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Unraveling the digital fluency of high school students

Emre Eçier [a], Serkan İzmirli [b] *

[a] Ministry of National Education, Türkiye.
[b] Çanakkale Onsekiz Mart University, Türkiye.

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Highlights

- We adapted the "Digital Fluency Scale," which was originally developed by Demir and Odabaşı (2022) for university students, to suit high school students.
- Digital fluency levels show significant differences based on gender, grade level, family-imposed technology limitations, frequency of internet use, programming skills, and device type.
- There were no significant differences in digital fluency levels concerning the type of school, enrollment in a Science and Art Centre, or the frequency of social network use.

Article Info: Research Article

Keywords: *Digital fluency, high school students, digital proficiency, digital literacy*

Abstract

The primary aim of this research is to assess the digital fluency levels of high school students and to investigate how digital fluency varies according to different variables. The study employed a descriptive research design using survey methodology. A total of 698 students from various high schools in Çanakkale province, Türkiye, representing five different school types, participated in the research. The "Digital Fluency Scale," originally developed for university students, was adapted to assess the digital fluency levels of high school students. Findings indicate that high school students possess a high level of digital fluency. Significant differences in digital fluency levels were observed based on gender, grade level, family-imposed limitations on technology use, frequency of daily internet use, programming proficiency, and the type of device used to access the internet. Conversely, digital fluency levels did not differ significantly based on the type of school, enrollment in a Science and Art Centre, and frequency of daily use of social networks.

1. Introduction

Educational paradigms have evolved alongside historical and technological advancements. The first proposed Education 1.0 paradigm involved a master-apprentice relationship, assuming a one-way transfer of knowledge from instructor to student (Puncreobutr, 2016). The Education 2.0 paradigm responded to the needs of industrial society, prioritizing teaching over creativity and using technology as a tool (Pooworavan, 2015). The Education 3.0 paradigm utilized technology multidimensionally, with technological elements left to user preference (Harkins, 2008). Education 4.0 was developed to meet the skills required by the Industry 4.0 revolution (Coşkun et al., 2019). For Education 4.0 to become functional, individuals must be ready to be creative and innovative. Education 4.0 includes skills such as leadership, collaboration, creativity, digital literacy, effective communication, emotional intelligence, entrepreneurship, digital citizenship, problem-solving, teamwork, and innovation (ISTE, 2014).

In the literature, there are a limited number of studies measuring individuals' ability to adapt to the innovations brought by the Industry 4.0 revolution. One of the essential skills for adaptation is digital

* Corresponding author. Department of Computer Education and Instructional Technology, Çanakkale Onsekiz Mart University, Türkiye.
e-mail address: sizmirli@gmail.com
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fluency. The concept of digital fluency was first extensively examined by the National Research Council in 1999 when considering the importance of fluency in computer usage. The study stated that a person is considered fluent in a language when they can express themselves creatively. From this point of view, it was argued that a person's ability to act creatively in a digital environment is also valid for digital fluency. Digital fluency is thought to develop over a lifetime in specific areas of interest, and it is foreseen that lifelong learning can be achieved depending on these areas of interest (National Research Council, 1999). Resnick (2002) emphasized that while individuals are taught how to search for information online and use certain platforms, they cannot be fluent in technology unless they understand how these tools work and build meaningful things with the tools they use. Resnick uses the analogy of learning a foreign language to explain the meaning of digital fluency. According to him, to be truly fluent in a foreign language, an individual must be able to express a complex idea or tell an interesting story. Similarly, being digitally fluent means knowing how to create important ideas with digital technology, not just knowing how to use digital technologies.

Beetham (2015) developed a digital fluency model to explain digital fluency. The digital fluency model he tried to explain consists of digital creation, innovation and sharing, communication, collaboration and participation, information, data and media literacy, digital learning and self-improvement, digital identity and well-being, and digital competency. The New Zealand Ministry of Education (2016) explained that digital fluency supports teachers, students, and learning outcomes to use digital technologies safely and effectively. The digital fluency model in the study consists of digital capabilities, digital principles, and digital literacy. Demir and Odabaşı (2016) defined digital fluency as the effective and efficient use of ICT, having ICT experiences, solving problems with ICT, critical thinking about ICT, demonstrating ability with ICT, flexibility in using ICT, quickly adapting to technological transformation with ICT, and abstract thinking about ICT (Fig. 1).

