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The Impact of a Mobile Phone and Mobile Application-Supported Science Laboratory on the Digital Literacy of Preservice Teachers and Their Disposition Toward Using Technology in Class

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Abstract

Science education at different levels can be supported by various mobile applications that can be downloaded for free onto mobile phones, tablets, and other devices. Such applications can also be used in laboratory work, but it must be said that their use in science laboratories is a relatively new approach. This study is aimed at determining the impact of mobile phone and mobile application-supported laboratory work on the digital literacy of preservice science teachers and on their disposition toward using technology in class. The study was carried out with 17 participants at the second-year level of a Science Teacher Education Program in Turkey. It was a single-group pretest-posttest study, representing a type of weak experimental research design. Data for the study were collected with the *Digital Literacy Scale* developed by Hamutoğlu et al. (Ege Journal of Education 18(1):408–429, 2017) and the *Disposition toward Using Technology in the Classroom Scale* developed by Gunuc and Kuzu (Journal of Theory and Practice in Education 10(4):863–884, 2014). The data collection tools were implemented prior to and following a 6-week teaching period, and the quantitative data compiled from the participants were analyzed with the SPSS 21.0 program. The parametric *t*-test of related samples was used in the pretest/posttest comparison of the data sets. The results of the study demonstrated that science laboratory activities supported by mobile phones and mobile applications provided preservice teachers with increased digital literacy and enhanced their disposition toward using technology in the classroom. It is recommended that preservice teachers make extensive use of experiments supported by the mobile applications in this study.

Keywords Mobile phone · Science laboratory · Experiment · Mobile technologies

Introduction

Laboratory experiments are widely used in science education and constitute one of the most important teaching techniques in this field (Lowe et al., 2013). The main advantages to this approach are ensuring that the knowledge to be transmitted is more comprehensible to the student, that knowledge can be retained and transferred in any situation, and that positive attitudes towards learning can be developed (Aladejana & Aderibigbe, 2007). Laboratory experiments are conducted using various techniques. Methods that can be cited in this context are traditional closed-ended experiments carried out step-by-step and open-ended inquiry-based experiments (Wilcox & Lewandowski, 2016). Another method is to ask students to perform an experiment, in small groups or individually, and present a demonstration of the experiment in front of as large an audience as possible (Antonio, 2018). Teachers make the decision as to which method to employ according to conditions in the classroom and the students' level of gained knowledge. The problems that arise from having limited time to allot to experimentation or to perform experiments as frequently as might be desired and in some cases, the complete impossibility of performing experiments have led researchers to seek new and effective approaches to teaching in the laboratory (Domínguez Alfaro et al., 2022). This is why technological advances that have impacted so many areas in today's world have been integrated into science education and laboratory applications. It is in this context that many devices—from mobile phone sensors to tablets and computers—and many tools, from augmented reality to Web 2.0 are now being used in the science laboratory.

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Using Mobile Technologies to Support the Science Laboratory: Mobile Phones and Mobile Applications

Relatively new technologies that allow portable devices (like mobile phones and tablets) to accommodate actions in daily life such as taking pictures and videos, taking notes, playing games, and listening to music are defined as mobile technologies (Nikolopoulou & Kousloglou, 2019). Mobile phones, tablets, and laptop computers are among the available mobile devices (Abd Samad et al., 2020). When these tools are adopted to education to support the learning and teaching process through the use of mobile technology, this is defined as mobile learning, or m-learning (Sin, 2020). Mobile learning provides many advantages for science education, a fact that is also reflected in its effectiveness in the laboratory setting. Laboratory practices enhanced with the use of devices and applications are free of the time and space limitations that are placed on learning in the traditional laboratory (Wisman & Forinash, 2011). At the same time, they provide the opportunity to avoid investing in the expensive equipment and the specialized personnel needed for some of the experiments performed in the classic laboratory (Li et al., 2023). Additionally, laboratory practices supported by mobile technologies stimulate an increased interest in the material taught, supporting learning and also facilitating the task of drawing and interpreting graphs (Carreño et al., 2022).

It can be said that mobile phones are among the devices that are the most widely used for adding mobile technologies to science education and laboratory practices. Indeed, the camera feature of mobile phones, their connectivity to the Internet, and their use of different types of sensors have allowed the effective use of these devices in science education (Ürek & Çoramık, 2023). Mobile phones can generally be used in the learning process for scanning information, the exchange of information, communicating lesson contents, and data-saving while also functioning as vehicles of cognitive learning (Kuhn & Vogt, 2013). Performing experiments with mobile phones is an activity that students can take part in conveniently in their familiarity with their own devices, which hold an important place in their lives, all with the added attraction of being able to carry out experiments outside of the classroom as well (Hochberg et al., 2018). For example, in learning about the circulatory system, students can use various applications on their mobile phones to measure the pulse rate and transfer this data onto the medium of the computer. Furthermore, measurements taken at rest and during rapid activity can be compared. In the present study, the mobile technologies Phyphox, augmented reality, and laboratory applications were used to support the work in the science laboratory.

Phyphox

Phyphox is a cost-free application that students can easily use on their own mobile phones or tablets to perform experiments, giving them the opportunity to collect and analyze digital data (Staacks et al., 2022). This application uses mobile phone sensors to make mathematical calculations of collected data, presenting this in a visual format (Stampfer et al., 2020). Phyphox provides a general means of performing experiments on topics in the physics classroom. It has the capacity to generate tones at different frequencies from some easily obtainable measurements, to determine the coordinates of our specific location, and register atmospheric pressure, light intensity, the inclination angles of a telephone, or the period of a pendulum.

A look into the field literature shows that there are studies in which Phyphox has been used in science experiments to explore the topics of simple pendulum periods (Nanto et al., 2022; Ürek & Çoramık, 2023), kinematics (Pierratos & Polatoglou, 2020), and the kinetic friction coefficient (Çoramık & Ürek, 2021). These studies are new and limited, but it is striking to see that they are steadily becoming more widely used in the physics laboratory.

