



# THE EFFECT OF CRITICAL THINKING PRACTICES ON DIGITAL FOOTPRINT

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## Abstract

*Individuals equipped with critical thinking skills are capable of evaluating the consequences of their actions in digital environments and ensuring their personal safety while actively using technology. This study aims to examine the impact of critical thinking practices on reducing the digital footprints of prospective teachers. The research was designed as a quasi-experimental study with a pretest-posttest control group model. The study group consisted of 66 pre-service teachers enrolled in the fourth year of the Social Studies Teacher Education Program in Türkiye during the fall semester of the 2022–2023 academic year. Over a five-week implementation period, the experimental group (n=32) received critical thinking instruction aimed at minimizing digital footprints, while the control group (n=34) continued with the standard curriculum. Data were collected using the “Survey on Higher Education Students’ Use of Digital Media,” a semi-structured interview form, and a peer assessment form, all developed by the researchers. The findings revealed a statistically significant improvement in the experimental group regarding digital footprint reduction. Additionally, data obtained from the peer assessments and interviews supported the quantitative findings, demonstrating the positive impact of critical thinking practices.*

**Keywords:** critical thinking, digital footprint, pre-service teachers, social studies teaching

## Introduction

Significant advancements in science and technology have considerably enhanced individuals’ quality of life. While the active use of technology offers convenience and new opportunities, it has also introduced challenges, particularly related to security and privacy violations (Selwyn, 2010). Among the primary causes of these challenges are the digital footprints individuals leave behind in digital environments. Search histories, Location-Based Service (LBS) records, social media activities, Point-of-Sale (POS) data, and surveillance footage all contribute to digital footprints. These traces are valuable sources of information for governments, corporate entities, employers, and cyberbullies. Today, digital footprints are used by states to ensure national security, by corporations to expand their markets, by employers to screen candidates, and by cyberbullies to perpetrate harassment. However, most individuals remain unaware of their digital footprint and the potential long-term consequences. Thus, it is increasingly essential for individuals to develop competencies that allow them to manage and minimize their digital footprints. Education is considered a crucial tool in achieving this goal.

This raises the question: How should digital footprint education be delivered? It is believed that thinking skills in general, and critical thinking in particular, can play a significant role in reducing digital footprints.

The 21st century, an era when individual aspirations have become globally interconnected, marks a turning point in both technological development and in breaches of security and privacy rights. Epochs such as the “network society” and “information society” have transformed human life through scientific and technological advances, moving much of daily activity into online environments (Castells, 2000; Receptoğlu & Ergün, 2017; Yıldız et al., 2021). As a result, personal information has become increasingly digitized, contributing to the expanding digital footprint of individuals and highlighting the importance of cybersecurity (Weaver & Gahegan, 2007). In such a context, individuals are expected to reflect on their digital actions, question the implications, and produce rational solutions to the problems they encounter online. Critical thinking skills, which involve the use of metacognitive strategies to solve problems and draw logical conclusions, are seen as essential in this process (Facione, 1990; Halpern, 1999).

Scholars widely agree that it is difficult to provide a singular, universally accepted definition of critical thinking (Dinuta, 2015; Masa, 2014). This may stem from its interdisciplinary nature and the varying perspectives of researchers. Dewey (1910) defines critical thinking as “a way of thinking that begins with the identification of a problem, continues with persistent inquiry based on relevant information, and culminates in self-reflection.” Similarly, critical thinking has been described as the cognitive effort to analyze, focus on, and decide upon a course of action (Daud & Husin, 2004; Smith, 2003). Lipman (1988) emphasizes its evaluative dimension, viewing critical thinking as context and criteria-based judgment. Paul (2006) succinctly defines it as “thinking about your thinking while thinking about improving your thinking,” highlighting both its cognitive and metacognitive elements. Ennis (1996) views critical thinking as “reasonable and reflective thinking focused on deciding what to believe or do,” stressing its basis in observation, inference, and reasoning. Likewise, Siegel (1988) emphasizes that critical thinking involves the careful evaluation of beliefs, arguments, and actions.

In applying critical thinking, individuals learn to identify fallacious arguments, unsupported claims, and ambiguous statements, thereby distinguishing truth from misinformation (Burbules & Berk, 1999). The potential of critical thinking to promote questioning and logical reasoning may reduce one’s digital footprint in online environments. Therefore, educational practices that nurture critical thinking are of critical importance (Harrell, 2011; Jones, 2015).

The educational origins of critical thinking can be traced back to Dewey (Ennis, 1991), who equated it with reflective thinking. Dewey regarded it as a catalyst for fostering individuals who are curious, analytical, socially responsible, and committed to universal values. Different educational approaches have emerged for cultivating critical thinking. One involves teaching critical thinking as a stand-alone course. This method, however, has been criticized for its limited scope and time constraints (Wright, 2002). The second, the integrative approach, embeds critical thinking across all subjects. Although it promises comprehensive development, it requires all educators to possess expertise in critical thinking, which presents practical challenges (Kökdemir, 2003; Wright, 2002). Nevertheless, both approaches are considered valuable, and pedagogical strategies such as the Six Thinking Hats, role-play, concept mapping, analogies, case studies, and problem-based learning are known to foster critical thinking (Bonk & Smith, 1998). Therefore, cultivating critical thinking is both possible and necessary across all educational levels and disciplines.