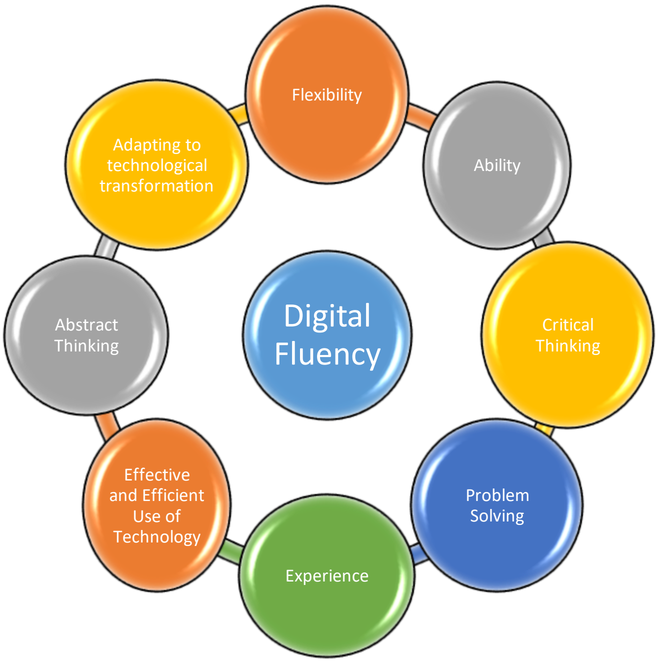

Fig. 1. Components of digital fluency (Demir & Odabaşı, 2016)

Digital fluency encompasses a range of higher-order thinking skills, such as critical thinking, problem-solving, and adaptability, which are essential for thriving in today's digital economy (Demir & Odabaşı, 2016; Resnick et al., 2009). Assessing the digital fluency levels of high school students, who represent the future workforce, is crucial for understanding their preparedness to meet the demands of a rapidly evolving technological landscape. By identifying their current digital fluency, this study aims to shed light on the development of these critical competencies and inform educational strategies to better equip students for future challenges.

Durmus Cemcem et al. (2023) identified the duration of internet use as a key variable influencing digital fluency but found that it did not significantly impact the digital fluency of prospective teachers. Nevertheless, the time students spend online and their ability to use that time effectively and efficiently can shape their digital fluency. However, the widespread and frequent use of the internet has also led to issues such as excessive and addictive social media use, often linked to cyberloafing. Deniz and Gürültü (2018) found that high school students exhibited moderate levels of social media addiction. The literature, however, lacks sufficient studies exploring how social media use affects high school students' digital fluency. Investigating this relationship is essential for understanding whether social media engagement supports or hinders the development of critical digital competencies. Such insights could help educators and policymakers promote balanced and intentional internet use among students.

A wide range of technological devices enables individuals to connect to the internet and engage with digital technologies. It is not precisely known on which devices individuals demonstrate their digital fluency skills necessary for adapting to social change. From this perspective, examining the role of the types of devices high school students use to connect to the internet can help determine their digital fluency. Families sometimes restrict access to smartphones or other technological devices, such as computers, thinking it negatively affects students' academic success (Türel & Gür, 2019). Understanding how general digital fluency levels are affected by technology usage restrictions can guide families and students regarding technology use.

Providing programming education in K-12 schools can develop students' 21st-century skills, such as problem-solving, decision-making, critical thinking, creativity, and ICT literacy (Hu, 2024). From this perspective, students' programming skills can influence their digital fluency, which includes problem-solving skills (Demir & Odabaşı, 2016). Therefore, examining the differentiation of students' digital fluency levels according to their programming skills is necessary, as it can provide insights into how programming education contributes to broader digital competencies. Understanding this relationship can help educators design targeted interventions and curricula to enhance digital fluency in alignment with the demands of the digital age.

Although the literature has established that the digital literacy levels of Generation Z individuals are sufficient (Pala & Başıbüyük, 2020), information on their digital fluency levels is still lacking. In light of these statements, it is essential to determine the digital fluency levels of high school students.

1.1. Research Purpose and Questions

The present research aims to determine the digital fluency levels of high school students and examine these levels across various variables. In line with this aim, this study seeks answers to the following questions:

1. What is the level of digital fluency of high school students?
2. Do the digital fluency levels of high school students significantly differ according to
    a. gender,
    b. grade level,
    c. the type of school they are enrolled in,
    d. whether they are students at a Science and Art Center (SaARC),
    e. the situation of families' restrictions regarding technology use,
    f. the frequency of internet use,
    g. the frequency of social network use,
    h. the proficiency in computer programming, and
    i. the device they use to connect to the internet?

