacted their levels of online self-efficacy.

5.6 Online Engagement Constructs

5.6.1 Social Engagement

The results for the social engagement give some clear messages about what PSTs value most about the social aspect of the online learning environment. The most highly rated requirements are a sense of belonging, trust, and consideration of personal lives outside of class. Developing a sense of community and personal relationships are valued slightly less. The high rating of the item on online courses' benefit when they are seen as having lives outside of class, may be related to the demographic characteristics of the participants (Table 1). Most PSTs are female, working online, mature aged, and studying part-time for primary or early childhood education, suggesting the image of a typical PST as a mature aged female, studying primary or early childhood education part-time and online. Many of these women are likely juggling study, family and work commitments and require programs of study to recognise these extra demands. Although they appreciate the value of belonging and trust when involved in the social dynamics of online study, they may have limited time to participate in the broader online community or develop other personal relationships. Interestingly, our study's participants exhibit a notably more positive view of online social engagement than those in a recently published study. Shin and Hickey (2021) investigated the social-emotional experiences of college students during the COVID-19 pandemic and reported PSTs ratings ranging from 2.75 to 3.64 on a five-point Likert scale. In contrast, our participants demonstrated higher ratings, indicating a stronger positive perception of online social engagement. Prior et al. (2016) found a relationship between self-efficacy and engagement and different forms of interaction and engagement.

5.6.2 Cognitive Engagement

Elevated levels of cognitive engagement hold significant importance as they are closely linked to enhanced knowledge and skill development (Zhu, 2006). This becomes especially crucial in an online learning environment, where synchronous dialogue opportunities between PSTs, teachers, and peers are limited. The participants in our study strongly emphasised their expectations of how online courses should be designed to support their cognitive engagement. Notably, all items received very high ratings. The PSTs expressed their desire for courses to offer clear explanations of conceptual connections, facilitate the deepening of content knowledge, provide opportunities for feedback to monitor learning progress and support metacognitive thinking. In contrast, a study of college students during COVID-19 by Aguilera-Herminda (2020) found that cognitive engagement and attitude of students were rated highly. The study also found a relationship between self-efficacy and cognitive

engagement, where their self-efficacy or belief in themselves was strongly associated with academic outcomes.

5.6.3 Behavioural Engagement

The PSTs demonstrated a remarkably high expectation that online courses should support them in managing their study and other commitments and developing broad academic skills (see Table 6). Additionally, they placed significant value on courses that offer opportunities for interaction with peers and provide information about appropriate online behaviour. However, the PSTs hesitated regarding taking on a personal role in supporting others in an online course. Nonetheless, research suggests that expanding opportunities for increasing student dialogue online may enhance students' interaction with and support of their peers (Roman et al., 2022). A recent Bowden et al. (2021) study unveiled a strong relationship between behavioural engagement and self-efficacy. Given the high to very high values observed in their behavioural engagement in this study, it is plausible that the participants have a solid foundation for maintaining the high levels of self-efficacy they reported in response to the self-efficacy items previously discussed. Roman et al. (2022) suggested that increasing online student dialogue could further develop behaviour engagement.

5.6.4 Collaborative Engagement

The ratings provided by participants regarding collaborative engagement follow a similar pattern to that observed for online social and behavioural engagement, with lower ratings for items involving peer interactions. Collaboration with teaching staff received the highest rating, closely followed by opportunities at the university level (see Table 6). However, PSTs expressed less enthusiasm for building online networks and engaging in group work. In a recent study exploring computational thinking and teacher development conducted by Kong and Lai (2023), collaborative engagement significantly enhanced teacher and PSTs' learning. Given the relevance of developing effective collaborative strategies for primary and secondary classrooms, this finding holds significance for PSTs. Our study further reveals that entry-level PSTs exhibit lesser positivity about whether online collaboration assists their learning. Given that PSTs are involved in professional field experience, it was disappointing that the level of professional engagement was not higher. However, Pittaway and Moss (2014) found that PSTs leverage their professional engagement in the industry to help reflect and make sense of their industry experiences.

5.6.5 Emotional Engagement

Participants gave the highest rating to four of the items of the emotional engagement construct. First, a strong sentiment was expressed for the need for clarity of course information. The PSTs expect courses to clearly state what is required of them to succeed, what is expected at each stage of the course, what prior knowledge is assumed, and to cater for PSTs with different circumstances and needs. On the other hand, the PSTs are less comfortable expressing feelings in an online course. In this regard, Molinillo et al. (2018) found that through emotional engagement, there is a direct relationship between social presence and

teacher-student interactions and a positive impact on active learning. These are all positive outcomes of engaged learners.

5.7 Considerations for Designing Online Courses

One of the research questions in this study was investigating the implications of PSTs' understanding of digital technologies and their perception of digital attitude, literacy, self-efficacy, and engagement in online learning, particularly in the context of course design. As a result of the findings, several recommendations are presented and should be considered when designing courses in teacher education in various contexts. Firstly, online course designers should consider that a significant minority of entry-level PSTs may not comprehensively understand digital technology's use and purpose. Therefore, it is essential to implement support mechanisms to enhance the digital skills and knowledge of PSTs. Secondly, course designers working with entry-level PSTs sharing a similar demographic profile to the participants in this study should be mindful that implementing unsupported changes to digital platforms and introducing new learning and assessment applications could pose challenges for some PSTs with limited experience in using diverse digital technologies. Such PSTs may develop low self-efficacy in navigating these novel tools. Therefore, it is crucial to provide adequate support and guidance to ensure a smoother transition and boost their self-efficacy in utilising various digital resources.

