



DETERMINING THE DIGITAL LITERACY LEVELS OF MATHEMATICS PRE-SERVICE TEACHERS

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Abstract

Information technologies have increased the need to understand and use mathematics, enabling mathematics to go beyond being just a theoretical discipline. This research aims to specify the digital literacy levels of mathematics pre-service teachers and to examine the differences in this level according to age, gender, type of upper-secondary school graduated from, grade level, socioeconomic level, parental education status, place of residence, and computer ownership status variables. The descriptive research method, one of the quantitative research approaches, was used in this research. The research participants consisted of 412 volunteer university students selected using the convenience sampling method, one of the non-random sampling methods. The Digital Literacy Scale was used in the research. The study found that the perceived digital literacy levels among the participating pre-service teachers were above average. Similarly, the mean values of the informatics and technology literacy sub-factors are also above the midpoint of 3.00, suggesting that perception levels are above average. The study recommends including information and technology literacy in mathematics teacher training programs. The necessary tools and resources should be provided to enhance students' access to and use of informatics and technology.

Keywords: information and technology literacy, mathematics education, descriptive research, pre-service teacher.

Introduction

An undergraduate student who is unfamiliar with digital technology and lacks the necessary skills will struggle to succeed academically and to function effectively in the higher education landscape of the 21st-century (Nkansah & Oldac, 2024). The incorporation of digital tools and technologies in higher education institutions is increasing every day (Müller & Leyer, 2023). Educational designs that align with technology demand educators who can implement them effectively and require an emphasis on pedagogical, contextual, and technological elements that will foster teachers' growth in digital technologies (Authour, 2021; Koehler & Mishra, 2005). Instead of making educational institutions obsolete, technological advancements present new opportunities to enhance the functionality and efficiency of these institutions (İlhan et al., 2025). A society composed of individuals who cannot integrate technologies into their daily lives will allow these technologies to affect their social lives without realizing it (Celik et al., 2024). For this reason, individuals must be equipped with contemporary literacy skills to maintain uninterrupted social communication between generations and live a life in harmony with technology.

In the United States, mathematics education projects such as "Technology for All Americans" (1994-2005) and "Advancing Excellence in Technology Literacy: Student Assessment, Professional Development, and Program Standards" have been funded by the National Science Foundation (Dugger, 2010). According to the American National Research Council, mathematics education's primary purpose is to train experts in mathematics, support

mathematics-based work areas, and train individuals with mathematical literacy (Uğraş & Genç, 2018). In the 21st-century, mathematics education is rapidly gaining importance to train future mathematicians, technologists, and scientists (Dugger, 2010).

Mathematics, along with mathematical and computer sciences, has entered a new era through greater integration. In this context, technology assumes a pivotal role—not only in facilitating the teaching and learning of mathematics, but also in substantially fostering the development of students' higher-order thinking skills (Hansson, 2020). Rapid technological changes in mathematics teaching have significantly changed methods and techniques (Karaş & Abdüsselam, 2009). Concretization methods are suggested for more permanent and easier learning of abstract concepts in mathematics, and it is thought that this process can be made more effective with information technologies (Demir et al., 2023). As a tool in teaching mathematics, technology plays an important role in obtaining data, processing it, expressing it with graphics, and solving mathematical problems. Accordingly, the purposeful and effective use of technology in mathematics education enhances students' mathematical proficiency and equips them with the ability to devise more effective solutions to problems encountered in everyday contexts (Baki, 2001).

Theoretical Framework

Access to students via computers began in educational practices in the 1960s and continued with the internet in the 1990s (Kim, 2006). Computers have been the most used main element in the formation and use of information technology. Computers have provided the means to achieve the effective use of their components. Software has been developed on computers for education, and as a result of scientific research, it has been observed that this software is beneficial in education (Tor & Erden, 2004). In the last century, information technology literacy has become necessary to understand mathematics and use it in every aspect of life (Kent, 2005). Many scholars have examined and defined the concepts of digital and technological literacy. Martin, in his study, highlighted that digital literacy entails the acquisition of the awareness, dispositions, and skill sets necessary for navigating and utilizing technological tools effectively and ethically. This includes accessing and evaluating digital resources, integrating, analyzing, and synthesizing the information derived from these resources, creating new content, communicating with others, and applying these skills (Martin, 2005). Digital literacy is also conceptualized as the capacity of an individual to discern how, where, and when to appropriately engage with digital technologies (Mike & Gerald, 2007). It involves the capacity to interpret, analyze, and assess information presented through visual or written mass media, as well as to communicate messages effectively within this context (Potter, 2020).

In recent years, digital technologies have expanded globally, and their role in education has grown increasingly crucial. This transformation calls for the development of twenty-first-century skills, including digital and technological proficiency in individuals (Reis-Andersson, 2024). Technology has become a central element in redefining education in the 21st-century, leading to new demands for infrastructure as well as the technological readiness and capabilities of both educators and learners (Brianza et al., 2024). Information technology literacy, which encompasses technical and vocational skills, is a key marker for monitoring dignified employment, entrepreneurship, and employment across both younger and older age groups (Nkansah & Oldac, 2024). It has been observed that digital and technological literacy particularly impacts young people, who progressively utilize technological tools to acquire knowledge about their counterparts (Efimova & Grudin, 2008).