Augmented Reality

Augmented reality constitutes a part of digital reality technologies and is used in different areas such as medicine, architecture, and art as well as in science education. The technology of augmented reality brings virtual objects into real-time, creating a sense of reality (Carmigniani et al., 2011). While augmented reality can be thought to be the same as virtual reality, the concept differs from virtual reality in that it offers users the opportunity to experience a real world that is enhanced with virtual content (Kerawalla et al., 2006). This technology is used in various applications that can be downloaded for a fee or free of charge onto a tablet or a mobile phone. Also, when real educational materials can be viewed with the help of a mobile phone or tablet camera, learners have the opportunity to make a detailed exploration of the content appearing on their phone or tablet screens. Thus, the technology of augmented reality can be used not only in the classroom but also in informal settings (Kozcu Cakir et al., 2021).

In reviewing the literature, it can be seen that there are studies that have integrated augmented reality technology into chemistry (da Silva et al., 2019; Domínguez Alfaro et al., 2022; Karnishyna et al., 2022; Plunkett, 2019), physics (Akçayır et al., 2016; Thees et al., 2020), and biology laboratories (Celik et al., 2020; Kozcu Cakir et al., 2021). The instruments implemented in these studies have used the technology of augmented reality to offer students two- or three-dimensional presentations designed to support their traditional learning (Thees et al., 2020).

Mobile Laboratory Applications

There are a series of mobile applications for science learning, of which some are designed to allow for the experience of performing a laboratory experiment. In this study, the term *mobile laboratory* was used for such applications. Mobile laboratory applications, as mentioned before, are applications that students can download onto their mobile phones, tablets, or other mobile devices for performing experiments that may or may not be able to be undertaken in the laboratory (Wisman & Forinash, 2011). Lellis-Santos and Abdulkader (2020) have categorized types of mobile laboratories under three headings: simulators, built-in, and plug-in. According to this classification, simulators are programmed with algorithms that will make experimentation possible, while built-in apps are designed to collect and process data. Plug-in apps, on the other hand, need a connection by way of an external device containing a sensor or via Bluetooth.

A look into different mobile laboratory applications in various topics reveals that some examples of mobile applications for the chemistry laboratory are BEAKER-Mix Chemicals, Chemistry Lab-ChemEx 3D, BEAKER by THIX, Toca Lab: Elements, and Unreal Chemist-Chemistry Lab (Ayyıldız & Karabulut, 2022). Sin (2020) developed the ChemEx application to be used in the topics of chemistry lab equipment safety, molar concentrations, and dilution. Additionally, it is observed that applications designed for the physics laboratory use the Tracker program to make an analysis of videos produced (Aththibby et al., 2021; Çoramık & Ürek, 2021; Ürek et al., 2021). Rochadel et al. (2013) have also reported in their study on using the RExMobile application for physics experiments. An example of mobile applications that can be used in the biology laboratory is the Plan+Net app that allows learners to identify plants captured in a photo (Stepanyuk et al., 2020). It is also noted that mobile laboratory applications are used in biotechnology (Kumar et al., 2015) and histology/anatomy courses (Ostrin & Dushenkov, 2016).

The common characteristic of all of the mobile applications mentioned above is their capability of allowing students to perform various experiments not only in the formal classroom setting but conveniently in their own homes or during a distance learning period, also having the opportunity to repeat the experiment whenever they wish to do so. It can therefore be said that these applications support learning and increase motivation.

Disposition Toward Using Technology in the Classroom and Digital Literacy

The new technologies referred to above require that our teachers follow up on such innovations and acquire the knowledge and skills to make use of them in the classroom so that they can be employed at optimum effectiveness in science education. A disadvantage that is cited with respect to mobile tools is that they can create demoralization among teachers (Carreño et al., 2022). This underlines the importance of including these tools in the preservice education of science teachers, thus ensuring that prospective teachers are appropriately equipped to work with the applications. Introducing preservice science teachers to the use of technology in the classroom can have a positive effect on their disposition toward including technology in their teaching.

The immense volume and variety of the data available today have made the use of digital tools inevitable (Koltay, 2011). This development has caused the concept of *digital literacy* to enter the vocabulary of the field literature. In essence, the foundations of the concept of digital literacy were established in the 1980s when the concept of computer literacy was introduced and therefore it is not an entirely novel idea (Buckingham, 2016). At the same time, the concept is closely associated with the notions of information and media literacy and is seen to be used interchangeably with these terms (Park et al., 2021). The concept of digital literacy in the field literature does not refer to a series of tools or technologies but rather is described as the skills an individual needs to acquire in order to thrive in the twenty-first century (Marty et al., 2013). In other words, the term digital literacy encompasses the skills of critical thinking and problem-solving needed in effectively solving the problems that can emerge in a technologically enriched environment (Onursoy, 2018). It is these skills that are among those required in today's world for all young people starting out on their careers and constitute the skills that preservice teachers must acquire in their education.

A look into the results reported in the literature reveals that some preservice teachers and university students have high levels (Ocak & Karakuş, 2019; Prachagool et al., 2022), moderate levels (Hairida et al., 2023; Ilhami et al., 2021; Tyger, 2011; Yontar, 2019), or unsatisfactory levels (Onursoy, 2018) of digital literacy. Shopova (2014) reports various strengths and weaknesses of university students in terms of their digital literacy skills. Furthermore, there are studies that have assessed digital literacy skills in terms of gender differentiation. Some researchers have compared male and female preservice (Ocak & Karakuş, 2019) and staff teachers in terms of their digital literacy and found no difference between the genders in this respect (Hairida et al., 2023). Some other studies, however, demonstrate a significant difference between the genders in favor of male participants (Aslan, 2021; Ata & Yıldırım, 2019; Yontar, 2019). It has also been asserted that the particular department a student is enrolled in (Aslan, 2021; Ata & Yıldırım, 2019; Ocak & Karakuş, 2019) and owning a computer are factors that impact digital literacy (Aslan, 2021; Ata & Yıldırım, 2019; Ocak & Karakuş, 2019). These results lead to the suggestion that university students display differences in digital literacy and that there is a need for studies geared to develop these skills.