1.2. Literature Review

Liu et al. (2018), in their study investigating the relationship between digital fluency and social media use, concluded that digital fluency affects social media use. They found that digital fluency has positive effects on expanding social networks, meeting information needs, usage, and fulfillment. Bennet and Maton (2010) noted that individuals with high digital fluency generally have strong learning abilities and rich experiences with digital technologies and particularly with social media. Briggs and Makice (2012) also stated that personal experiences are seen as the best way to develop the knowledge, skills, and understanding needed to improve digital fluency. They likened digital fluency to fluency in language or music, emphasizing that digital fluency can be developed through practice and using existing skills. As an example of this, they mentioned that a digitally fluent person would not only understand the functionality of Twitter but also why and when its use is valuable. Similarly, Niessen (2013) stated that digital fluency includes not only using digital media easily for communication and obtaining information but also knowing why and when we use it. Demir et al. (2015) viewed digital fluency as the ability to know when and where to use technology.

Bologa et al. (2009) mentioned that digital fluency represents the knowledge, skills, and responses necessary for individuals to use digital technologies for various reasons in the digital age. In their study, Resnick et al. (2009) concluded that digital fluency is closely related to computer programming. They also concluded that digital fluency is an increasingly essential prerequisite for the digital age and that creative problem-solving skills can be developed based on computer programming to improve digital fluency. Similarly, in their research aimed at developing problem-solving skills using Scratch, one of the block programming tools, Kim et al. (2013) found that students who used the Scratch programming tool increased their digital fluency.

Ross (2015) emphasized the social aspect of digital fluency in his study, highlighting that having communication, collaboration, and connection skills is a requirement for being digitally fluent. He noted that digital fluency plays a role in facilitating effective communication, learning, connection building, and strengthening social and cultural ties. He defined digital fluency as the ability to use mobile technologies to communicate, collaborate, and connect with people. Hsi (2007) viewed digital fluency as a developmental process in which users interact with mobile devices, developing different expertise and skills based on their interests, needs, and the technical limitations of the mobile devices. Savin-Baden (2015) found that individuals with high digital fluency tend to meet their social needs more digitally compared to those with low digital fluency. McQuggan et al. (2015) stated that digital fluency is among the critical skills for surviving in a digital society. Spencer (2015) mentioned that digital fluency is a combination of digital or technical proficiency, digital literacy, and social competence. Wenmoth (2015) considered digital fluency to show wisdom and self-confidence in the application and use of digital technologies and related the concepts that make up digital fluency with cognitive, application, and analysis evaluation steps.

Chigona (2018) conducted a study with 36 teachers from different schools and found that teachers with low levels of digital fluency lacked confidence in effectively using technology in digital classrooms. Fulgence (2020) suggested that both individual and institutional mechanisms need to be employed to develop the digital skills and digital fluency of prospective teachers. It was concluded that providing education, infrastructure, and online programs could be beneficial for developing digital fluency. Dias-Trindade and Ferreira (2020) stated that prospective teachers need to be trained in the use of digital technologies and resources, teaching and learning, and assessment to evolve from digital competence to digital fluency.

Karakuş and Kılıç (2022), who examined the levels of digital awareness, digital competence, and digital fluency of prospective teachers and the relationship between them, found that prospective teachers have high levels of digital awareness, digital competence, and digital fluency. They think that the Covid-19 process may have influenced this situation.

2. Method

2.1. Research Design

This study, which aims to determine the digital fluency levels of high school students, is designed using a descriptive survey model. The descriptive survey model is a research method that aims to depict the existing situation as it is (Karasar, 2014). The survey model aims to describe the characteristics of societies, institutions, and objects (Fraenkel et al., 2012).

2.2. Participants

A convenience sampling method was used to select the research sample. The participants of the study consist of 698 students studying in public high schools in the province of Çanakkale, Türkiye. Of these students, 348 (49.9%) are female, and 350 (50.1%) are male. Among the students, 234 (33.5%) are in the 9th grade, 253 (36.2%) are in the 10th grade, 95 (13.6%) are in the 11th grade, and 116 (16.6%) are in the 12th grade. Additionally, 393 (56.3%) of the students attend Science High School, 127 (18.2%) attend Anatolian High School, 126 (18.1%) attend Vocational and Technical Anatolian High School, 30 (4.3%) attend Imam Hatip Anatolian High School, and 22 (3.2%) attend Social Sciences High School.