The Foundation for Critical Thinking, established in 1997, has promoted the integration of critical thinking into all levels of education (Eldeleklioğlu & Özkılıç, 2008). This foundation particularly supports higher education institutions in preparing students to be thoughtful and reflective citizens. In many Western universities, critical thinking is considered a core component of academic success (Moore, 2013). It is incorporated into university curricula through

dedicated programs and projects. As such, critical thinking can serve as a vital component of digital footprint education.

We appear to be living in a time when George Orwell's phrase, "Big Brother is watching you," from his novel *1984*, is increasingly relevant. Technological advancements have enabled constant surveillance, mirroring Orwell's dystopia. In many countries, citizens are monitored by governments under the guise of ensuring public safety (EPIC, PI, 2002). Such monitoring is often criticized for infringing on privacy rights. Privacy risks are not limited to government surveillance; technological advancements themselves have created significant vulnerabilities. Cross-referencing databases allow access to individuals' personal data in a matter of hours (Golder & Macy, 2014). For instance, LBS allows individuals to find nearby amenities, but it also raises privacy concerns (Barkhuus, 2004; Taylor, 2003). Similarly, POS systems, while offering convenience, can be used to infer individuals' preferences, behaviors, and even political or religious affiliations (Curry, 1993; Raper et al., 1992). Social media, a major tool for communication and entertainment, has made it even easier to access personal information. As of 2022, 4.62 billion of the world's 7.91 billion people use platforms like Facebook, Twitter, and Instagram (We Are Social, 2022). User profiles often contain full names, birth dates, occupations, hobbies, and photos (Lambiotte & Kosinski, 2014), and they also reveal personal connections and interests. Such databases are valuable to states, employers, and corporations. A single photo posted online can hinder one's job prospects or, in the case of public officials, ignite national debate, such as the controversy surrounding Norwegian Justice Minister Emilie Mehl's swimsuit photos. As Beal (2008) aptly stated, "Google is a reputation engine rather than a search engine."

Digital transformation has deeply embedded technology into our lives, leaving digital traces often referred to as digital footprints (Uzule et al., 2024). These are defined as "information and data that individuals generate through intentional actions or passive interactions in online environments" (Thatcher, 2014). Digital footprints include social media activity, web browsing, emails, Bluetooth pairings, and LBS data (Chen et al., 2017). The Pew Internet and American Life Project categorizes digital footprints as either active (e.g., social media posts and websites created by users) or passive (e.g., data collected via cookies and search histories) (Madden et al., 2007). With technological evolution, the scope and nature of these footprints have broadened, often extending beyond individuals' direct control. For example, others may share a person's information or photos without consent.

Given that digital footprints are expected to grow in tandem with technological advancements, increasing awareness is crucial. Education can help young people understand the long-term consequences of their digital actions and learn how to cultivate a positive digital identity (Van Dijck, 2013). However, most educational systems do not offer dedicated courses on digital footprints. While related concepts are included in digital and media literacy courses, these references are often indirect. A designated course could empower students with the knowledge and skills to create and manage a positive digital identity (Van Ouytsel et al., 2014).

The importance of teaching what digital footprints are, their potential future consequences, and how to manage them cannot be overstated. Critical thinking, essential for autonomous living, lifelong problem solving, and informed decision making, is especially valuable in this context (Gega, 1986). Individuals with strong critical thinking skills are more likely to consider the implications of their online actions and to navigate digital environments safely and responsibly. Therefore, incorporating critical thinking into digital footprint education is essential. Universities, as institutions designed to foster independent and critical thinkers, play a central role. Yet, most lack dedicated courses on digital footprints, instead embedding the concept within science and technology curricula. Whether taught directly or indirectly, education on digital footprints must be supported by classroom activities that nurture critical thinking. As the intellectual hubs of society, universities bear the responsibility of cultivating

awareness of digital footprints. Their mission to develop autonomous, responsible, and globally aware citizens requires that such awareness be integrated into higher education. This calls for a comprehensive educational process, particularly for pre-service social studies teachers, whose training spans multiple disciplines. Such a process should provide opportunities to practice critical thinking, participate in decision making, and find solutions to contemporary digital challenges.

The aim of this study was to examine the impact of critical thinking practices on reducing the digital footprints of pre-service teachers. Specifically, the research seeks to answer the following questions:

1. Is there a statistically significant difference in the digital footprint scores of pre-service social studies teachers who receive instruction through critical thinking practices compared to those in the control group?
2. What are the perceptions of pre-service social studies teachers regarding the use of critical thinking practices to reduce digital footprints?
3. How do pre-service social studies teachers assess each other in relation to the critical thinking practices aimed at reducing digital footprints?