Purpose and Significance of the Research

The research is aimed at providing preservice science teachers with the opportunity to perform science experiments with the help of various mobile applications that can be downloaded to their mobile phones. Another aim in this context was to explore the effect of this kind of experimentation on their digital literacy as well as their disposition to use technology in class.

The study focuses on including mobile technologies in the curriculum prepared for science teacher education. It can be seen that studies tend to concentrate on the use of these types of applications in certain areas such as in the chemistry laboratory (Li et al., 2023) or physics laboratory (Carreño et al., 2022; Çoramık & Ürek, 2021). The present study, however, was designed to provide preservice science teachers with the use of different mobile applications in the fields of physics, chemistry, and biology in their future teaching experiences. The objective therefore has been to explore how current technological applications can be used in experimental studies in science laboratories. At the same time, it is striking to note that studies in which these types of technologies are used call attention to the need to form associations with twenty-first-century skills (Abd Samad et al., 2020). The present study thus assesses digital literacy skills and explores the tendency to use technology in class. The experiments performed in the study will provide an addition to the literature in an effort to encourage other researchers and teachers to conduct similar experiments.

The Research Questions

The research questions posed for this study are the following:

1. Do mobile phones and mobile application-supported science laboratories have a significant impact on the digital literacy of preservice science teachers?
2. Do mobile phones and mobile application-supported science laboratories have a significant impact on the disposition of preservice science teachers toward using technology in class?

Method

Study Design

This study employed a single group and a pretest and posttest and was of weak experimental design. This type of design does not include randomly assigned matched groups but rather the process is tested on a single group (Büyüköztürk et al., 2010). The study explored the impact of mobile phone and mobile application-supported science laboratories on the digital literacy of preservice science teachers and their disposition toward making use of technology in the classroom. Measurements taken in the form of a pre- and posttest for the variables studied were compared to assess the effectiveness of laboratory work.

Sample

The study sample comprised 17 s-year students enrolled in the Science Teacher Education program of a state university located in western Turkey. The sample was made up of 6 male and 11 female preservice teachers. The convenience sampling approach was employed in the selection of the sample group. This enabled a more economic use of energy, time, and cost for the researcher in the study process (Yıldırım & Şimşek, 2018). All preservice teachers were in the third semester of their education program and taking the Science Education electives of Laboratory Practices and Experimental Design.

Data Collection Instruments

Two different quantitative data collection instruments were used in the study. The first, the Digital Literacy Scale, which was originally developed by Ng (2012), was adapted into the Turkish language by Hamutoğlu et al. (2017). This scale contains 17 items and is in the 5-point Likert format. The items on the scale are arranged under four factors pertaining to the following dimensions: attitude, technical, cognitive, and social. None of the items are reversely scored; the researchers calculated the Cronbach's alpha coefficient as 0.93 (Hamutoğlu et al., 2017). In the present study, Cronbach's alpha coefficient was found to be 0.929 on the pretest and 0.928 on the posttest.

The other data collection instrument used in the study was the Disposition toward Using Technology in the Classroom Scale which was developed by Gunuc and Kuzu (2014). This scale comprises 16 items collected under the two subfactors of disposition: emotional and behavioral. It is a 5-point Likert-type of scale. There are no reversely scored items. The researchers calculated the Cronbach's alpha coefficient to be 0.93 (Gunuc & Kuzu, 2014). In the present study, a value of 0.949 was found for the pretest and 0.950 for the posttest. With these values proving to be more than 0.70, the data analysis can be said to be reliable (Büyüköztürk, 2010).

The Study Process

The study process began with the pretests of the data collection tools. Then, the researcher conducted a 6-week course of two classes a week. This program involved the face-to-face participation of the preservice teachers in an actual laboratory setting. The first 3 weeks of the program were based mostly on theoretical instruction, which included the participation of the preservice teachers in basic experimental practices from time to time. The remaining 3 weeks were devoted to the experiments the preservice teachers carried out together in groups. The procedures can be described as follows:

- Week 1: Introductions, a general introduction to the laboratory, rules to follow
- Week 2: Introduction to the laboratory equipment
- Week 3: General first aid rules and safety precautions in the laboratory
- Week 4: The biology laboratory equipped with augmented reality cards: Cells (AR Science Cards) and the systems in our body (Our Body 4D)
- Week 5: The Unreal Chemist application along with chemistry experiments: Chemical reactions
- Week 6: Physics experiments with Phyphox: Taking measurements for different physical quantifications