Literature Review

In the 1960s and 1970s, the rapid development and proliferation of technology were driven by apprehensions regarding the potential technological lag of developing nations. With the inclusion of informatics technology, especially computers, and the internet, in our lives, several new literacy types have emerged due to digital innovations, including various literacies such as network, computer, scientific, internet, digital/numeric, informatics technology, technology, web, hyper-literacy, e-literacy, and multimedia (Mete, 2020). The concept of literacy offers a broad perspective by including knowledge and competencies in various fields. Technology-based literacies emerge as part of 21st-century competencies (Jakes, 2006; Palalas et al., 2024). Martin asserted that without acquiring digital literacy skills, individuals are unable to participate in social life or to develop the knowledge and skills essential for thriving in the 21st-century (Martin, 2005). Digital literacy includes using data analysis tools to understand content better and accelerate technology learning processes (Holum & Gahala, 2001).

The technology and developments in the modern age have enabled significant innovations to emerge and continue rapidly in education and teaching. These technological innovations have significantly impacted mathematics teaching in particular and have been applied in a wide range of areas (Karal & Abdüsselam, 2009; Tatar et al., 2013). Many studies, especially in mathematics education, have revealed that the opportunities offered by digital technologies positively affect students' educational development (Byun & Joung, 2018; Ran et al., 2022). The technology used in teaching mathematics has increased success by making abstract lessons concrete. This has led to changes in methods and techniques in education and training (Alakoç, 2003; Choi-Lundberg et al., 2023). The beneficial effects of digital technology-supported education on students' mathematics and geometry achievement were reflected in the findings of many studies (Burns, 2000; Chan & Leung, 2014; Diković, 2009; Ran et al., 2022). Research in the fields of education and technology has concentrated on how people understand and are competent to use technology critically and effectively, hence digital literacy (Buckingham, 2010). Lankshear and Knobel pointed out that digital literacy is progressively being recognized as an official educational purpose (Lankshear & Knobel, 2007). Kuhlemeier and Hemker emphasized that individuals' internet access and computer usage within educational contexts are closely linked to their proficiency in technology (Kuhlemeier & Hemker, 2007). Digital literacy in education goes beyond merely knowing how to use technology; it involves critical thinking skills, proper information management, and appropriate online behavior (Tang & Chaw, 2016). Digital literacy should be integrated at every educational level and utilized effectively. Individuals who develop digital literacy will experience its positive effects in both their professional and personal lives, leading to greater success (Leffler, 2015). It has also been suggested that digital literacy should be incorporated into teacher training programs (Campbell, 2016), with pre-service teachers expected to use technological resources (Wetzel et al., 2014). The digital competence of teachers is a crucial factor for the effective application of technology in education (Tzafilkou et al., 2023). Therefore, this study explored the digital literacy skills of 21st-century mathematics pre-service teachers across various variables. The central question of this study was the extent to which future mathematics teachers possess these essential skills.

Purpose and Importance of the Research

Digital literacy includes developing mathematical thinking skills, analyzing data, and using technology effectively. These skills facilitate understanding rapidly changing technologies by helping to understand mathematical concepts. Consequently, individuals interested in the convergence of mathematics and technology should demonstrate fundamental proficiency in arithmetic and mathematics, as well as skills pertinent to digital literacy. Therefore, it is

thought that a good mathematician should have traditional mathematical literacy and the ability to use technology effectively. It is important to determine future mathematics teachers' "Digital Literacy" levels and conduct studies in this area. This study has aimed to fill this international literature gap and raise awareness. Since there are not enough studies on literacy in mathematics, which is intertwined with information and technology, such a study was deemed necessary. This study is based on the overarching research question, "Do the next generation of mathematics teachers have the 21st-century digital literacy skills needed to be competent teachers?". In this context, it was examined how pre-service teachers' digital literacy has been affected by gender, type of upper-secondary, age, place of residence, class level, parents' education level, socio-economic level, and personal computer ownership.

Research Methodology

General Background

This research was undertaken following the authorization of the Local Social and Human Sciences Research Ethics Committee dated 03/05/2024 and numbered 2024/05(01). This descriptive research examined the digital literacy levels of mathematics pre-service teachers. In this context, the screening model was preferred among quantitative research methods. It is a method in which the questions and answers asked about a specific subject are described in the screening model. Descriptive scanning is a type of research conducted on large groups, where the opinions and attitudes of individuals concerning a phenomenon or event are gathered, and the phenomenon or events are then described (Karakaya, 2012). In order to achieve generalization in this modeling, data collection must be done on a large scale (Cohen et al., 2002). In the screening model, data is obtained from a sample selected from the universe, inferences are made about the universe, and the findings obtained are generalized. In the screening model, a numerical or quantitative description of the attitudes, tendencies, and opinions towards the population is provided based on the sample of the study (Pala & Başbüyük, 2020).

Participants

The research participants consist of individuals studying in the undergraduate mathematics teaching program. In statistical analyses, it is recommended that the sample size be determined as 5 or 10 times the number of variables (number of questions, number of items) (Akbulut & Çapık, 2022). The sample comprised 412 volunteer pre-service teachers, selected through convenience sampling, a type of non-probability sampling method. The data were collected online using Google Forms, allowing access to pre-service teachers from 64 universities across Türkiye. After data collection was completed, data cleaning and examination processes began. First, missing data were checked, and it was confirmed that no data were missing. Then, standardized values of the total score on the scale were examined for outliers, and it was found that three values were outside the ± 3.00 range; these data points were removed from the analysis. So, the research was conducted with a sample of 409 pre-service teachers. The sample was drawn based on the researcher's available financial resources and time, focusing on participants who could be accessed within these constraints. Table 1 presents the descriptive statistics related to the socio-demographic characteristics of the participants. It was seen that most of the pre-service teachers were women. When the age distribution was examined, the results indicated that the highest number of the participants was 20 years old and below, and the lowest was 24-26 years old.