2.3. Data Collection Tool

To determine the digital fluency of students, Demir and Odabaşı's (2022) Digital Fluency Scale, originally developed for the undergraduate level, was adapted for high school students. The reasons for adapting the scale are as follows:

1. The sample group is different (at the high school level), requiring the structure to be rediscovered.
2. One of the items on the scale used at the undergraduate level, "I serve as a role model for my students in using digital tools," was not suitable for the theoretical background of high school students. Therefore, it was removed from the scale based on the opinions of two academics specializing in Computer Education and Instructional Technology.

3.3.1. Pilot Study

After obtaining feedback from subject matter experts, the 29-item Digital Fluency Scale (Demir and Odabaşı, 2022) was administered to students. The item "I serve as a role model for my students in using digital tools," which was not suitable for high school students, was removed, resulting in a 28-item scale. The scale was administered face-to-face to 30 students from different academic levels and school types (Science High School, Social Sciences High School, and Anatolian High School). During the pilot application, students took 15-25 minutes to complete the items and reported that there were no cognitively challenging items on the scale. Subsequently, exploratory factor analysis (EFA) was conducted.

3.3.2. Exploratory Factor Analysis

In many studies, a sample size of over 300 has been deemed sufficient to understand the adequacy of the sample size (Comrey & Lee, 1992; Field, 2013). For the adaptation of the Digital Fluency Scale (Demir & Odabaşı, 2022) to high school students and to perform EFA, the scale was administered to 360 high school students. To determine whether the data were suitable for factor analysis, the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity were conducted. The KMO value for factor analysis is considered "adequate" if it is between .50 and .70, and "good" if it is .70 or above. Additionally, Bartlett's test is expected to be significant ($p<.05$) (Can, 2020). The EFA results for the 28-item Digital Fluency Scale showed a KMO value of .928. Bartlett's test of sphericity resulted in $\chi2=5066.4388$, which was significant at $p=.000$. Given that Bartlett's test was significant ($p<.05$) and the KMO value was greater than .70 (considered "good"), it was concluded that the conditions were met for performing exploratory factor analysis on the scale.

When conducting exploratory factor analysis, principal components analysis, one of the most commonly used techniques, was preferred to reduce the data by grouping and to obtain the most accurate information with the least number of measurements (Can, 2020). For eigenvalues to be considered significant, they must be greater than 1 (Green & Salkind, 2002). In the factor analysis, the Digital Fluency Scale was constrained to three factors based on its predetermined sub-dimensions. Since the scale's sub-dimensions comprise awareness, self-efficacy, and affective components, the analysis was conducted with a fixed three-factor structure. The analysis revealed that the three factors explained 55.874% of the total variance. Considering the number of factors, a factor loading of .40 or above was recommended (Costello & Osborne, 2005; Çokluk et al., 2012).

When examining communalities, the item with a communalities value below .40, item 26 ("I don't have enough time to develop my digital skills") with a value of .297, was removed. After removing this item, the exploratory factor analysis revealed communalities values between .441 and .678. Since no result below .40 was obtained in communalities, the varimax technique, one of the orthogonal rotation methods, was used for clearer understanding of the factor structure (Field, 2013). After examining the analyses resulting from the orthogonal rotation, item 16 ("I can understand the working principles of websites"), which loaded on multiple factors, was removed from the scale. The analysis was repeated after removing the overlapping item, and the final exploratory factor analysis was completed after removing another overlapping item, item 18 ("I can know how to solve problems I encounter in the digital environment"). The items removed from the scale are presented in Table 1.

Table 1.

The items removed from the scale as a result of the analyses

Items
I serve as a role model for my students in using digital tools
I don't have enough time to develop my digital skills
I can understand the working principles of websites
I can know how to solve problems I encounter in the digital environment

After the exploratory factor analysis, the factor and item analyses of the scale are presented in Table 2.

Table 2.