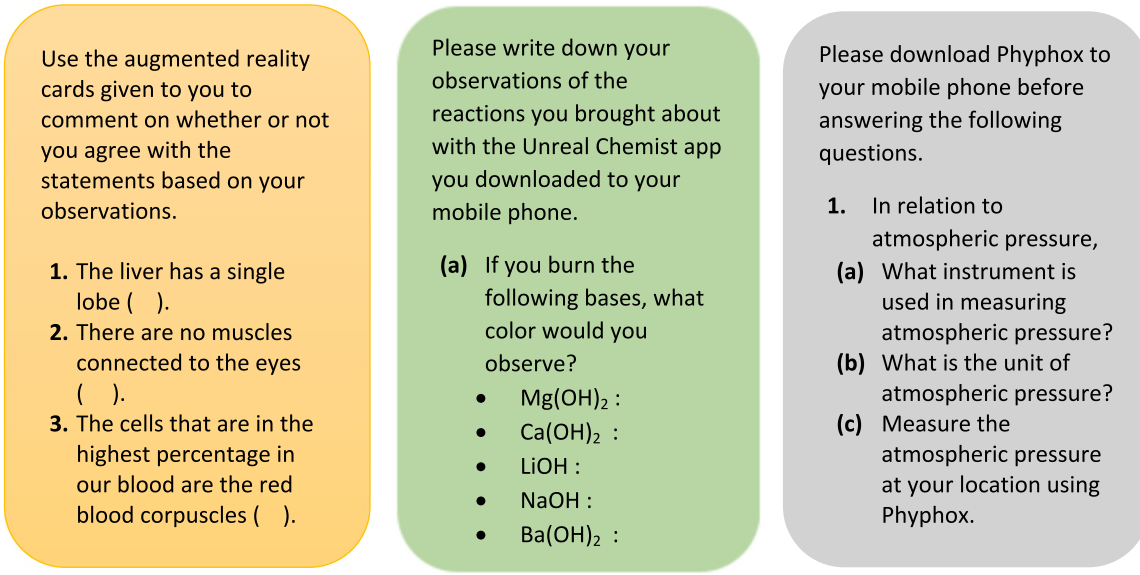
As mentioned above, the experiments carried out in the study focused on topics in biology, chemistry, and physics. Each week, the preservice teachers were asked to download to their mobile phones the mobile application that related to the experiment they would be carrying out. Care was given to ensure that the applications were free of charge and easily downloadable. Then, the students were furnished with an explanation as to how they were to use the application. The mobile applications used in the study can be seen in Fig. 1.

Besides engaging in the experiments, the student groups were given worksheets prepared by the researcher to fill out over the course of the experimentation. The experiments included an examination of the structure of our body systems and their organs, enhanced by augmented reality in the Our Body 4D app that the students worked with in week 4. The students also made observations of cells and organelles with the help of the AR Science cards. Using the Unreal Chemist app in week 5, the students were asked to experiment with various chemical reactions, after which they made observations of the changes and products that were the results of these reactions. In week 6, using the Phyphox app, the students were asked to determine their locations and take quantitative measurements of magnetic fields, atmospheric pressure, and light and sound intensity. These quantitative findings were expressed in their respective units. Sections of the worksheets used in the experimentation can be seen in Fig 2.

Our Body 4D **AR Science Cards** **The Unreal Chemist** **Phyphox**

(a) Week 4 **(b) Week 5** **(c) Week 6**

Fig. 1 Screenshots of the mobile apps used in the experiments carried out in the study. Source: Our Body 4D App [Vücudumuz 4D], AR Science Cards App [AR Bilim Kartları], Unreal Chemist App, and Phyphox App

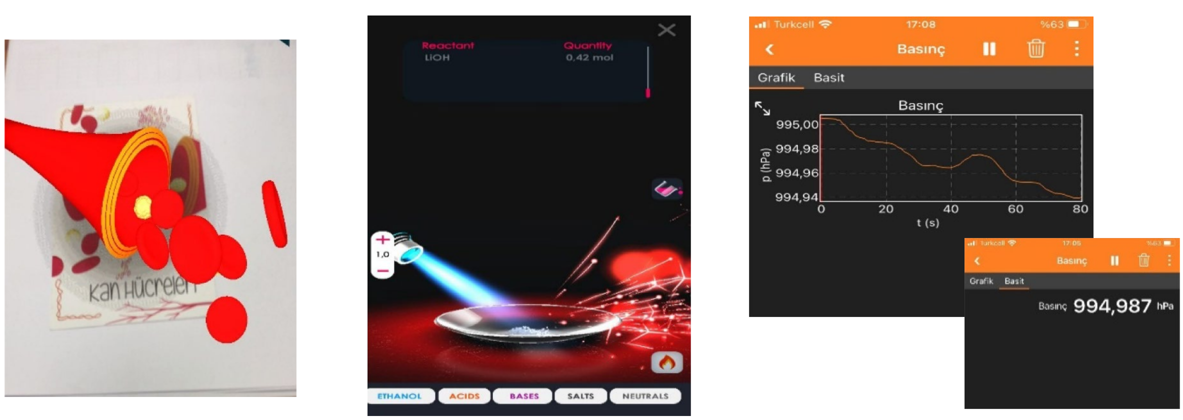


(a) From the worksheet for Week 4 **(b) From the worksheet for Week 5** **(c) From the worksheet for Week 6**

Fig. 2 Sections of the worksheets used in the experimentation

The preservice teachers and the researcher together evaluated and revealed the findings of the experiments. Figure 3 displays examples of the findings of the laboratory work on the questions asked in the worksheets shown in Fig 2.

According to Fig. 3, one of the observations made in the biology laboratory concerned the cells that appear at the highest percentage in the blood. The observations made with the AR Science Cards indicated that it was the red blood corpuscles that appeared in the blood in the highest percentage. Second, the students had been asked about the colors they observed when some base elements were burned in the chemistry laboratory. Figure 3 shows how the color red is obtained when LiOH is burnt. Third, it was observed in the physics laboratory with the help of the Phyphox app that the atmospheric pressure was about 995,000 hPa. The applications produce voiced or written explanations of the experiments. After performing the experiments, the participants discussed how they could carry out the same experiments



(a) Augmented reality supported observations **(b) The Unreal Chemist application-supported observations** **(c) Phyphox-supported observations**

Fig. 3 Sections from the observations made of the experiments shown on the worksheets. Source: AR Science Cards App [AR Bilim Kartları], Unreal Chemist App, and Phyphox App with actual laboratory equipment. It was explained to the students that a microscope and a sample of human blood could be used for the first experiment; in the second experiment, the end of a metal wire dipped first in water and then in the LiOH base could be held over a Bunsen burner at intense heat. The third experiment would require a barometer for the measurement. Lastly, the preservice teachers were assigned homework in which they were asked to prepare a report on their experimentation.

The same data collection instruments were administered to the participants as posttests immediately following the instruction. The comparison of the pre- and posttest data made it possible to examine the effect of the instruction.