## Research Methodology

### *Background*

The study was designed using a quasi-experimental pretest-posttest control group design. When the objective is to measure variables and determine the relationships between them, a quasi-experimental design incorporating pretest and posttest control groups is recommended (Çepni, 2014; Emaikwu, 2010). This design allows for the identification of experimental and control groups, the implementation of an intervention with the experimental group, and the evaluation of its impact on outcome variables (Creswell, 2021).

In this study, the quasi-experimental pretest-posttest control group design was employed to examine the effect of critical thinking practices on the dependent variable of digital footprint reduction. The experimental and control groups were assigned in an unbiased manner. A pretest was administered to both groups, after which the critical thinking intervention was applied exclusively to the experimental group. Subsequently, a posttest was conducted to assess the differences between the two groups.

To further support the research process, peer assessments were incorporated. Peer assessment is particularly valuable for evaluating group dynamics, as students engage in collaborative learning and communicate with their peers throughout the educational process (Lingard, 2010). Additionally, a semi-structured interview form was utilized to complement the quantitative findings and to gain in-depth, process-based insights from the students in the experimental group.

Thus, this study represents a quasi-experimental design that integrates both quantitative and qualitative methods to comprehensively support the research process and enable holistic data interpretation.

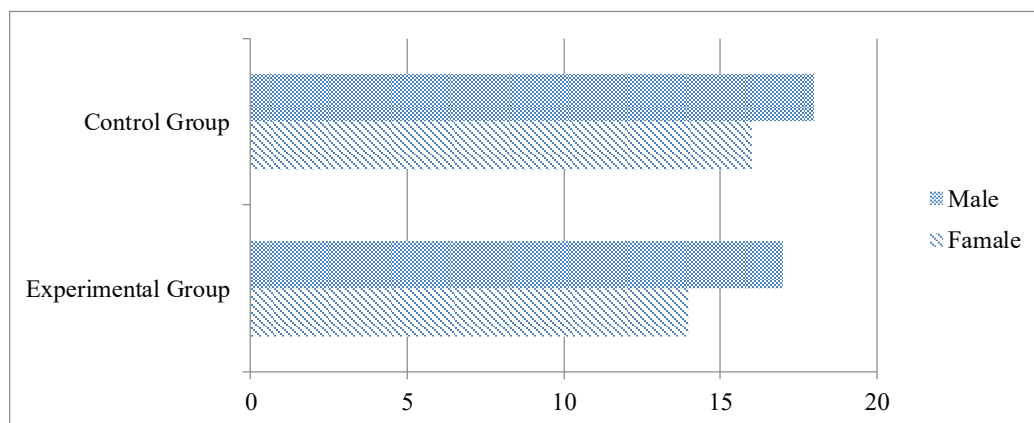
### *Participants*

The convenience sampling method, a type of non-random sampling, was employed to determine the experimental and control groups of the study. In this approach, participants are selected based on accessibility and ease of participation (Frankel, Wallen, & Hyun, 2015). One of the researchers was responsible for teaching the “Media Literacy and Education” course during the 2022–2023 academic year to fourth-year students in the Social Studies Teaching

Department. The study was conducted with the voluntary participation of 32 pre-service teachers in the experimental group (eg) and 34 in the control group (cg).

The digital tools most frequently used by the participants included WhatsApp (eg: 32, cg: 34), Instagram (eg: 30, cg: 31), Spotify (eg: 29, cg: 28), Netflix (eg: 28, cg: 28), YouTube (eg: 32, cg: 34), Adobe Photoshop (eg: 25, cg:21) and Canva (eg: 30, cg: 29). The experimental group received instruction on Wednesdays from 11:00 to 12:30, while the control group attended classes on Thursdays during the same time slot. This scheduling was intended to control for variables such as timing, physical environment, and peer interaction across both groups. Descriptive information regarding the study group is presented in Figure 1.

**Figure 1**  
*Group Participants*



#### *Data Collection Instrument*

In this study, the “Higher Education Students’ Digital Media Usage Survey,” a “Peer Assessment Form,” and a “Semi-Structured Interview Form” were employed as data collection tools.

The “Higher Education Students’ Digital Environment Usage Survey” was developed by Surmelioglu and Seferoglu (2019) to assess university students’ digital footprint awareness and experiences and to offer recommendations for enhancing their awareness. The survey uses a 5-point Likert scale. The “Digital Footprint Awareness” dimension comprises 12 items with a reliability coefficient of .87, while the “Digital Footprint Experience” dimension consists of 16 items with a reliability coefficient of .78. Responses for the awareness dimension range from “Strongly Disagree” to “Strongly Agree,” and for the experience dimension from “Never” to “Always.” In the current study, the reliability coefficient for the “Digital Footprint Awareness” subscale was found to be .96, and for the “Digital Footprint Experience” subscale, .93. The overall reliability coefficient for the instrument in this study was calculated as .91.