The factor and item analyses of the scale

Factors	Load on factor 1	Load on factor 2	Load on factor 3	x̄	SD	Communalities
Self-efficacy (α=.912)						
I can find where to access correct information on the internet.	.833			4.20	.847	.706
I can find how to access correct information on the internet.	.819			4.28	.815	.688
I can decide when digital tools will be useful.	.756			4.02	.953	.621
I can adapt to new technologies.	.694			4.27	.909	.553
I can verify the accuracy of the information I access on the internet.	.692			3.99	.950	.535
I can know how digital tools work.	.684			4.08	.976	.576
I can use digital tools without problems.	.674			3.81	1.034	.610
I can use the necessary digital technologies to solve problems.	.634			3.77	1.077	.587
I can use different digital devices.	.627			4.27	.909	.446
I can work online with others on the same project.	.558			3.81	1.148	.435
I can learn the features of digital tools on my own.	.524			3.76	1.086	.443
I can understand how search engines produce results.	.489			3.71	1.114	.410
Awareness (α=.893)						
I have enough interest to develop my digital skills.		.795		3.38	1.304	.697
I can produce digital content uniquely and to the desired quality.		.753		3.06	1.261	.635
I have the necessary motivation to improve my digital competencies.		.734		3.40	1.236	.588
I can be a role model in using digital tools.		.726		2.99	1.264	.604
I can perform any task on different operating systems.		.663		2.81	1.258	.513
I can think abstractly about concepts related to computers.		.659		3.43	1.137	.676

I can install the software I need myself.		.627		3.00	1.373	.486
I want to learn new information about digital technologies.		.591		3.87	1.162	.442
I am curious about new technologies.		.574		4.17	.973	.459
I can benefit from expert guidance on new technologies.		.565		3.53	1.156	.523
Affective (α=.671)						
I feel anxious about acquiring digital skills.			.783	3.48	1.325	.619
I fear facing too much workload if I demonstrate my digital skills.			.767	3.09	1.338	.595
I feel lazy about improving my digital skills.			.670	2.64	1.363	.523
Eigenvalues	10.098	2.032	1.838			
Variance Explained	25.448	22.886	7.540			
Total Variance	25.448	48.334	55.874			

As seen in Table 2, the Digital Fluency Scale-High School Form, resulting from the EFA, emerged as a 3-factor, 25-item scale consisting of self-efficacy, awareness, and affective factors. The scale's self-efficacy dimension consists of 12 items, the awareness dimension consists of 10 items, and the affective dimension consists of 3 items. The internal consistency reliability coefficient for the self-efficacy sub-dimension is $\alpha_{\text{self-efficacy}}$ = .912, for the awareness sub-dimension is $\alpha_{\text{awareness}}$ = .893, for the affective sub-dimension is $\alpha_{\text{affective}}$ = .671, and for the entire scale is α_{total} = .912. According to these results, it can be stated that the entire scale and its sub-dimensions provide reliable measurements. The scale is in the form of a five-point Likert scale with the following options: "Strongly Disagree (1)," "Disagree (2)," "Somewhat Agree (3)," "Agree (4)," "Strongly Agree (5)."

2.4. Data Analysis

Since the prerequisites were met for each research question, parametric tests were used. Descriptive statistics were employed for analyzing the first research question. The data collected using a five-point Likert-type scale was coded as follows: strongly disagree = 1, disagree = 2, moderately agree = 3, agree = 4, and strongly agree = 5. To interpret the mean scores obtained from the scale, the $(n-1)/n$ formula (where n represents the number of Likert points) was applied, resulting in a range of 4/5=0.8. The interpretation ranges were defined as follows: 1.00–1.80 = "very low", 1.81–2.60 = "low", 2.61–3.40 = "moderate", 3.41–4.20 = "high", and 4.21–5.00 = "very high". For the sub-questions of the second research question, an independent samples t-test was used when comparing two groups, and a one-way analysis of variance (ANOVA) method was used when comparing more than two groups (Field, 2013). In the study, the significance level (p) was accepted as .05, and for questions with a significant difference, the eta squared (η^2) effect size value was calculated. The effect size value was interpreted as small if between .01 and .06, medium if between .06 and .14, and large if .14 or above (Cohen, 1988).

2.5. Ethical Procedures

Approval for this research was obtained from the Scientific Research Ethics Committee of the Graduate Education Institute at Çanakkale Onsekiz Mart University, confirming that it complies with ethical principles (Date: 24.05.2021, No: 09/67). Permissions for data collection were also obtained from the Directorate of National Education and from parents. Additionally, necessary permissions were obtained from the original developers of the Digital Fluency Scale for preservice teachers, Demir and Odabaşı (2022), to adapt the scale for high school students.