Data Analysis

In the data analysis, the data collected were first encoded and transferred to the SPSS 21.0 program. Then, a normality analysis was made of the data sets obtained. Since the number of participants was less than 50, the results of the Shapiro–Wilk test in addition to skewness and kurtosis values were evaluated in the normality analysis (Büyüköztürk, 2010). Shapiro–Wilk test results indicated normality for data gathered with the Digital Literacy Scale (pre: $W=0.964$, $p=0.701$; post: $W=0.975$, $p=0.896$). Also, skewness (pre: −0.751; post: −0.005) and kurtosis values (pre: 1.072; post: −0.484) were determined to be within +2 to −2 range which showed normality (Garson, 2012; Tabachnick & Fidell, 2013). In addition, data gathered with the Disposition toward Using Technology in the Classroom Scale indicated normality as a result of Shapiro–Wilk test (pre: $W=0.912$, $p=0.110$; post: $W=0.916$, $p=0.126$). The skewness (pre: 0.220; post: −0.118) and kurtosis values (pre: −1.307; post: −0.844) were also within +2 to −2 range (Garson, 2012; Tabachnick & Fidell, 2013). Hence, the parametric t-test of related samples was used in the pretest/posttest comparison of these data sets that had displayed normal distribution. The analyses displayed a 0.05 level of significance.

The results of the analysis, in which a significant difference was noted, were examined to find the effect size by calculating Cohen's *d*. The $t/\sqrt{n}$ formula was used in the calculation of this coefficient for the *t*-test analysis of related samples (Büyüköztürk, 2010). Effect sizes are considered as small, medium, and large for 0.2, 0.5, and 0.8 in particular (Cohen, 1988).

Findings

Findings on the Digital Literacy of the Preservice Teachers

Findings on the effect of the science laboratory instruction on the digital literacy of the preservice teachers are presented in Table 1.

The results of the *t*-test analysis for the related samples shown in Table 1 are striking in that they show that the laboratory work made a significant difference in the preservice teachers' digital literacy ($t(16)=3.52$, $p=0.003$). It was observed that the preservice teachers' digital literacy mean score at the beginning was 62.18 (SD = 10.99) and rose to 69.00 (SD = 8.78) at the end of the study. This finding points to the significant increase in the preservice teachers' digital literacy. At the same time, the attitude ($t(16)=3.08$, $p=0.007$) and technical subscales of digital literacy displayed a significant increase at the end of the instruction ($t(16)=3.56$, $p=0.003$). On the other hand, in the other two cognitive ($t(16)=1.78$, $p=0.094$) and social subscales, it was seen that while an increase was seen as a result of the instruction, this was not statistically significant ($t(16)=1.95$, $p=0.069$).

When, as shown in Table 1, Cohen's *d* coefficients are examined for the significant difference displayed in digital literacy skills and in terms of the two subscales, it can be seen that there is a large effect size ($|d| \geq 0.8$). Meanwhile, since the mean scores on the cognitive and social subscales did not exhibit any significant difference; therefore, effect size was not calculated.

Table 1 Comparison of the preservice teachers' digital literacy in all of its dimensions

Digital literacy	Pretest M (SD)	Posttest M (SD)	df	*t*	*p*	Cohen's *d*
Total scale	62.18 (10.99)	69.00 (8.78)	16	3.52	0.003*	0.85
Attitude	26.18 (4.36)	28.94 (3.90)	16	3.08	0.007*	0.75
Technical	21.47 (4.19)	24.06 (3.53)	16	3.56	0.003*	0.86
Cognitive	7.76 (1.75)	8.41 (1.00)	16	1.78	0.094	-
Social	6.76 (1.86)	7.59 (1.62)	16	1.95	0.069	-

M mean, *SD* standard deviation

*$p<0.05$

Findings Regarding the Preservice Teachers' Disposition Toward Using Technology in the Classroom

Findings regarding the preservice teachers' disposition toward using technology in the mobile app-supported science laboratory are presented in Table 2.

According to the results of the *t*-test for related samples shown in Table 2, the instruction had a significant impact on the disposition of the preservice teachers' toward using technology in the classroom; this effect displayed an increase on the posttest ($t(16) = 2.36$, $p = 0.031$). It was thus observed that the mean score for the preservice teachers' disposition toward the use of technology in the classroom at the beginning was 64.29 (SD = 9.83) and rose to 68.71 (SD = 8.98) at the end of the study.

On the subscales, it was striking to note that the preservice teachers exhibited a difference in both the emotional ($t(16) = 5.59$, $p = 0.0001$) and behavioral subscales ($t(16) = 2.18$, $p = 0.045$). This meant that the disposition of the preservice teachers toward using technology in the classroom showed an increase in terms of both emotions and behavior.

The Cohen's *d* coefficient calculated for the results displayed in Table 2 indicates that the size of the effect of the instruction in terms of the total scale was medium ($|d| \geq 0.5$). Furthermore, Cohen's *d* coefficient calculated for the emotional subscale indicated a large effect ($|d| \geq 0.8$), while the effect for the behavioral subscale was medium ($|d| \geq 0.5$).

Discussion

Discussion Regarding the Digital Literacy of the Preservice Teachers

It was observed that the different types of mobile technologies used in the experiments carried out in this study resulted in a positive, large, and significant impact on the preservice teachers' digital literacy. According to Gound (2023), although teachers cannot fully prepare themselves for their profession in terms of digital literacy, it is still important that they experience as much exposure to digital literacy and technological applications as possible in their program of education. Rizal et al. (2019) also report that the digital literacy of preservice teachers is influenced by the activities they conduct in science classes and the assignments they are given in their training program. It can be seen, as in this study, that applications used in the preservice stage of teachers' education are effective tools to work with. Furthermore, digital literacy by its nature is the product of an interdisciplinary foundation (Park et al., 2021). It can therefore be said that in view of the science-technology-engineering-mathematics (STEM) approach to science education, which has become a growing trend in education, bringing different disciplines together, the integration of mobile technologies into the education program of preservice teachers is of significant importance.