When the class levels were examined, the highest participation of pre-service teachers was in 1st-grade, and the lowest was in 3rd-grade. It was determined that the majority of the pre-

service teachers live in dormitories. When the education level of the mothers was examined, it was determined that the highest number of pre-service teachers was primary school, the lowest number was a university graduate, the father's education level was the highest number of secondary schools, and the lowest number was a university. Socio-economic levels of the participants were at the middle level. In addition, it was found that the majority of pre-service teachers have their computers.

Data Collection Instruments

In this study, the "Digital Literacy Scale" developed by Sulak was utilized (Sulak, 2024). The scale was developed with reference to the foundational studies of Noh and Ng (Ng, 2012; Noh, 2016). The developed scale was a 5-point Likert-type instrument consisting of 44 items distributed across three factors: instructional technologies, information and communication, and technique. According to the findings of the exploratory factor analysis and confirmatory factor analysis, it was observed that the first factor comprised 18 items, with factor loadings ranging from .367 to .803; the second factor included 15 items, with loadings between .482 and .675; and the third factor consisted of 11 items, with loadings ranging from .509 to .742. The Cronbach's Alpha reliability coefficients were calculated as .92 for the first factor, .90 for the second, and .91 for the third, indicating a high level of internal consistency across all factors. Consequently, the "Digital Literacy Scale" can be considered a highly reliable and valid tool for assessing the digital literacy skills of teachers, educators, and pre-service teachers.

Reliability Analysis and Testing of Normality Assumptions for Data Collection Instruments

When factor analysis was performed on the relevant questions in the measurement tool used in the study, it was found that they consisted of four dimensions. The values for skewness and kurtosis were analyzed to assess the distribution of the measurements obtained from the instrument and its sub-factors. Additionally, Cronbach's alpha values were calculated to supply evidence for the scale's reliability and sub-factors. Table 2 shows the measurement instruments and sub-dimensions' skewness, kurtosis, and reliability values. Table 2 shows that the kurtosis and skewness values for the total score and sub-factors of the digital literacy scale fall within the ± 1.96 range. This finding indicates that the distributions of these values display normality (Cartwright & Greaney, 2015; George & Mallery, 2010). The reliability values for the total score and sub-factors of the digital literacy scale were above .70. Since reliability values above .70 indicate good reliability (Salvucci et al., 1997) and values between .60 and .70 are considered acceptable (Van Griethuijsen et al., 2015), it can be concluded that the measurements obtained from the instrument and its sub-factors have high reliability. To determine the perception levels of pre-service teachers based on the digital literacy scale used in the study, cutoff scores were calculated using the following formula (Uzunboylu & Sarigoz, 2015).

The choice range (SA)=(The highest choice (YS)– The lowest choice (DS))/ the number of choices (SS)

The range of options was found to be .80 when the formula above was used. Accordingly, values close to the average of five are high, and values below three are low. Accordingly, if the mean value of a factor is above 3.00 for a five-point Likert, it can be considered above average.

Data Analysis

For data analysis, descriptive statistical measures (frequency and percentages), kurtosis and skewness statistics, Cronbach's alpha coefficient for reliability analysis, independent

samples t-test, and one-way analysis of variance (ANOVA) were used. The SPSS software package (version 25) was utilized for data analysis, with a significance level of .05, which is considered statistically significant.

Research Results

First, descriptive statistics for the measurements obtained from the instrument and its sub-factors, used to pre-service teachers' levels of digital literacy, are illustrated in Table 3. Reviewing Table 3, the average score of pre-service teachers on the scale's total score is 3.54, above the midpoint of 3.00. This indicates that the participants' digital literacy perception level is above average. Similarly, the mean values of the digital literacy sub-factors are also above the midpoint of 3.00, suggesting that perception levels are above average.

After determining the perception levels of participants of digital literacy, the differentiation of these levels based on various variables was examined. First, to determine if digital literacy and its sub-factors varied by gender, an independent samples t-test was performed. In Table 4, it is evident that there is a statistically significant difference in perception levels regarding the technical sub-factor of digital literacy based on gender ($t(407) = 2.86; p < .05$). The means indicate that male pre-service teachers have higher perceived levels in the technical sub-factor than females. The effect size was calculated for the practical significance of the significant difference and found to have a negligible effect. For the overall digital literacy level and the other two sub-factors, no significant variation was detected between genders ($p > .05$). Then, the differentiation by age was examined (Table 5). Table 5 indicates that pre-service teachers' perceptions of their digital literacy levels and sub-factors do not show statistically significant differences by age ($p > .05$).

After analyzing whether digital literacy levels and perceptions of sub-factors vary by age, the differences were examined based on the type of upper-secondary school they attended (Table 6). It is seen from Table 6 that pre-service teachers' perception levels related to digital literacy and its sub-factors do not differ based on the type of upper-secondary attended ($p > .05$). Accordingly, pre-service teachers exhibit similar levels of digital literacy regardless of the type of upper-secondary they attended.

After examining differences in pre-service teachers' perception levels of digital literacy and its sub-factors based on upper-secondary type, the study investigated differences according to class level. Table 7 shows that the perception levels of digital literacy showed a statistically significant difference by class level ($F(3-405) = 4.65; p < .05$). To specify which group the significant difference originated from, the Bonferroni test (since the homogeneity of variances was ensured) was performed as a multiple comparison test and the results showed that the perception levels of the 2nd and 3rd-grade pre-service teachers regarding information and technology literacy were higher than the 1st-grade pre-service teachers. It was determined that the perception levels of pre-service teachers regarding the educational technologies sub-factor of information and technology literacy had a statistically significant difference according to the grade level ($F(3-405) = 3.89; p < .05$). A Bonferroni test was performed to determine which group caused the significant difference and, the perception levels of the pre-service teachers studying in the 2nd and 3rd-grades regarding educational technologies were higher than those of the pre-service teachers in the 1st-grade. No statistically significant difference was found for the informatics and communication sub-factor based on class level ($F(3-405) = 2.42; p > .05$), indicating similar perception levels across class levels regarding this sub-factor. However, for the technical sub-factor, a statistically significant difference was identified based on class level ($F(3-405) = 7.05; p < .05$). The Bonferroni test revealed that pre-service teachers in the 2nd and 3rd-grades had higher perception levels for the technical sub-factor compared to 1st-grade pre-service teachers.