3. Findings

3.1. Digital Fluency Levels

The mean digital fluency level of high school students was found to be 3.64, indicating that their overall digital fluency is at a high level. Analyzing the average scores across the sub-dimensions of digital fluency revealed the following: the awareness sub-dimension scored at a moderate level ($\bar{x}$ = 3.39), the self-efficacy sub-dimension scored at a high level ($\bar{x}$ = 4.01), and the affective sub-dimension scored at a moderate level ($\bar{x}$ = 2.97). These results suggest that while students demonstrate a high level of self-efficacy in digital fluency, their awareness and affective dimensions remain at a moderate level.

3.2. Change in Digital Fluency Levels According to Various Variables

The change in students' digital fluency levels according to gender was examined using the independent samples t-test. It was found that the digital fluency scores of male students ($\bar{x}$ = 95.88) were significantly higher than those of female students ($\bar{x}$ = 86.16) ($t_{(696)}$=8.184; p<.05) (Table 3).

Table 3.

Change in digital fluency according to gender

Gender	n	$\bar{X}$	SD	df	t	p
Female	348	86.16	15.865	696	8.184	.000*
Male	350	95.88	15.497			

*: p<.05

To determine whether students' digital fluency significantly differed according to their grade levels, a one-way ANOVA was conducted for independent groups. The analysis showed that students' digital fluency significantly differed according to their grade levels ($F_{(3, 694)} = 4.669$; $p < .05$; $\eta^2 = .019$). According to the Tukey test conducted to determine the source of the difference, a significant difference was found between the digital fluency scores of 10th and 9th graders, favoring the 10th graders (Table 4).

Table 4.

Change in digital fluency according to grade level

Source of variation	Sum of squares	df	Mean squares	F	p	η^2	Direction of difference**
Between groups	3712.533	3	1237.511	4.669	.003*	.019	2 > 1
In groups	183925.571	694	265.022				
Total	187638.105	697					

Note. *: p<.05
**: 1: 9th grade; 2: 10th grade; 3: 11th grade; 4: 12th grade

Whether students' digital fluency significantly differed according to the type of school (Science High School, Anatolian High School, Vocational High School, Social Sciences High School, Imam Hatip High School) was tested using a one-way ANOVA for independent groups. It was determined that students' digital fluency did not significantly differ according to the type of school ($F_{(4, 693)} = .728$; $p > .05$) (Table 5).

Table 5.

Change in digital fluency according to school type

Source of variation	Sum of squares	df	Mean squares	F	p
Between groups	785.568	4	196.392	.728	.573
In groups	186852.537	693	269.628		
Total	187638.105	697			

The Turkish Ministry of National Education identifies gifted students through tests and provides them with after-school education at SaARC centers. To understand whether students' digital fluency differs based on their status as SaARC students, an independent samples t-test analysis was conducted. It was found that there is no significant difference between the digital fluency averages of SaARC students ($\bar{x}$ = 91.95) and non-SaARC students ($\bar{x}$ = 90.95) ($t_{(696)}$ = .460; p > .05). (Table 6).

Table 6.

Change in digital fluency according to studentship at SaARCs

Is participant a SaARC student?	n	x̄	SD	df	t	p
Yes	62	91.95	15.320	696	.460	.646
No	636	90.95	16.518			

To determine whether students' digital fluency differs according to whether their families restrict technology use, a one-way ANOVA was used for independent groups. It was found that the digital fluency of high school students significantly differed based on their families' restrictions on technology use ($F_{(2, 695)} = 3.125$; $p < .05$; $\eta^2 = .0089$). The Tukey test was conducted to determine the source of the difference. It was found that the digital fluency levels of students whose technology use was restricted during the week by their families were significantly higher than those whose technology use was not restricted at all by their families (Table 7).

Table 7.

Change in digital fluency according to the families' restrictions regarding technology use

Source of variation	Sum of squares	Sd	Mean squares	F	p	η^2	Direction of difference**
Between groups	1672.351	2	836.175	3.125	.045*	.0089	2>1
In groups	185965.754	695	267.577				
Total	187638.105	697					

Note. *: p<.05
**: 1: Not restricted at all; 2: Restricted on weekdays; 3: Completely restricted

Whether students' digital fluency differs according to the frequency of internet use was examined using a one-way ANOVA for independent groups. It was found that high school students' digital fluency significantly differed based on the frequency of internet use ($F_{(4, 693)} = 5.115$; $p < .05$; $\eta^2 = .028$). The Tukey test was conducted to determine the source of the difference. It was found that the digital fluency of students who used the internet for 7 hours or more per day was significantly higher than those who used the internet for less than 1 hour, 1-2 hours, 3-4 hours, and 5-6 hours per day (Table 8).