In the experiments performed in this study, three different mobile applications and the preservice teachers' own mobile phones were used to examine the change in the preservice teachers' digital literacy levels. The study offers an innovative contribution to the literature in this respect. Indeed, Bernacki et al. (2020) have emphasized that there is a need for studies reporting on the way in which mobile technologies used in either formal or informal learning settings can impact students' ability to acquire skills such as digital literacy. At the same time, the literature did not reveal any study that actually aimed to develop preservice teachers' digital literacy through the use of their own mobile phones and downloaded applications that pertained to the science laboratory. In the present study, the preservice teachers made use of their own accustomed mobile phones, which made it easier for them to conduct the experiments. The use of mobile phones provides an advantage when carrying out science experiments (Hochberg et al., 2018). Moreover, it has been reported that using mobile technologies in this way has reduced science teachers' anxiety over working with new technologies, allowing them to be more receptive to such methods (Chiu & Churchill, 2016). Additionally, it can be seen from the field literature that science experiments are generally based on a single mobile application, and it is the impact of only a single app that has been examined in studies (Akçayır et al., 2016; Carreño et al., 2022; Celik et al., 2020; Domínguez Alfaro et al., 2022; Karnishyna et al., 2022; Kozcu Cakir et al., 2021; Li et al., 2023; Plunkett, 2019;

Table 2 Comparison of the findings for the disposition of the preservice teachers toward using technology in the classroom, in terms of the total scale and its subscales

Use of technology disposition	Pretest M (SD)	Posttest M (SD)	df	*t*	*p*	Cohen's *d*
Total scale	64.29 (9.83)	68.71 (8.98)	16	2.36	0.031*	0.57
Emotional	45.71 (6.26)	52.18 (6.18)	16	5.59	0.0001*	1.36
Behavioral	18.59 (3.83)	20.41 (3.97)	16	2.18	0.045*	0.53

M mean, *SD* standard deviation

*$p < 0.05$

Thees et al., 2020). The present study, however, included three different mobile apps in its scope. Also, it can be seen that the field literature reveals only a limited number of studies on developing digital literacy. In this context, Marty et al. (2013) have reported on an online and mobile Habitat Tracker application for fourth and fifth grade students that provides students with both formal and informal learning opportunities and results in an increase in students' digital literacy levels. In this study, the students made use of their tablets and a specially developed mobile learning program. Other studies have similarly reported that when the important positive impact of the factors of internet access (Aslan, 2021) and owning a computer (Aslan, 2021; Ata & Yıldırım, 2019) are considered, it can be said that using technology and participating in educational programs in which technology is used are instrumental in developing digital literacy skills.

Examining in detail the increase in the preservice teachers' digital literacy skills leads to the observation that the attitude and technical subscales pointed to a significant improvement. On the other hand, while there was an increase in the scores on the cognitive and social subscales, this increase was not significant. Digital literacy is a wide-reaching concept that goes significantly beyond the use of a computer and performing an online search for information (Buckingham, 2016). It can be said therefore that the preservice teachers had only a limited perception of digital literacy since the two dimensions mentioned did not show any significant change or improvement in this study. Accordingly, the results of a study carried out by Shopova (2014) with first- and second-year university students of social sciences indicated that although some basic skills such as social networking, internet surfing, emailing, and gaming could be seen among the students, the participants showed a deficiency in the effective use of technology in their learning process. In another study conducted with preservice teachers, Tyger (2011) also determined that participants displayed a high level of self-efficacy in terms of using technology in the classroom but found at the same time that the preservice teachers did not fully understand the concept of digital literacy. The results of the present study along with what has been reported in the literature suggest that there is a need for more comprehensive studies to ensure that university students effectively develop digital literacy. It is also believed that designing teaching material geared to improve digital literacy skills is a matter of effectively emphasizing the underlying characteristics of these skills. In this context, Tsinakos (2013) has drawn attention to the need for a solid pedagogical approach when seeking to lift the barriers standing in the way of the integration of mobile technologies in education.

In the present study, significant improvements were observed in digital literacy skills and, in particular, of the two sub-dimensions, the technical subscale (Cohen's $d = 0.86$) displayed a larger effect compared to the attitude subscale (Cohen's $d = 0.75$). This may have stemmed from the fact that the preservice teachers displayed a more developed perception about the more detailed technical subscale than the attitude subscale, which incorporated a more general approach. For example, in the technical subscale, the new technologies are described as easy to learn and capable of being used to produce new products without the use of any particular skills. On the other hand, in the attitude subscale, liking these technologies, finding motivation in them, and being able to learn more effectively with the help of technology are the notions stressed. The preservice teachers comprising the study group had been using computers, smartboards, projection screens, and other similar technological tools throughout their school years. It would therefore not be incorrect to infer from this that the use of these technologies had left a positive impact on the teachers' attitudes toward technology. The mobile technologies in the present study in fact also had a positive impact on the attitudes of the preservice teachers. It might however be said that the reason this effect was more limited than in the technical subscale was because the students had already been introduced to new technologies in the past and this had enabled them to achieve limited improvements in their attitudes. At the same time, changing individuals' attitudes is a more difficult process (Chiu & Churchill, 2016). The medium to large effect on the preservice teachers' attitudes in this study however is a positive outcome of our study. On the technical side, however, the preservice teachers who found the opportunity to perform experiments in the laboratory one-on-one with the help of mobile technologies experienced the more pronounced effect of feeling technically equipped to handle the work. At the end of the various applications reported in different studies, it has been seen that students perceive themselves to have a higher level of self-efficacy in terms of the technical aspects of using mobile technologies (Sin, 2020; Willcockson et al., 2011). Besides, if it is considered that research favors male students in terms of digital literacy (Aslan, 2021; Ata & Yıldırım, 2019; Yontar, 2019), it is significant to note the importance of ensuring a greater effect and improving preservice teachers' skills in learning and using new technologies from a study sample two-thirds of which consisted of female students. Similarly, Hairida et al. (2023) reported in their work with preservice chemistry teachers that the participants' technical subscale of digital literacy displayed a higher level than the cognitive and social/emotional dimensions.