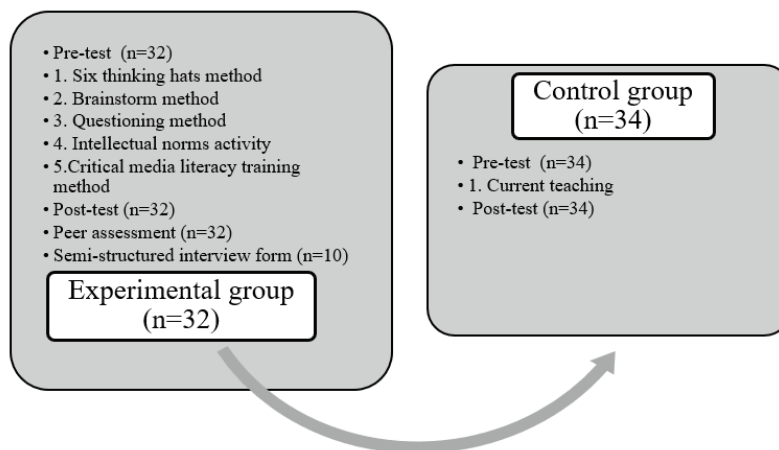
The dimensions of digital footprint awareness and digital footprint experience in this questionnaire are aligned with critical thinking practices such as evaluating one’s own digital footprint and examining overlooked elements like privacy settings. Furthermore, the content of the “Media Literacy and Education” course specifically, topics such as responsible internet and social media use, critical reading of media, and understanding propaganda techniques complement the digital footprint awareness dimension of the scale. Similarly, activities focusing on accessing information online and developing critical perspectives on written, visual, and auditory media support the digital footprint experience dimension in a holistic manner.

**Peer Assessment Form:** This form was designed by the researchers to assess the critical thinking practices of pre-service teachers in the experimental group related to reducing their digital footprints. The form was developed in line with the research objectives and relevant literature, and was revised based on feedback from two experts. The finalized version contains 10 items. Each item is rated as “Insufficient” or “Sufficient.” The form was administered during the final week of the experimental process (week 8).

**Semi-Structured Interview Form:** This qualitative data collection tool was developed to explore students’ perceptions of the intervention following the experimental process. The interview form was reviewed by two experts, one in Turkish education and one in social studies education, and revised accordingly. It includes five open-ended questions and was administered to a randomly selected sample of students from the experimental group in the final week (week 8) to provide deeper insight into the quantitative findings and to explore participants’ perspectives on the process.

*The Process Flow of the Study*

**Figure 2**  
*Flow Chart Showing the Study Process*



The implementation process of the study is detailed below.

**Stage 1:** The pilot study, including the entire process of data collection tools, was conducted within the scope of the “Media Literacy and Education” course. It involved 32 students from a different university, where one of the researchers was teaching the same course at a similar level. This pilot study took place in the first week of October 2022. The main implementation of the study was carried out with 66 pre-service teachers in November and December 2022. In this process, the students in the experimental group were first informed about the main methods used in teaching digital footprint and critical thinking. These methods included the Six Thinking Hats method, Brainstorming method, Questioning method, Intellectual Norms activity, and Critical Media Literacy training method. A pre-test was administered during the last week of November, and a post-test was conducted during the second week of December (week 8) for both the experimental and control groups.

**Stage 2:** During the first two weeks of November, the researchers delivered lectures on the topic of digital footprint within the context of the course objectives and the weekly lesson plan to the experimental group. Additionally, the students were briefed on the critical thinking activities to be implemented and were prepared for these activities. The students were instructed to form four groups, each consisting of eight members, for the following week (week 3).

Stage 3: After the week of briefing on digital footprint and critical thinking activities, the aim was to develop questioning skills to cultivate critical thinking in student groups. To achieve this, within the scope of the weekly topic (Look at Your Digital Footprint), analytical questions were discussed using the questioning method. This was done to identify the main and sub-problems encountered during the process of accessing, analyzing, evaluating, and sharing data in the digital environment.

Stage 4: In order for students to develop a critical attitude toward the information disseminated by the media, questioning skills in critical media literacy education were practiced with the topic of the week (Which Websites Are Safe?).

Stage 5: The weekly topic (What Happens to Old Accounts in Digital Environments?) was addressed through a newspaper article, encouraging students to critically evaluate digital accounts. This activity allowed students to express the core problem using the depth norm study from the Intellectual Norms activities.

Stage 6: The objective was for students to become aware of the visibility of their private information, particularly in social media/online accounts. The topic of the implementation week (Overlooked Settings: Privacy Settings) was discussed using the Six Thinking Hats method, enabling students to consider all possible scenarios collectively.

Stage 7: The aim was for students to reflect on their actions in digital environments, both consciously and unconsciously. The lesson on the weekly topic (Keep My Digital Footprint Hidden) was conducted using the Brainstorming method, prioritizing the generation of a large number of ideas in a non-judgmental, free atmosphere.