Table 8.

Change in digital fluency according to the frequency of internet use

Source of variation	Sum of squares	df	Mean squares	F	p	η^2	Direction of difference**
Between groups	5380.835	4	1345.209	5.115	.000*	.028	5>1, 5>2, 5>3, 5>4
In groups	182257.269	693	262.998				
Total	187638.105	697					

Note. *: p<.05
**: 1: Less than an hour; 2: 1-2 hours; 3: 3-4 hours; 4: 5-6 hours; 5: 7 hours or more

High school students' digital fluency does not significantly differ according to the frequency of social network use ($F_{(4, 693)} = 1.737$; $p > .05$**)** (Table 9).

Table 9.

Change in digital fluency according to the frequency of social network use

Source of variation	Sum of squares	df	Mean squares	F	p
Between groups	1863.074	4	465/769	1.737	.140*
In groups	185775.030	693	268.074		
Total	187638.105	697			

Note.*:p<.05; Social network usage frequencies: 1: Less than an hour; 2: 1-2 hours; 3: 3-4 hours; 4: 5-6 hours; 5: 7 hours or more

Whether students' digital fluency differs according to their level of programming ability was examined using a one-way ANOVA for independent groups. It was found that high school students' digital fluency significantly differed according to their level of programming ability ($F_{(3, 694)} = 33.555$; $p < .05$; $\eta^2 = .126$). According to the Tukey test results, the digital fluency levels of those who can program at an advanced level were significantly higher than those who do not know how to program and those who are at the beginner level. It was also found that the digital fluency levels of those who can program at an intermediate level were higher than those who do not know how to program. Additionally, the digital fluency levels of those who can program at a beginner level were higher than those who do not know how to program (Table 10).

Table 10.

Change in digital fluency according to the ability of programming

Source of variation	Sum of squares	df	Mean squares	F	p	η^2	Direction of difference**
Between groups	23769.340	3	7923.113	33.555	.000*	.126	3>4, 3>1, 2>4, 1>4
In groups	163868.765	694	236.122				
Total	187638.105	697					

Not.*:p<.05

**:1: Beginner level; 2: Intermediate level; 3: Advanced level; 4: I don't know how to program

Whether students' digital fluency differs according to the devices they use to connect to the internet was examined using a one-way ANOVA for independent groups. It was found that high school students' digital fluency significantly differed based on the devices they use to connect to the internet ($F_{(4, 694)} = 13.435$; $p < .05$; $\eta^2 = .054$). The Tukey test was conducted to determine the source of the difference. It was found that the digital fluency levels of students who connect to the internet using desktop computers were significantly higher than those who use smartphones, laptops, and tablets (Table 11).

Table 11.

Change in digital fluency according to the device used to connect to the internet

Source of variation	Sum of squares	df	Mean squares	F	p	η^2	Direction of difference**
Between groups	10298.862	4	3432.954	13.435	.000*	0.054	3>1, 3>4, 3>2
In groups	177339.242	694	255.532				
Total	187638.105	697					

Note:.*:p<.05

**1: Smartphone; 2: Laptop; 3: Desktop; 4: Tablet

4. Discussion, Conclusion, and Recommendations

The results of the study indicate that the digital fluency levels of high school students are high. In contrast, Demir and Odabaşı's (2022) study measured the digital fluency of teacher candidates at a medium level. This difference may be attributed to the fact that high school students belong to a younger generation that has grown up with more ubiquitous access to digital technologies and social media platforms, making them more accustomed to using these tools in their daily lives. University students, being slightly older, may have had less exposure to advanced technologies during their formative years, which could explain the disparity in digital fluency levels. The research also found that male students had higher digital fluency levels than female students. This finding aligns with other studies in the literature (Demir & Odabaşı, 2022; Wang et al., 2012). It is recommended to implement practices, such as educational activities, to increase women's digital fluency.