In this study, no significant improvement was seen in the preservice teachers' social and cognitive subscale skills. The social subscale focuses on improving students' knowledge and communication skills as well as their being knowledgeable about internet-based activities. The fact that the preservice teachers did not achieve a significant increase in the social subscale of digital literacy was a result that was similar to what was reported by Prachagool et al. (2022). This researcher defined the aspects of the digital literacy levels of university students as *high* and *very high*, also reporting the remarkable result that the only aspect that could be defined as *moderate* was the teamwork-based learning dimension. In the present study, one of the aspects of the social dimension of the digital literacy scale was related to becoming knowledgeable about cybersecurity issues. Similarly, in their study with preservice science teachers, Rizal et al. (2019) found that the cybersecurity aspect of digital literacy displayed one of the two lowest mean scores in the subscales. In today's world, however, it is important that information and communication technologies are used in cyberspace with a full awareness of the difference between reliable and alternative facts (Tinmaz et al., 2022). The focus of the present study however was the use of different mobile applications that can be used within the scope of science experiments and not matters related to cybersecurity. It is true, on the other hand, that the individual may encounter various advertising, malicious links, and similar examples of malware when downloading any mobile application to a mobile phone. It is useful therefore to ensure that preservice teachers are made aware of this in their use of mobile technologies as this will be an effective method of comprehensively improving digital literacy.

Another sub-dimension on the digital literacy scale that did not display significant improvement was the cognitive subscale. The scores on this subscale were also low in the study by Hairida et al. (2023). In the present study, the cognitive subscale of the digital literacy scale focuses on how instructors can use of information and communication technologies in their lectures to address students working on cooperative projects. The lack of a significant improvement in this subscale may be explained by the fact that the preservice teachers concentrated more on using these technologies for individual learning rather than collective studies. Indeed, the researchers of another study reported that mobile technologies used in the chemistry laboratory proved to be effective in achieving students' self-directed learning (Seyhan, 2022). Although the preservice teachers in the present study worked in groups and performed experiments under the supervision of the researcher, due to the conditions created by the recent COVID-19 pandemic and the devastating earthquake in Turkey that took place during the study sample's second semester (Disaster & Emergency Management, 2023), the ensuing remote learning arrangements may have caused the students to perceive their mobile phones as more of a tool of self-directed learning. Because of this, it can be said that the preservice teachers went through an adaptation period from a social perspective and their related skills may have been influenced by these circumstances.

Discussion Regarding the Disposition of Preservice Teachers Toward Using Technology in the Classroom

Another result of the study was that the disposition of the preservice teachers toward the use of technology in the classroom showed a significant increase both on the overall scale and in the subscales. Domingo and Garganté (2016) state that the preference teachers show toward the use of mobile applications in their classes is associated with how they perceive these technologies. When it is considered that the study group represents the teachers of the future, their tendency to use technology in their classes is a predictor of the effective role mobile technologies will play in their future careers and for this reason must be recognized as an important development. Also, Çelik et al.'s (2021) study conducted with preservice science teachers showed that the disposition to use technology in the classroom was significantly improved and that senior-year preservice teachers showed significantly more of a tendency to use technology compared to freshmen. This may stem from the education the preservice teachers received over the course of their school program. Indeed, Gunuc and Kuzu (2014) assert that their discussions with preservice teachers led to the conclusion that the main factor influencing the tendency to use technology in the classroom was whether or not their instructors at the university tended to make use of technology in class. On the other hand, it has also been reported that instructors of preservice teachers do not sufficiently use technology in the classroom and that preservice teachers do however wish to have their classes supported by mobile phones, tablets, augmented reality, and other technology (Çelik et al., 2021). The results of this study in which mobile technologies were used are consistent with the opinions that preservice teachers have set forth.

The disposition of preservice teachers to use technology in the classroom significantly improved from both a behavioral and an emotional perspective in this study. In other words, the preservice teachers not only showed a positive attitude toward integrating traditional science laboratory experimentation with digital age technology but also displayed behavior that was consistent with such a disposition. This is a significant outcome since it calls attention to the fact that the use of these applications has helped preservice teachers as early as their second year at the university to become aware of the importance of using technology in the science laboratory. Similarly, a study by Mayfield et al. (2013) revealed that university students in a mobile technology-supported anatomy laboratory became more aware of the importance of dissection in the anatomy course as compared to the control group. Furthermore, it can be seen in studies on laboratory work in different fields that mobile applications stimulate positive feedback on the part of students (Carreño et al., 2022; Hochberg et al., 2018; Li et al., 2023; Nikolopoulou & Kousloglou, 2019; Ostrin & Dushenkov, 2016; Rochadel et al., 2013; Sin, 2020). On the other hand, Kerawalla et al. (2006) showed in their work with 10-year-old students that instruction on the unit of the Earth and Sun supported by augmented reality instigated a decrease in the students' tendency to participate in the class, a result for which the researchers set down a series of recommendations to prevent this. Consequently, it can be said that students' cognitive levels and their preparedness for learning must be considered in the inclusion of mobile technologies in the classroom.