Stage 8: At the conclusion of the critical thinking practices aimed at reducing the digital footprint, both the experimental and control group students completed the “Higher Education Students’ Status of Using Digital Media Survey” as a post-test. Additionally, a Peer Assessment Form consisting of 10 statements was completed by the students in the experimental group. A semi-structured interview form was administered to 10 randomly selected students from the experimental group to gather in-depth insights.

### *Context*

The education process in the Social Studies Teacher Education program consists of eight semesters (four years). The courses offered during this education process include pedagogical courses (e.g., Instructional Technologies, Political Science), elective courses in vocational knowledge (e.g., Drama in Education, Museum Education), general culture elective courses (e.g., Human Relations and Communication, Science and Research Ethics), and field education elective courses (e.g., Environmental Education, Information Technologies in Social Studies). Teacher candidates graduate by taking these courses in the relevant semesters (Council of Higher Education, 2018).

The research was conducted during the fall semester of the 2022-2023 academic year, within the scope of the “Media Literacy and Education” course, which is one of the field-specific courses in the program. In the “Media Literacy and Education” course of the Social Studies Teaching Undergraduate Program, teacher candidates are taught about the conscious use of the internet and social media, the power of disseminating information and misinformation, media and perception management, legal rights and responsibilities regarding the media and the internet, copyright, personal rights, information privacy, and the violation of privacy. Students also develop skills to access, analyze, evaluate, and convey messages in various media environments such as television, advertisements, the written press, and the internet. Furthermore, they learn to apply appropriate teaching skills for fostering a critical perspective toward written, visual, and auditory media. The course also covers media’s effects on social, cultural, and economic life, with practical activities such as accessing information on

the internet and critically reading media content and propaganda techniques (Council of Higher Education, 2018).

### Data Analysis

An ANOVA test was used to assess the effectiveness of the experimental procedure in the experimental design with the pre-test and post-test control group.

The qualitative data of the study consisted of a semi-structured interview form and a peer assessment form. The qualitative data obtained were analyzed using the content analysis method. Responses regarding the categories and subcategories were explained in terms of frequency, and the statements of the prospective teachers were presented as direct quotes (e.g., “S1, S2, S3...”). To ensure the reliability of the data, it was analyzed by two different field experts, and the reliability coefficient was calculated as 89% using the reliability formula proposed by Miles and Huberman (1994). Thus, it can be concluded that the qualitative dimension of the study is reliable.

The data obtained from the peer assessment forms were analyzed and interpreted under the categories of “adequate” and “inadequate.” The results were then analyzed in accordance with the research objectives.

### Research Results

The results were obtained by applying the higher education students’ digital environment usage survey to the students as a pre-test and post-test.

#### Higher Education Students’ Status of Using Digital Media Survey

**Table 1**

*The Mean and Standard Deviation Values of the Pretest-Posttest Scores of the Students on Students’ Status of Using Digital Media Survey*

Group	Pre-test			Post-test			Cohen’s d
	N	$\bar{X}$	S	n	$\bar{X}$	S	
Experimental	32	75.62	4.60	32	89.53	14.83	.66
Control	34	71.88	4.40	34	80.63	25.17	

Table 1 shows that the pre-test mean achievement score of the experimental group students is  $M = 75.62$ , while the post-test mean achievement score is  $M = 89.53$ . In comparison, the pre-test mean achievement score of the control group students is  $M = 71.88$ , and the post-test mean achievement score is  $M = 80.63$ . Additionally, Cohen’s d value was calculated as .66, indicating a medium effect size. Based on the statistical data obtained, it can be concluded that the digital footprint size of the experimental group students, who were instructed using critical thinking practices, decreased to a greater extent compared to the control group students, who were instructed using the current teaching methods.

**Table 2**  
*ANOVA Results of Pre-Test and Post-Test Achievement Scores of Students on Students' Status of Using Digital Media Survey*

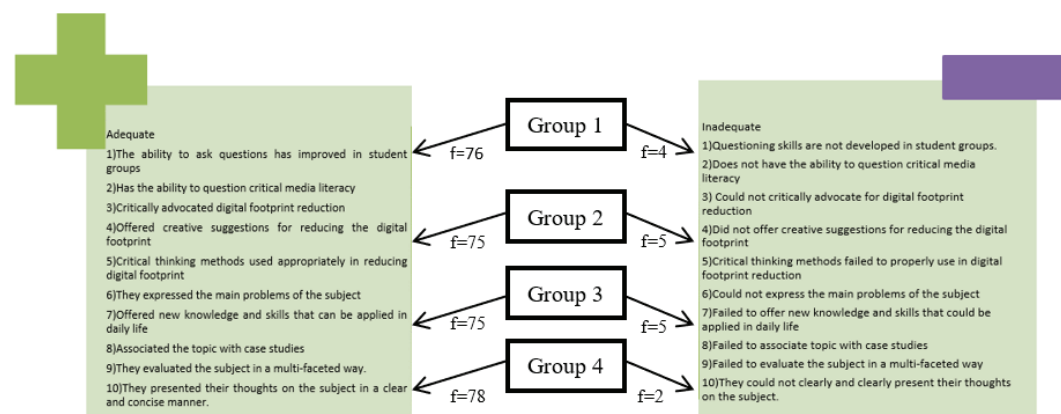
Source of variation	KT	SD	KO	F	p
Between groups	26,989,886	65			
Group (Experimental/Control)	694,909	1	1073,052	1,691	.0001
Error	26294,977	64	475,468		
Within groups	369,920	66			
Measurement (Pre-test-post-test)	1073,052	1	1073,052	58,378	.0001
Group*Measurement	1073,052	1	1073,052	58,378	.0001
Error	2146,104	64	8,168		
Total	36994,699	129			