After examining the variations in perception levels of digital literacy and its sub-factors by class level, the following analysis focused on differences based on the pre-service teachers' living arrangements. Upon examining Table 8, the perception levels of pre-service teachers regarding digital literacy and its sub-factors do not exhibit a statistically significant difference based on their living arrangements ($p > .05$). Therefore, regardless of where pre-service teachers live, their levels of digital literacy are similar.

After examining the variation in pre-service teachers' perception levels regarding digital literacy and its sub-factors based on living arrangements, the analysis then turned to differences based on maternal education level (Table 9). Table 9 reveals that pre-service teachers' perception levels of digital literacy significantly differ based on maternal education level ($F(3-405) = 6.91$; $p < .05$). A Bonferroni post-hoc test was conducted to examine the source of this difference, showing that pre-service teachers with mothers who have secondary or university education levels have higher digital literacy levels than those with mothers who have primary education or are literate.

Pre-service teachers' perception levels related to the instructional technology sub-factor of digital literacy also show a significant difference based on maternal education level ($F(3-405) = 6.69$; $p < .05$). The Bonferroni test revealed that pre-service teachers whose mothers have a secondary or university education level have a higher perception of instructional technology compared to those whose mothers have primary education or are literate. The findings demonstrate a difference in pre-service teachers' perceptions regarding the informatics and communication sub-factor of digital literacy according to maternal education level ($F(3-405) = 6.92$; $p < .05$). According to the Bonferroni test, pre-service teachers with mothers who have secondary or university education levels perceive informatics and communication skills as higher than those whose mothers have primary education or are literate. Similarly, the technical sub-factor of pre-service teachers' digital literacy significantly varies based on maternal education level ($F(3-405) = 5.30$; $p < .05$). The Bonferroni test indicates that pre-service teachers with mothers at the secondary education level have a higher perception of technical skills than those with mothers who have only primary education.

After examining the variation in pre-service teachers' digital literacy and sub-factor perception levels according to maternal education level, the analysis turned to differences based on paternal education level (Table 10). Table 10 shows that pre-service teachers' perception levels regarding digital literacy differ significantly based on paternal education level ($F(3-405) = 6.70$; $p < .05$). The Bonferroni test indicates that pre-service teachers with fathers who have a secondary or university education level have higher digital literacy levels than those with fathers who have only a primary education. The analysis also reveals a notable difference in the instructional technology sub-factor based on paternal education level ($F(3-405) = 6.61$; $p < .05$). The Bonferroni test shows that pre-service teachers whose fathers have a university education level perceive instructional technology as higher than those whose fathers have only primary education. Furthermore, the informatics and communication sub-factor also demonstrates a significant difference according to paternal education level ($F(3-405) = 7.95$; $p < .05$). Pre-service teachers with fathers who have a secondary or university education level rate their informatics and communication skills higher than those whose fathers have only primary education. Lastly, the technical sub-factor of digital literacy significantly varies based on paternal education level ($F(3-405) = 4.20$; $p < .05$). The Bonferroni test reveals that pre-service teachers with fathers who have a university education level have a higher perception of technical skills compared to those whose fathers have only a primary education.

After examining the variation in pre-service teachers' perception levels of digital literacy and its sub-factors based on paternal education level, the analysis then turned to differences based on socio-economic level (Table 11). Table 11 indicates that pre-service teachers' attitudes toward digital literacy and its sub-factors do not differ significantly based on socio-economic level ($p > .05$).

After examining the variation in pre-service teachers' perception levels of digital literacy and sub-factors based on socio-economic level, the analysis focused on the influence of personal computer ownership on these levels, as shown in Table 12. Examination of Table 12 reveals that pre-service teachers' perception levels of digital literacy significantly differ based on whether they own a personal computer ($t(407) = 4.82; p < .05$). When reviewing the averages, pre-service teachers who own a personal computer exhibit higher levels of digital literacy than those who do not. The effect size of the significant difference was moderate. The analysis also found that pre-service teachers' perception levels regarding the instructional technology sub-factor significantly vary according to personal computer ownership ($t(407) = 5.09; p < .05$). Pre-service teachers' who own a personal computer perceive their instructional technology levels to be higher than those without a computer, with the practical significance of this difference being of medium effect. Furthermore, the perception levels related to the informatics and communication sub-factor differ significantly based on personal computer ownership ($t(407) = 4.70; p < .05$). Pre-service teachers who own a computer exhibit higher perception levels in informatics and communication compared to those who do not, with a medium effect size for the observed difference. Lastly, pre-service teachers' perception levels in the technical sub-factor also significantly differ based on personal computer ownership ($t(407) = 4.02; p < .05$). Pre-service teachers with personal computers perceive their technical skills to be higher than those without, with a medium effect size noted for this difference.