Thirdly, course leaders should also be mindful that some entry-level PSTs may be less motivated to learn through digital technologies, preferring alternative learning modes and resisting increased digital technology usage. Fourth, entry-level PSTs report high levels of self-efficacy for learning, including meeting and completing online activities and assessments. This is a good starting point for the participants. Since digital technologies self-efficacy, attitude and literacy are correlated (Prior, 2016), online course designers should address the factors affecting PSTs' attitudes and digital literacy as these impact self-efficacy. Fifth, PST course designers for online programs need to be mindful of the demographic profile of PSTs enrolled in these courses. Incorporating strategies that foster a sense of belonging and trust among online participants is essential for creating a positive learning environment. Additionally, designers should avoid imposing unreasonable or excessive demands that could adversely affect the personal lives of PSTs. By considering these considerations, course designers can optimise the learning experience and overall well-being of PSTs in online settings.

In addition, to meet the expectations of PSTs and enhance their cognitive engagement, online course designers must develop structured courses that offer clear explanations of course concepts and content while fostering critical thinking and metacognition and providing opportunities for formative feedback. By doing so, course designers can create an environment conducive to active learning and cognitive growth among PSTs in online settings. In light of the findings, online course designers should focus on providing tools to assist PSTs in time management and the development of broad academic skills while also exploring strategies to enhance PSTs' interaction and support of their peers in the online learning environment. These efforts can lead to an enriched learning experience and foster a sense of community among PSTs. While exploring different forms of engagement in higher education in Mexico, Acosta-Gonzaga and Ramirez-Arellano (2022) found that effective emotional engagement is related to both cognitive engagement and effective scaffolding. Next,

online course designers must proactively model effective online collaborative pedagogies for PSTs studying online and provide meaningful opportunities for collaboration. By fostering a collaborative learning environment, course designers can enhance PSTs' learning experiences and equip them with valuable skills and practices for their future educator roles. Finally, PSTs highly rated four emotional engagement items, emphasising the importance of course clarity. As a result, to provide significant emotional support for online learners, online course designers should offer clear information about learning and assessment expectations, considering learners' diverse circumstances and needs. Creating a non-threatening online space where learners can freely express their feelings is also crucial.

6 Conclusion

This study results have provided substantial findings that enhance our understanding of how PSTs conceptualise digital technologies and view their own digital attitude, efficacy, literacy, and involvement in online learning. Additionally, it highlights the implications of designing courses based on these perceptions which can be applied in diverse contexts. The following paragraphs will spotlight these insights, particularly in relation to the research questions posed.

Research Question 1 explored how PSTs define digital technologies and their affective dispositions towards them. The findings revealed that more than half of the PSTs demonstrated a comprehensive understanding of the uses and purpose of digital technology. Moreover, the PSTs provided high mean ratings related to digital literacy, digital technology attitude, and digital self-efficacy. Additionally, they expressed higher mean ratings related to online engagement constructs. These results indicate that, on average, most PSTs entered their studies with positive affective dispositions towards digital technology, which holds valuable implications for their learning journey.

In Research Question 2, we explored the implications of PSTs' understanding of digital technologies and their affective dispositions. Considering the proportion of PSTs with varying understanding of digital technologies and their relative ranking of individual items in each affective construct, course designers can obtain nuanced information about the level of PSTs' understanding of digital technology and their affective dispositions. This analysis has crucial implications for course design, as it was found that 40% of PSTs had narrower definitions of digital technology, signalling the need for targeted support in using digital hardware and software for diverse educational purposes. Given the interrelated nature of digital technology attitude, literacy, self-efficacy, and online engagement (Prior, 2016), course leaders must design courses and incorporate pedagogies and support processes that enable PSTs to maintain these high levels of positivity. The identification of survey items with values less than four and those with large standard deviations indicate areas of concern that require incorporating appropriate pedagogical approaches and support mechanisms.

Despite the valuable insights gained from this study, certain limitations should be acknowledged. First, the study was conducted at a regional university, predominantly with female first-year PSTs, limiting the findings' generalisability to a broader context. Second, the reliance on self-reported measures may introduce bias and social desirability effects, impacting data accuracy and completeness. Future research could explore diverse tertiary education contexts, disciplines, universities, and cultures through interviews and focus

group discussions to enhance generalisation and enrich the understanding of digital literacy and online engagement. Nevertheless, this study lays the foundation for future research in other tertiary education contexts, such as postgraduate or research programs at various universities. The findings contribute to the growing literature on digital literacy and online engagement while continuing the dialogue about PSTs' attitudes towards digital technology, digital literacy, and self-efficacy. Future work could explore the comparison of different disciplines and modes of instruction, as well as delve into other disciplines, universities, and cultures to gain more in-depth and diverse data through interviews and focus group discussions for broader generalisation.

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