When Table 2 is examined, a significant difference is found between the pre-test and post-test total scores of the experimental and control group students  $F_{(1-64)} = .691; p < .05$ . A significant difference is also observed between the students' pre-test and post-test mean scores for digital footprint awareness  $[F_{(1-64)} = .378; p < .05]$ . The common effects of repeated measures (pre-test and post-test) on the digital footprint scores of the students are significant due to being in different treatment groups (experimental-control)  $[F_{(1-48)} = 58.378; p < .05]$ . Based on these findings, it is evident that critical thinking practices directly influence students' digital footprint scores and are effective in reducing their digital footprints.

### Results Regarding the Peer Assessment Form

Results were obtained from the peer assessment form given to the students in order to get peer opinions on their experiences in the implementation process.

**Figure 3**  
*Comparison of the Students' Experiences Regarding the Implementation process as Adequate and Inadequate as Expressed in the Peer Assessment Forms*



The opinions of four groups of eight students (a total of 80 opinions) were compared based on the criteria of being “adequate” or “inadequate” in relation to the peer assessment form. The majority of the students in the groups assessed their peers as adequate throughout the application process. However, it is observed that some students in each group assessed their peers as inadequate during the process.

The peer assessment form consists of 10 criteria in total. The frequency (total of 80 opinions) of each criterion, assessed as “adequate” or “inadequate,” was examined separately. When the frequency values of the 10 criteria were analyzed, the criteria for which students most frequently assessed their peers as “adequate” and had the highest frequency ( $f$ ) were: “questioning skill regarding critical media literacy ( $f = 50$ ),” “critically advocated digital footprint reduction ( $f = 52$ ),” and “appropriately used critical thinking methods in reducing the digital footprint ( $f = 55$ ).” The criteria for which students evaluated their peers as “inadequate” and had the lowest frequencies were: “could not associate the subject with case studies ( $f = 4$ ),” “could not present thoughts on the subject clearly and unequivocally ( $f = 3$ ),” “could not identify the main problems of the subject ( $f = 5$ ),” and “questioning skills were not developed in student groups ( $f = 4$ ).”

The peer assessment forms indicate that the experimental group students developed adequate critical thinking skills, such as questioning, multidimensional thinking, and asking analytical questions, through critical thinking practices aimed at reducing their digital footprints.

#### *Results Regarding the Semi-Structured Interview Form*

As a result of the semi-structured interviews, the students’ opinions were categorized into five main themes: (“the impact of the applications on students,” “the impact of the applications on reducing the digital footprint of students,” “the students’ approaches to media tools after the application,” “the impact of the applications on the development of students’ critical thinking skills,” and “the impact of the students on their relationship with the applications used while engaging in digital environments in their daily lives”). Opinions in these categories were grouped according to their frequency ( $f$ ). A student’s opinion may be included under multiple categories.

**Impact of the Applications on Students:** When examining the effects of the applications on students, the majority of students expressed positive opinions about the application ( $f = 9$ ). These positive views were associated with four subcategories: decision-making ( $f = 9$ ), research skills ( $f = 7$ ), developing different perspectives ( $f = 11$ ), and problem-solving ( $f = 6$ ). The subcategory most frequently mentioned was the development of different perspectives ( $f = 11$ ). Regarding this, S5 commented, “It showed that it is important to approach problems, events, and situations from different perspectives.” Concerning decision-making, S3 noted, “Before making a decision on a subject, it is necessary for me to make inquiries and access information or data on the subject to make the right decisions.” Regarding research skills, S8 stated, “It allowed me to conduct research on the cause-effect relationship with all its dimensions by approaching the situation or problems holistically.” On problem-solving, S4 said, “It showed that there can be more than one solution to a problem and that thinking about my own solution is one of the most correct ways of solving problems.”

**Impact of the Applications on Reducing the Digital Footprint:** When asked about the effect of the practices on reducing digital footprints, the opinions expressed by students were categorized into four subcategories. The most commonly expressed view was that the practices provided “awareness raising” ( $f = 8$ ). S9 expressed this as: “It created an awareness about what I need to do to reduce my digital footprint.” Following this, “acquiring information” ( $f = 7$ ), “multidimensional thinking” ( $f = 4$ ), and “gaining inquiry skills” ( $f = 3$ ) were also mentioned. Regarding acquiring information, S1 stated, “It showed that everyone in this world leaves a

digital footprint consciously or unconsciously, and these traces can have direct or indirect effects on our social and economic life.” S3 explained multidimensional thinking, stating, “It made me think about how I can shrink my digital footprint and what kind of results the digital footprint in the digital environment might have.” Finally, on gaining inquiry skills, S5 said, “It awakened an awareness in me that people should question all their actions in the digital environment.”