Discussion

This research aims to comprehensively examine how future mathematics teachers understand the concepts of informatics and technology, how they interpret them, and how much they apply them in their daily lives. According to the findings, mathematics pre-service teachers' digital literacy levels were high in educational technologies, informatics and communication, informatics and technology techniques, and informatics and technology literacy. A similar study by Usta and Korkmaz on pre-service teachers found that most possessed adequate computer skills (Usta & Korkmaz, 2010). In another study by Tasa on university students, it was observed that while most students felt competent in basic computer skills, they had low levels of software and computer awareness, with the lowest proficiency reported in programming (Tasa, 2011). Likewise, Yanık's study with pre-service teachers in Azerbaijan also showed that participants had developed informatics and technology literacy (Yanık, 2010).

The effects of the gender variable on digital literacy were examined. Based on the results, male pre-service teachers' perception levels in the technical sub-dimension were higher than those of females. These findings are consistent with the existing literature (Bingöl, 2025). The difference being statistically significant ($t(407) = 2.86; p < .05$) shows that the perception level of male pre-service teachers on technical issues is higher in males than in females. However, no significant gender difference was found in other sub-dimensions of digital literacy ($p > .05$), suggesting that gender did not substantially impact these areas overall. Previous studies have shown varied results regarding the influence of gender on digital literacy. For instance, Aydoğan found an absence of statistically significant difference in informatics technology literacy scores between 8th-grade students based on gender (Aydoğan, 2013). In contrast, Keskin found that male teachers had significantly higher scores in informatics technology literacy than female teachers (Keskin, 2008). Similarly, a study by Korkmaz and Mahiroğlu showed that male university entrants had significantly higher computer literacy scores than their female counterparts (Korkmaz & Mahiroğlu, 2009).

The effects of age on the digital literacy levels of mathematics pre-service teachers were also examined. The findings revealed an absence of significant difference between pre-service teachers' age and their perception of digital literacy and its sub-factors ($p > .05$). In contrast,

Gültekin and Özel found that students aged 21–25 had higher digital literacy skills compared to those aged 20 and younger (Gültekin & Özel, 2024). Similarly, students aged 26 and above had higher digital literacy levels than those aged 20 and under. The differences observed in their study may stem from the more comprehensive age range considered. It is suggested that a broader age range could result in a difference in digital literacy.

In terms of the type of upper-secondary attended, the study examined whether the level of digital literacy among mathematics pre-service teachers varied according to their upper-secondary background. Results indicated no statistically significant differences in digital literacy or its sub-factors (such as educational technologies, informatics and communication, and informatics and technology techniques) based on upper-secondary type ($p > .05$). Similar findings were reported in studies by Çetin (Çetin, 2008), and Tuncer and Tanaş, which showed no significant differences in computer self-efficacy levels among students based on their upper-secondary background (Tuncer & Tanaş, 2011). However, contrary results were observed in a study by Tekerek and co-workers, where vocational upper-secondary graduates exhibited greater confidence in their computer usage skills than general upper-secondary graduates (Tekerek et al., 2012). Similarly, other studies have also revealed a significant difference in the computer self-efficacy perceptions of students graduating from different types of secondary education (Akkoyunlu et al., 2005; Seferoğlu, 2005). These findings show that in some studies, the effect of the type of upper-secondary on computer skills is not clear, and the results on this subject may vary from study to study.

For the class level variable, the study identified differences in pre-service teachers' perceptions of digital literacy, educational technologies, and technical sub-factors based on their class level. Findings revealed that digital literacy levels were significantly greater among second- and third-year pre-service teachers than among those in their first year, indicating that pre-service teachers' literacy and skills in informatics and technology increase with academic advancement. However, analysis revealed no significant variation in pre-service teachers' perceptions of informatics and communication according to class level. Similarly, a study found that pre-service teachers' technology competencies and attitudes towards technology differed according to grade level. This study determined that the technology competency averages of 1st-grade pre-service teachers were significantly lower than those of 2nd, 3rd, and 4th-year pre-service teachers. In other words, 1st-grade pre-service teachers appeared less competent regarding technology competencies.

Regarding attitudes towards technology, it was observed that the attitudes of 3rd and 4th-grade students were more positive than those of 2nd-grade students (Menzi et al., 2012). These findings show that pre-service teachers' attitudes towards technology positively relate to grade level and exhibit more positive attitudes as they gain professional experience. These results are consistent with previous studies confirming the relationship between professional experience and increased proficiency in using technology (van Braak et al., 2004). Filiz and Morali found that the attitudes of mathematics pre-service teachers towards digital technology did not show a difference based on the grade level. In other words, pre-service teachers' attitudes towards digital technology remained at similar levels regardless of their grade (Morali & Filiz, 2023). This result shows that the grade level is not a determining factor in attitudes towards digital technology and that the grade level does not significantly affect this attitude. Besides, it is also thought that the differences between grade levels may be related to the courses students take in the undergraduate program at the universities they study.

Analyzing the impact of pre-service teachers' place of residence on their digital literacy levels showed an absence of significant difference in perceptions of informatics and technology literacy or its sub-factors ($p > .05$), indicating similar levels of digital literacy regardless of where pre-service teachers reside. Similarly, Tor and colleagues concluded that residence status was not a determining factor for digital literacy levels among pre-service teachers (Tor et al.,

2022). This outcome demonstrates that pre-service teachers generally have adequate access to information and communication technologies, regardless of where they live or what conditions they are housed in. In the literature, although a study found a notable correlation between students' internet access in their place of residence and their attitudes towards information technology control (Bahar & Kaya, 2013). The findings of Tor and colleagues indicate that housing status does not have a general effect on digital literacy (Tor et al., 2022). This suggests that housing conditions have lost their importance in access to digital technologies and that pre-service teachers have access to these technologies on a large scale.