The study also found that the digital fluency levels of 10th-grade students were significantly higher than those of 9th-grade students. This may be due to the increase in their experience related to computer science courses from 9th to 10th grade. However, there was no increase in digital fluency for 11th and 12th-grade students, possibly due to the emphasis on university entrance exam subjects, leading to less focus on computer science courses that are not part of the exam.

The research determined that students' digital fluency did not significantly differ according to school types. This finding aligns with Demir and Odabaşı's (2022) study, which similarly found no substantial variation in digital fluency based on school type. However, contrary to these studies, other literature suggests that school type influences digital fluency (Goode, 2010; Li & Ranieri, 2010). One possible explanation for the lack of significant differences in this study could be the increasing availability and standardization of digital technologies across various school types, which may reduce disparities in digital skill development.

There was no significant difference in the digital fluency levels of gifted students enrolled in SaARCs compared to other students. This finding suggests that, while SaARCs provide specialized education for gifted students, their curriculum may not sufficiently emphasize the development of digital fluency as a distinct competency. Although gifted students may excel in other areas prioritized within the SaARCs curriculum, the absence of targeted activities in information technologies could explain why their digital fluency does not significantly differ from that of their peers in regular educational settings. Further quantitative and qualitative studies on digital fluency among SaARCs students are recommended to gain deeper insights and identify strategies for enhancing their digital competencies.

Students whose technology use was restricted by their families during the week had significantly higher digital fluency levels than those whose technology use was not restricted at all. This finding indicates that structured and intentional technology use may contribute to the development of digital fluency by encouraging more focused and goal-oriented interactions with digital tools. This result suggests that limiting technology use during study times leads students to use technology more efficiently and effectively during their free time. Therefore, the time students allocate to technology use should be monitored in collaboration with families and schools to ensure they get the best benefit from the internet. In this context, it is essential for families to monitor technology use.

The study found that high school students who used the internet for 7 hours or more daily had higher digital fluency levels than those with other internet usage frequencies (5-6 hours, 3-4 hours, 1-2 hours, less than 1 hour). This result suggests that extended exposure to online environments may provide more opportunities to develop and practice digital skills, thereby enhancing digital fluency. Nevertheless, it should be noted that using the internet for 7 hours or more daily is concerning. Therefore, it is suggested to research the relationship between digital fluency and cyberloafing, defined as unproductive time spent on the internet (Ugrin et al., 2008).

The digital fluency of high school students did not significantly differ according to the frequency of social network use. This finding contrasts with studies in the literature (English & Duncan-Howell, 2008; Liu et al., 2018). One possible explanation for this discrepancy is that the type and purpose of social network use, rather than the frequency, may play a more critical role in shaping digital fluency. It is recommended that teachers plan activities to increase digital fluency on social networks and integrate these networks into lessons.

Programming skills are an expected competency for students today (ISTE, 2014). In this study, students with advanced programming skills had significantly higher digital fluency levels than those who did not know how to program and those at the beginner level. It was also found that students with intermediate programming skills had higher digital fluency levels than those who did not know how to program. Additionally, students at the beginner level had higher digital fluency levels than those who did not know how to program. The study's results indicate that as programming skills increase, digital fluency also increases. This relationship highlights that programming not only develops technical expertise but also enhances broader digital competencies such as problem-solving, critical thinking, and adaptability. There are studies in the literature supporting this finding, indicating that programming positively affects digital fluency (Bologa et al., 2009; Kim et al., 2013; Resnick et al., 2009). Therefore, students should be encouraged to participate in programming activities both in and out of the educational environment.

The study found that students who accessed the internet via desktop computers had significantly higher digital fluency levels than those who used smartphones, tablets, or laptops. This finding suggests that digital fluency may be inversely proportional to the portability of technological devices. As portability increases, digital fluency levels decrease. One possible explanation for this trend is that desktop computers are often associated with more focused, task-oriented activities, such as programming or content creation, which may contribute to the development of advanced digital skills. Similarly, Wang et al. (2012) found that mobile devices did not contribute to students' digital fluency. However, contrary to this, Bose et al. (2017) observed an increase in the digital fluency levels of engineering students after using tablet computers.

When examining the effect sizes of variables influencing high school students' digital fluency levels, programming ability was found to be the most significant factor ($\eta^2 = .140$). The device used to access the internet was identified as the second most important factor affecting digital fluency ($\eta^2 = .126$). These findings suggest that hands-on technical skills, such as programming, play a pivotal role in developing digital fluency, while the type of device shapes how effectively students engage with digital tools and resources.

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