**Impact of the Applications on Students’ Approaches to Media Tools:** When examining the effects of the applications on students’ approaches to media tools, the majority of students expressed that the application led to “questioning the reasons why media messages are created” ( $f = 10$ ). S9 remarked, “I now make effective decisions by making comments because media messages interest me.” Some students indicated that the applications also made them more focused on “thinking about the striking elements in media messages” ( $f = 6$ ) and “questioning the purpose of using media” ( $f = 4$ ). S1 stated, “Now I question why I laugh at the messages and why the messages attract my attention.”

**Impact of the Applications on the Development of Critical Thinking Skills:** Regarding the effects on students’ critical thinking skills, positive views were categorized under three subcategories. The most common view was that the practices provided “creating a new approach” ( $f = 7$ ). S5 commented, “All practices contributed positively to our critical thinking skills, as they enabled us to approach the subject with a critical perspective and showed that we could reach the right information through questioning.” This was followed by “acquiring effective thinking skills” ( $f = 6$ ) and “acquiring an evaluation process” ( $f = 3$ ). Regarding the acquisition of effective thinking skills, S4 said, “As the practices led us to be mentally active in both problem-solving and accessing information, they positively influenced our critical thinking skills.” S3, regarding multidimensional thinking, stated, “It made me think about how I can shrink my digital footprint and what kind of results the digital footprint in the digital environment might have.” Finally, on acquiring an evaluation process, S8 explained, “We had the opportunity to review and evaluate both our friends’ and our own ideas, especially when using the brainstorming and questioning methods.”

**Impact of the Applications on Students’ Relationships with Digital Tools in Daily Life:** The final category focused on the effects of practices on students’ connections to digital tools in their daily lives. A commonly agreed-upon subcategory was “updating security settings in digital environments” ( $f = 9$ ). S6 remarked, “I strengthened my password to increase the security of the mobile banking application on my phone, and I deleted some of my Twitter posts.” S8 added, “After these applications, I organized my images and family photos on my social media so that only my friends could see them.” Another subcategory was “reducing the footprint in digital environments” ( $f = 6$ ). S1 commented, “I started to be more careful while downloading things on the Internet. I did not enter my personal information in every application, and I did not comment on social media.” Lastly, in the subcategory “informing others about digital footprints” ( $f = 3$ ), S4 said, “I also explained digital footprints to my family members.”

## Discussion

The main objective of this research is to determine the effect of critical thinking and related practices on reducing the digital footprint of prospective teachers. The study was informed by Lynn Thompson’s (2012) assertion that “the footprints of the individual in the digital environment can be associated with the thinking and questioning skills of the individual.” Critical thinking-based practices were applied with the experimental group to reduce the digital footprint. These findings form the quantitative results of the research and reveal significant outcomes. It was determined that the experimental group, which underwent critical thinking-based practices, differed from the control group, with the digital footprints of the experimental group students being reduced to a greater extent than those of the control group students who

received conventional teaching. Furthermore, the emergence of a significant difference in favor of the post-test digital footprint scores for the experimental group serves as an important indicator that the critical thinking-based practices employed in the process were effective in reducing the digital footprint. The results obtained in this study are important in terms of demonstrating the effect of critical thinking on an individual's re-evaluation and review of the traces left by their activities in the digital world. This is because critical thinking is grounded in the effort to analyze the accuracy of outcomes and the process of mental filtering by examining various situations, events, or phenomena to reach valid conclusions (Halpern, 1996). When an individual initiates a mental process regarding the accuracy and consequences of their actions in the digital environment, they employ these skills. In other words, the critical thinking process begins within the individual. Open-mindedness, inquisitiveness, systematicity, analyticity, truth-seeking, self-confidence, and maturity dispositions associated with critical thinking also support this process (Facione et al., 1995). Individuals with critical thinking skills possess a distinctive character rather than specific skills. This character is based on seeking reasons, making judgments, and justifying one's actions with sound arguments, while rejecting partiality and arbitrariness (Siegel, 1990). In this context, an individual's ability to think critically and their effective use of these skills are vital for accurately evaluating the results of their digital footprint. The development of digital footprint technology, particularly in teacher education, will contribute to an effective educational environment that fosters professional skills and competencies, facilitates critical thinking, and expands the range of competencies (Pozdeeva et al., 2021).