The present study indicated that the program of education had a more significant effect on the emotional aspect of the preservice teachers' tendencies when compared to behavioral tendencies. A similar result was reported in a study by Çelik et al. (2021), where the authors found that the emotional aspect of preservice teachers' disposition toward using technology in the classroom was greater than their behavioral tendencies. While the behavioral tendencies of preservice teachers are associated with their willingness to take part in classroom activities, their emotional tendencies are related to their satisfaction with using technology in class. The results show a large effect (Cohen's $d=1.36$) in the emotional subscale, depending on the type of application used clearly demonstrating the preservice teachers' satisfaction with making use of such technologies. Preservice teachers attach importance to these types of technology and show an interest in them. On the other hand, mobile technologies have a lesser impact (Cohen's $d=0.53$) on translating this interest into appropriate behavior such as continuing the course or becoming more active in class. The observations of the researcher included notes on some preservice teachers that showed borderline absenteeism. As mentioned before, this outcome may have been a consequence of the online education program adopted due to the pandemic and the earthquake disaster that followed soon afterward. Indeed, absenteeism seems to be an issue in online education (Hibbi et al., 2021). However, since lessons can be saved online during distance learning sessions, not appearing in class has never been regarded as negative an outcome as a student's lack of academic achievement (Nieuwoudt, 2020). This is however not so in lessons conducted face-to-face. For this reason, as mentioned in the discussion on digital literacy, the preservice teachers experienced a period of adaptation in their third year of school, and the results of the study are a reflection of this period.

Conclusion

To conclude, differing from the traditional laboratory approach, the use of modern mobile applications in this study and the experimentation carried out with the preservice teachers' own mobile phones had a positive impact on the participants' digital literacy and their tendency to use technology in the classroom. Thanks to the mobile technologies used in this process, many of the limitations normally experienced in the classic laboratory were eliminated and the preservice teachers were offered many benefits that are in line with the requirements of the times in which we live. Turning their own mobile phones into a mobile laboratory, learning to make use of different mobile apps for science, being able to take various measurements without having to rely on costly equipment in the laboratory, the ability to repeat experiments as much as they liked, and the capability of applying what they had learned outside of school as well proved to be the advantages of technology for the preservice teachers. Thus, the applications made an impact on the emotional and behavioral subscales of the preservice teachers' tendency to use technology in the classroom and had an even larger effect on the overall emotional subscale compared to the behavioral subscale. At the same time, in the evaluation of the preservice teachers' digital literacy, it was seen that there were significant improvements in the attitude and technical subscales, while there was a more limited improvement in the cognitive and social subdimensions. Furthermore, when the attitude and technical subscales that displayed significant improvement were compared, it was seen that the development was more pronounced in the technical subdimension. These results indicate that the augmented reality, mobile laboratory, and Phyphox applications on the mobile phones used in the study showed different degrees of effectiveness in terms of the preservice teachers' abilities but that they generally had a positive impact.

Implications, Limitations, and Recommendations

Based on the results of the study and considering various special circumstances such as a pandemic or an earthquake that may come about in today's world, it is safe to say that a laboratory class relying on mobile applications in addition to traditional methods is a requirement that must be adopted in science teacher education programs. To carry the scope of the present study even further, it would be useful to conduct more studies to examine in more detail the effect of mobile applications on a semester's laboratory course in terms of their impact on students' achievement, motivation, self-efficacy, and other aspects of learning. Zhai et al. (2019) state that the impact of mobile technologies depends on multiple factors based on variables such as who started the students off on the structuring of their knowledge, how much they have been able to reinforce the process of learning, or the degree to which students have been able to focus on their learning. Also, a laboratory class designed with these factors in mind may be compared with practices employed in a traditional laboratory setting. This may contribute to evaluating the impact of the circumstances of our times on traditional science laboratory instruction and provide insight to teachers and researchers about instruction in the science laboratories of the future.

The augmented reality technology app used in the study was only applied to biology, while the mobile laboratory app was used in the chemistry course, and Phyphox for physics topics. Although theoretical instruction was provided prior to the applications in the science laboratory, the applications could only be implemented in a limited space of time. This constitutes a limitation for the study. For this reason and for future reference, it would be beneficial to design more comprehensive content for a science laboratory course supported by mobile phones and mobile apps that would be used to explore the subjects of physics, chemistry, and biology.

It is believed that the use of mobile applications in science teacher education should not be limited to only laboratory courses. It may be suggested that mobile technologies can also be included in classes where theoretical knowledge is shared, such as in the principal courses of general physics, general chemistry, general biology, and astronomy that are offered in science teacher education. Mobile apps may again be downloaded to the students' own mobile phones during the instruction. It is believed that this will allow preservice teachers the opportunity to gradually expand upon their tendency to improve their digital literacy and technology skills over the course of their university education.

This study was designed as quantitative research and sought to employ two different measures to determine the disposition of preservice teachers to make use of their digital literacy and technology skills. Despite the generally positive results of the research, however, it is found that the increase in the cognitive and social dimensions of digital literacy that the preservice teachers displayed was not statistically significant. The fact that no interviews were held to discover the reasons for this can be considered another limitation of the study. Although the results obtained from the overall scales and the subscales provided a framework for a successful study, posing more questions for each dimension and for the overall scale can perhaps uncover more information and serve as a guidepost for future research.

The last limitation of the study that can be mentioned is the fact that the differences in the variables were not explored with respect to gender. This was a result of the small sample size and the much higher percentage of female participants in the study. The field literature, in fact, draws attention to the difference in digital literacy that can be seen between male and female students (Aslan, 2021; Ata & Yıldırım, 2019; Yontar, 2019). Therefore, the outcomes of such comparisons may lead to taking measures to remove any disadvantages that may exist related to gender.

In this context, the following recommendations may be listed in the light of the results:

- The use of mobile technologies must be made more prevalent in the science teacher education curriculum
- It might be suggested that laboratory classes supported with mobile technologies are given as a separate course in the teacher education program
- The effectiveness of these applications on various variables such as academic achievement, misconceptions, learning retention, laboratory anxiety, and laboratory self-efficacy should be tested
- The impact of the gender factor can be explored in the analysis of the research results
- Mixed methodologies may be used in evaluating the effectiveness of the programs designed

Author Contribution The study has a single author. Therefore, all the study was conducted by herself.

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Availability of Data and Materials Data and material related to the study are available upon request.

Declarations

Ethical Approval The study was conducted considering ethical concerns. Also, ethical approval was taken from the institutional Research Ethics Board.

Informed Consent All participants took part in the study voluntarily, and they could withdraw from the study at any time.

Competing Interests The author declares no competing interests.

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