Pre-service teachers' perceptions of digital literacy varied significantly according to parental education. This finding reveals that pre-service teachers whose mothers have completed secondary school or university education exhibit higher levels of digital literacy compared to those whose mothers have attained only primary education or are merely literate. It is thought that educated parents may have contributed to their children being more prone to technology by providing them with more support and guidance in this regard, and that they tend to have a better understanding of technology and information technology issues and develop stronger skills in these areas. A similar situation was also pointed out in Telli and Deniz's research. Although the parents' education levels are generally at the primary school level, it was observed that they follow educational content sites in order to support their children's education (Telli & Deniz, 2022). This finding reveals that despite the low education levels of the parents, they have developed a particular awareness about technology literacy and are trying to help their children in this area. Consequently, parental educational attainment may have an indirect effect on children's access to and engagement with technology. Another study examined the effect of the parents' education level on students' information technology literacy and found significant differences. Students whose mothers are upper-secondary or undergraduate graduates have higher information technology literacy levels than those whose mothers are illiterate or do not have a diploma. This situation shows that students' inclinations and skills in information technology may increase as the mother's education level increases. In addition, a study revealed that students with mothers who graduated from upper-secondary exhibit greater literacy levels compared to those whose mothers attained only primary education (Aydoğan, 2013).

Regarding the father's education level, it was determined that pre-service teachers whose fathers are undergraduate, or postgraduate graduates have a higher information technology literacy level than those whose fathers are illiterate or do not have a diploma. The literacy level of pre-service teachers whose fathers were primary school graduates was lower than that of those whose fathers had a higher level of education. These findings show that the father's education level can also significantly affect pre-service teachers' inclinations and skills in information technology. In particular, the fact that pre-service teachers whose fathers are undergraduates have higher levels of information technology literacy than those whose fathers are middle school and upper-secondary graduates highlights the critical role of education in this regard. These results show that parents' education level significantly impacts their children's ability to access and use information technology.

The study found no significant effect of socio-economic status on pre-service teachers' perceptions of digital literacy. This situation suggests that pre-service teachers' access to digital literacy resources may not be restricted by their socio-economic conditions, implying equal opportunity in accessing such resources. However, Telli and Deniz indicated that budgetary constraints could impact students' access to technology, particularly in households with more children or fewer working adults (Telli & Deniz, 2022). This research highlights that children from low-income families have more difficulty accessing technology. Aydoğan's research also showed that family income level significantly affects information technology literacy. It was determined that students with low income have lower digital literacy levels than students with higher incomes. It was observed that students below a certain income level have lower

digital literacy levels, and that students' competence in this area increases as their income level increases. These results reveal that the economic status of families directly affects how much students know about information technology and how they use this information (Aydoğan, 2013). The different results among the studies are thought to be due to the fact that pre-service teachers have easier access to technology in the university environment.

Significant differences were found based on whether pre-service teachers owned a personal computer. Pre-service teachers with personal computers had higher perceived digital literacy levels than those without, indicating that personal computer ownership positively influences access to and proficiency in technology. In addition, the effect size calculation performed to evaluate the practical significance of this difference revealed that this difference had a medium-sized effect. Similarly, according to the research conducted by Saygıner, it was determined that individuals who have a personal computer and internet access have higher computer competence (Saygıner, 2016). This shows that having a personal computer significantly affects pre-service teachers' digital literacy. In other words, whether or not pre-service teachers have a personal computer stands out as an important determining factor in their knowledge and skills regarding technology. This reveals that having technology alone does not directly affect perceptions towards technology; how much time individuals spend with technological tools and their interest in them are also important.

Conclusions and Implications

The study sought to answer the question "What is the level of digital literacy of mathematics pre-service teachers?" to reveal the competencies of future mathematics teachers in digital technologies and the factors affecting these competencies. The digital literacy levels of the pre-service teachers participating in the study were determined to be high in the sub-areas of information and communication, instructional technologies, information and technology techniques, and information and technology literacy. In addition, it was determined that as the grade level progressed, the perception and skills in information and technology literacy increased, the education level of parents had a significant effect on their children's access to and use of information technologies, the perception levels of male pre-service teachers were higher than female pre-service teachers in the technical sub-dimension, and having a personal computer increased digital literacy. The results indicate the importance of developing digital competencies to increase the acceptance of the integration of technologies into education.

The research findings indicated that as individuals' use of technology increased, their digital literacy also increased. Within the framework of the findings obtained, it is recommended that strong technological infrastructure systems be established so that pre-service teachers can benefit more effectively from information and technology resources in their education processes. Establishing information and technology laboratories in faculties that do not have these laboratories can contribute to developing information and technology literacy. It may benefit students who want to improve their digital literacy by opening online courses to free access in university databases. Licenses for software frequently used by mathematics teachers (Cabri, GeoGebra, Graphmatica, Maple, Maxima, Mathematica, Mathcad, MathType, Microsoft Math, MuPAD, Octave, LaTeX, MATLAB) can be obtained and made available for use. The results from the study are consistent with the existing literature, emphasizing the positive impact of digital literacy as an important component of technological competence in education. This perspective is also in line with policymakers' efforts to advocate for a more conscious increase in digital literacy and emphasize the importance of ensuring the well-being of future generations.

Limitations must be considered when evaluating the study's findings. It is important to note that all participants in the study were from Türkiye and that the results may differ in

different cultural and geographical conditions. Studies conducted in other countries with more participants in this field may reveal the effects of different variables. In addition, the results are based on self-reports, so the self-efficacy of some factors may be exaggerated. Therefore, focus group discussions and semi-structured interviews can further deepen future studies.

Supplementary Material

Relevant URL:

https://www.researchgate.net/publication/394926128_DETERMINING_THE_DIGITAL_LITERACY_LEVELS_OF_MATHEMATICS_PRE-SERVICE_TEACHERS_TABLES

Declaration of Interest

The authors declare no competing interests.