The results obtained from the peer assessment form are noteworthy. A significant number of the pre-service teachers assessed their peers as having acquired a satisfactory level of critical thinking skills, such as questioning, multidimensional thinking, and asking questions in relation to reducing the digital footprint. Additionally, some pre-service teachers evaluated their peers as inadequate in criteria such as supporting their ideas with case studies, expressing their thoughts clearly and precisely, and stating the problem. These results can be attributed to the practices that enable individuals to acquire effective thinking skills and apply them in the digital world. Effective thinking skills, which are based on pre-service teachers' awareness of problems they currently face and those they may encounter in the future in the digital world, and their potential solutions, are a subcomponent of critical thinking. The skill that enables the acquisition of this awareness is critical thinking, which prioritizes questioning and research-based participation (Kuhn, 1999). This characteristic allows individuals to create an understanding process by questioning in every environment they participate in, both in the real and digital domains, while reducing the risk of their impact on the environment in the future. In the context of reducing the digital footprint, critical thinking is especially effective in finding answers to a question or problem situation (Ulu Aslan & Baş, 2022). Furthermore, pre-service teachers emphasized in the peer assessments that creative suggestions and critical thinking methods are effective in minimizing digital footprints. This outcome can be considered expected, as critical thinking involves not accepting the views expressed on any subject at face value, but instead examining and evaluating the process in which the individual is involved and creating a new perspective and route for themselves (Thomas & Lok, 2015). Critical thinking can be defined as the ability to question, verify, and evaluate thoughtfully before making decisions about a phenomenon (Ennis, 1989). This form of thinking can be effective in raising awareness of digital footprints and reducing them. Indeed, critical thinking requires individuals to possess various skills and metacognitive abilities, such as analysis, synthesis, comparison, and evaluation (Garside, 1996).

The results of the research indicate that the applications made a significant difference in the post-test data in favor of the experimental group, showing the impact of these applications on reducing the digital footprint of teacher candidates. The semi-structured interviews conducted to clarify this effect provided qualitative findings that support the quantitative data. As a result,

it was determined that the practices based on critical thinking had a positive impact on reducing the digital footprint. These positive effects occur when critical thinking enables the individual to enhance the quality of their thinking skills by masterfully managing the structures within their thought system and imposing intellectual standards on these structures (Kurfiss, 1988). Critical thinking also plays a vital role in logical thinking, decision-making, and finding solutions to certain problems (Liu et al., 2014, p. 1). It offers opportunities to describe forms of cognition, analysis, and learning beyond mere memorization and recall of facts and information (Alhowail & Albaqami, 2024). The responses from the interview form are significant as critical thinking skills effectively increase digital footprint awareness through related aspects. Additionally, the research highlights the importance of awareness-raising activities at an early age concerning digital footprint awareness (Soylu et al., 2020).

The positive views and statements of the prospective teachers regarding the practices were positively reflected in the holistic evaluation of the research results. These findings, while supporting the quantitative data, reveal important insights into the awareness that critical thinking skills create in prospective teachers when interacting in digital environments. Indeed, critical thinking skills and practices emphasized in the context of 21st-century skills contribute to individuals' effective coping with "social, scientific, and practical problems" (Shakirova, 2007; Demirbaş et al., 2023). Self-awareness and environmental awareness, two of the most important features of critical thinking, are based on the self-direction and self-discipline of the individual in both real and digital environments, reviewing and verifying results (Paul & Elder, 2006). Thanks to this aspect of critical thinking, the desire to participate in interactions in the digital environment through digital tools is controlled by individuals, and the process is constantly questioned and re-evaluated. Furthermore, the fact that the students in the experimental group expressed the idea of "questioning the reasons for creating media messages" can be considered evidence of the effect of the inquiry-based approach of critical thinking on the pre-service teachers in the experimental group. Indeed, critical thinking involves identifying questions worth investigating, seeking knowledge by directing one's own efforts, pursuing problems through questioning, and providing evidence to support one's arguments (Pithers & Soden, 2000). The statement in the subcategory of "updating security settings in digital environments" reflects the prospective teachers' awareness of taking necessary precautions against the traces left by individuals in the environments they interact with in the digital world. This reference is an example of the reflection of critical thinking on information, thought, and practical literacy in daily life (Grafstein, 2017).

## Conclusions and Suggestions

Branding the 21st century as a digital age directs individuals, especially the younger generation, toward the digital environment. Individuals leave traces in the digital environments they use, whether they are aware of it or not, and they cannot foresee the consequences it may bring. The focus of this study revealed that critical thinking practices had positive effects on reducing the digital footprints of pre-service teachers. In this context, several recommendations are presented below:

The effects of the digital world and participation in this world should be conveyed to pre-service teachers in a practical manner, considering the past, present, and future, in order to increase their awareness and attention levels.

The proficiency of pre-service teachers, who are the future educators, in methods that support critical thinking for reducing and managing digital footprints should be enhanced.

Scientific studies (e.g., articles, papers, books) focusing on the individual and societal effects of the digital world, while employing critical thinking and critical thinking practices, should be integrated into the academic community.

Critical thinking skills aimed at reducing digital footprints can be applied not only in the Media Literacy and Education course but also in other courses across the curriculum.

## Declaration of Interest

The authors declare no competing interest.

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