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DETERMINING THE DIGITAL LITERACY LEVELS OF MATHEMATICS PRE-SERVICE TEACHERS (TABLES)

Table 1

Frequency and Percentage of Socio-Demographic Informatics of Pre-service Teachers

Variables	Variable Levels	Frequency	Percentage (%)
Gender	Female	246	60.1
	Male	163	39.9
Age	19 years and under	79	19.3
	20 years	79	19.3
	21 years	58	14.2
	22 years	51	12.5
	23 years	42	10.3
	24-26 years	37	9.0
	27 years and above	63	15.4
Type of Upper-secondary	Anatolian	235	57.5
	Science	47	11.5
	Imam Hatip	41	10.0
	Vocational and Technical	44	10.8
	Other	42	10.3
Class Level	1 st Year	126	30.8
	2 nd Year	125	30.6
	3 rd Year	47	11.5
	4 th Year	111	27.1
Place of Residence	Dormitory	215	52.6
	Family	109	26.7
	Other	85	20.7
Mother's Education Level	Literate	35	8.6
	Primary School	178	43.5
	Secondary School	157	38.4
	University	39	9.5
Father's Education Level	Primary School	135	33.0
	Secondary School	184	45.0
	University	90	22.0
Socio-Economic Level	Low	22	5.4
	Medium	321	78.5
	High	66	16.1
Owns a Personal Computer	Yes	281	68.7
	No	128	31.3
Total		409	100.0

Table 2*Skewness, Kurtosis, and Reliability Values for Measurement Instruments and Sub-Dimensions*

Measurement instruments and sub-factors	Skewness	Kurtosis	Cronbach α
Instructional technologies	-0.18	-0.49	.937
Informatics and communication	-0.54	-0.34	.942
Technical	-0.52	-0.53	.937
Informatics and technology literacy	-0.43	-0.39	.975

Table 3*Descriptive Statistics for Measurement Instruments and Sub-Factors*

Measurement Instrument and Sub-Factors	Min.	Max.	Mean (\bar{X})	Standard Deviation (SD)
Instructional technologies	1.17	5.00	3.41	0.80
Informatics and communication	1.27	5.00	3.62	0.80
Technical	1.09	5.00	3.58	0.91
Informatics and technology literacy	1.35	5.00	3.54	0.79

Table 4*Comparison of Pre-service Teachers' Digital Literacy Levels by Gender*

Variable	Gender	N	Mean (\bar{X})	SD	df	t	d
Instructional technologies	Female	246	3.39	0.79	407	0.66	--
	Male	163	3.44	0.81			
Informatics and communication	Female	246	3.60	0.80	407	0.56	--
	Male	163	3.65	0.80			
Technical	Female	246	3.48	0.95	407	2.86*	0.29
	Male	163	3.74	0.84			
Informatics and technology literacy	Female	246	3.49	0.80	407	1.50	--
	Male	163	3.61	0.78			

Note: * $p < .05$

Table 5*Comparison of Pre-service Teacher' Digital Literacy Levels by Age Variable*

Variables	Age Group	N	Mean (\bar{X})	SD	df	F	Difference
Instructional Technology	19 and under	79	3.37	0.82	6-402	1.28	--
	20	79	3.34	0.71			
	21	58	3.63	0.69			
	22	51	3.43	0.78			
	23	42	3.46	0.83			
	24-26	37	3.47	0.88			
	27 and above	63	3.27	0.89			
Informatics and Communication	19 and under	79	3.65	0.82	6-402	1.45	--
	20	79	3.61	0.71			
	21	58	3.83	0.67			
	22	51	3.59	0.83			
	23	42	3.58	0.83			
	24-26	37	3.67	0.86			
	27 and above	63	3.42	0.87			
Technical	19 and under	79	3.42	1.00	6-402	2.12	--
	20	79	3.47	0.83			
	21	58	3.89	0.75			
	22	51	3.56	0.93			
	23	42	3.62	0.93			
	24-26	37	3.78	0.99			
	27 and above	63	3.54	0.92			
Informatics and Technology Literacy	19 and under	79	3.48	0.84	6-402	1.51	--
	20	79	3.47	0.70			
	21	58	3.79	0.66			
	22	51	3.53	0.81			
	23	42	3.56	0.83			
	24-26	37	3.64	0.87			
	27 and above	63	3.41	0.86			

*Note: *p < .05*

Table 6
Comparison of Pre-service Teacher' Perceptions of Digital Literacy Levels by Type of Upper-secondary Attended

Variables	Type of upper-secondary	N	Mean (\bar{X})	SD	df	F	Difference
Instructional Technologies	Anatolian	235	3.37	0.77	4-404	1.65	--
	Science	47	3.65	0.83			
	Religious	41	3.34	0.76			
	Vocational-Technical	44	3.33	0.91			
	Other	42	3.52	0.81			
Informatics and Communication	Anatolian	235	3.60	0.80	4-404	1.37	--
	Science	47	3.80	0.76			
	Religious	41	3.54	0.77			
	Vocational-Technical	44	3.47	0.87			
	Other	42	3.73	0.77			
Technical	Anatolian	235	3.54	0.93	4-404	1.87	--
	Science	47	3.82	0.88			
	Religious	41	3.49	0.91			
	Vocational-Technical	44	3.43	0.96			
	Other	42	3.80	0.73			
Informatics and Technology Literacy	Anatolian	235	3.51	0.79	4-404	1.76	--
	Science	47	3.76	0.78			
	Religious	41	3.45	0.75			
	Vocational-Technical	44	3.41	0.88			
	Other	42	3.68	0.73			

Note: *p < .05

Table 7

Comparison of Pre-service Teacher' Perceptions of Digital Literacy Levels According to Class Level

Variables	Class Level	N	S.S.	SD	F	Difference
Instructional Technology	1 st Year (1)	126	3.26	0.78	3-405	3.89*
	2 nd Year (2)	125	3.53	0.73		
	3 rd Year (3)	47	3.64	0.81		
	4 th Year (4)	111	3.36	0.85		
Informatics and Communication	1 st Year (1)	126	3.51	0.81	3-405	2.42
	2 nd Year (2)	125	3.72	0.72		
	3 rd Year (3)	47	3.78	0.84		
	4 th Year (4)	111	3.56	0.83		
Technical	1 st Year (1)	126	3.30	0.94	3-405	7.05*
	2 nd Year (2)	125	3.76	0.80		
	3 rd Year (3)	47	3.84	0.84		
	4 th Year (4)	111	3.60	0.96		
Informatics and Technology Literacy	1 st Year (1)	126	3.36	0.80	3-405	4.65*
	2 nd Year (2)	125	3.67	0.71		
	3 rd Year (3)	47	3.75	0.80		
	4 th Year (4)	111	3.51	0.84		

Note: *p < .05

Table 8

Comparison of Pre-service Teacher' Perception Levels Regarding Digital Literacy Based on Living Arrangements

Variables	Living Arrangements	N	S.S.	SD	F	Difference
Instructional Technology	Dormitory	215	3.38	0.73	2-406	0.84
	Family	109	3.41	0.84		
	Other	85	3.51	0.89		
Informatics and Communication	Dormitory	215	3.62	0.74	2-406	0.02
	Family	109	3.61	0.86		
	Other	85	3.63	0.86		
Technical	Dormitory	215	3.56	0.88	2-406	0.32
	Family	109	3.58	0.96		
	Other	85	3.65	0.93		
Informatics and Technology Literacy	Dormitory	215	3.52	0.74	2-406	0.31
	Family	109	3.53	0.85		
	Other	85	3.60	0.87		

Note: *p < .05

Table 9

Comparison of Pre-service Teachers' Perception Levels Regarding Digital Literacy Based on Maternal Education Level

Variables	Maternal Education	N	S.S.	SD	F	Difference
Instructional Technology	Literate (1)	35	3.19	0.83	3-405	6.69*
	Primary (2)	178	3.26	0.76		
	Secondary (3)	157	3.56	0.78		
	University (4)	39	3.69	0.83		
Informatics and Communication	Literate (1)	35	3.37	0.79	3-405	6.92*
	Primary (2)	178	3.47	0.76		
	Secondary (3)	157	3.79	0.79		
	University (4)	39	3.84	0.79		
Technical	Literate (1)	35	3.35	0.90	3-405	5.30*
	Primary (2)	178	3.43	0.92		
	Secondary (3)	157	3.75	0.89		
	University (4)	39	3.82	0.82		
Informatics and Technology Literacy	Literate (1)	35	3.30	0.79	3-405	6.91*
	Primary (2)	178	3.39	0.77		
	Secondary (3)	157	3.70	0.78		
	University (4)	39	3.78	0.77		

*Note: *p < .05*

Table 10

Comparison of Pre-service Teachers' Perception Levels Regarding Digital Literacy Based on Paternal Education Level

Variables	Paternal Education	N	S.S.	SD	F	Difference
Instructional Technology	Primary (1)	135	3.23	0.79	2-406	6.61*
	Secondary (2)	184	3.45	0.80		
	University (3)	90	3.61	0.74		
Informatics and Communication	Primary (1)	135	3.43	0.82	2-406	7.95*
	Secondary (2)	184	3.65	0.79		
	University (3)	90	3.84	0.70		
Technical	Primary (1)	135	3.41	0.94	2-406	4.20*
	Secondary (2)	184	3.62	0.94		
	University (3)	90	3.76	0.78		
Informatics and Technology Literacy	Primary (1)	135	3.36	0.81	2-406	6.70*
	Secondary (2)	184	3.57	0.80		
	University (3)	90	3.74	0.71		

*Note: *p < .05*

Table 11

Comparison of Pre-service Teachers' Perception Levels Regarding Digital Literacy Based on Socio-Economic Level

Variables	Socio-economic Level	N	S.S.	SD	F	Difference
Instructional Technology	Low	22	3.41	0.91	2-406	1.99
	Medium	321	3.38	0.79		
	High	66	3.59	0.77		
Informatics and Communication	Low	22	3.53	0.87	2-406	0.98
	Medium	321	3.60	0.79		
	High	66	3.74	0.78		
Technical	Low	22	3.60	0.89	2-406	0.68
	Medium	321	3.56	0.93		
	High	66	3.70	0.83		
Informatics and Technology Literacy	Low	22	3.51	0.84	2-406	1.21
	Medium	321	3.51	0.80		
	High	66	3.68	0.76		

*Note: *p < .05*

Table 12

Comparison of Pre-service Teachers' Digital Literacy Levels Based on Personal Computer Ownership

Variable	Personal Computer Ownership	N	S.S.	SD	t	d
Instructional Technology	Yes	281	3.54	0.77	407	5.09*
	No	128	3.12	0.79		
Informatics and Communication	Yes	281	3.74	0.75	407	4.70*
	No	128	3.35	0.83		
Technical	Yes	281	3.70	0.88	407	4.02*
	No	128	3.32	0.94		
Informatics and Technology Literacy	Yes	281	3.66	0.76	407	4.82*
	No	128	3.26	0.80		

*Note: *p < .05*