



# A Case Study on the Integration of Phyphox into Science Lesson Plans: Preservice Teachers' Experiences and Opinions

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Received: 20 January 2025 / Accepted: 3 November 2025  
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## Abstract

Becoming proficient in lesson planning is an important skill that preservice teachers must gain in their education. The aim of this article is to examine in detail how preservice science teachers can make use of the mobile application Phyphox by downloading it onto their mobile phones and incorporating the system into the lesson plans they prepare in line with the 5E Learning Model. The study also seeks to report on the opinions and experiences of preservice teachers in this context. This is a case study that was carried out with 43 preservice teachers. Accordingly, after a two-hour Phyphox training session, the participating preservice teachers were asked to prepare a lesson plan on a topic of their choice in science using the Phyphox application. The study data were collected with the lesson plans, a lesson plan evaluation questionnaire, and a semi-structured interview form. Descriptive analysis and content analysis were used in the data analysis. At the end of the study, the highest grade level the preservice teachers' lesson plans addressed was the fifth grade and the application was largely used in the Explore stage. Also, the "light" experiment was the most popularly utilized Phyphox feature. Furthermore, the study showed that the activity of preparing Phyphox-supported lesson plans proved to be beneficial to the preservice teachers in various ways. It is suggested that additional qualitative studies are conducted on the impact of offering preservice teachers the opportunity to gain the experience of preparing Phyphox-supported lesson plans.

**Keywords** Mobile technologies · Science lesson plan · Mobile phone · 5E model

## Introduction

Lesson planning requires a complex set of skills that are founded on an understanding of pedagogy and field knowledge (Strangis et al., 2006). To become effective instructors in the classroom, preservice teachers need to plan their lessons based on their knowledge of pedagogy and be able to make use of applications that allow them to interpret and respond to student activities (Lim et al., 2018). At the same time, although preservice teachers face various challenges due to their limited experience at school and because they have not yet adequately mastered teaching strategies (Atkinson, 2000), they are still expected to create unique and stimulating activities for their students as well as prepare lesson plans appropriate to the topics covered. The

literature reveals that preservice teachers benefit from the lesson planning process in preparing themselves for their future careers (Beyer & Davis, 2009; Blömeke et al., 2008; Canbazoglu Bilici et al., 2016; Haryanto et al., 2021; Lim et al., 2018; Namdar & Kucuk, 2018; Nilsson, 2009; Pekdağ et al., 2021; Sungur Gül & Saylan Kırmızıgül, 2023).

Today, student-centered methodologies and approaches that guide the learning and teaching process such as argumentation and problem-based learning are utilized in the preparation of lesson plans. Another commonly used method is the 5E Learning Model (Ekiz-Kıran et al., 2021; Harrell & Subramaniam, 2015; Sungur Gül & Saylan Kırmızıgül, 2023). According to this model, lessons are planned for five stages of action: Engage, Explore, Explain, Elaborate and Evaluate (Bybee et al., 2006). There are accompanying teaching activities related to each stage. The goal of the Engage stage is to discover the extent of students' prior knowledge and their misconceptions. This stage also involves providing students with motivation. The process is one in which teachers can make use of various questions, photographs and news excerpts to draw the students' attention. In the Explore

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stage, the students are directly introduced to a learning activity where they can observe, collect data and make deductions. In the Explain stage, students are expected to produce mental constructs based on the observations they made in the previous stage. The teacher facilitates this process through explanatory instruction, thereby playing a more essential role. The Elaboration step is designed to allow students to transfer what they learned into a different situation and solve a different problem using this knowledge. The Evaluation phase constitutes determining, through alternative methods, how the entire learning process has contributed to the students. The stage that is the most teacher-centered is the Explain stage while the other steps are predominantly student-centered. At all these stages, the more traditional methods of using “pen and pencil” (written news excerpts, photographs) and applications based on tangible materials (various lab equipment) may be accompanied by technological tools (computers, sensors, projectors). For example, in the Engage stage of the 5E Model, instead of asking the students what comes to mind when they are confronted with the concept of density and listening to their answers in class, the teacher can alternatively collect the students’ responses via their mobile phones on the “Mentimeter” application. At the same time, this application can help the teacher understand the students’ cognitive framework regarding a certain concept by sharing their responses in the form of a word cloud with the classmates via a computer or projector. Similarly, at the Explore stage, while students experiment to see if different objects placed in a beaker full of water can float, they can also perform the same experiment using a digital program such as Algodoo. It can therefore be said that developments in technology and increased access to knowledge have necessitated the reformulation of how concepts of learning and teaching are to be perceived (Avraamidou, 2008). It is a fact that “technology” has found new channels of usage in science education.

### Using Technology in Science Classes

Different types of technological applications are now being used in science classes to enhance effective teaching. For example, while in the past, the overhead projector had been used to reflect a visual on a board or curtain, smartboards are being used today, offering the advantages of providing students with higher quality resolution and interactive visuals. Among other technological applications that are commonly used in science classes are Web 2.0 tools, augmented reality cards, 3D-printers, and simulations. Additionally, although Zoom and YouTube were in use before the COVID-19 pandemic, it may be said that the concepts of online education and flipped classrooms (Divjak et al., 2022) have made these applications more popular (Fackler & Sexton, 2020).

Also, mobile phones and the various mobile applications downloaded to these phones are now being used in supporting science classes.

Domingo and Garganté (2016) assert that the contributions of mobile phones and mobile applications to science education include providing learning opportunities of different forms, increasing participation in the learning process, encouraging learning on one’s own, facilitating access to knowledge, and promoting cooperative learning. Furthermore, mobile tools provide students with unique opportunities to monitor digital records that are superior to self-reporting and other participant-driven data collection methods (Bernacki et al., 2020). While the effect of mobile technologies on student achievement remains a controversial subject in the literature, it is emphasized that the many variables that must be considered in order to reach a clear conclusion in this context include “participants, tools, software, content and the classroom environment,” making it clear that the resolution of this matter is not an easy task (Zhai et al., 2019). There are many mobile applications used in science education today, but it can be said that this field is still open to development. At the same time, while some science subjects benefit from an abundant supply of teaching materials, it is striking to note that didactic tools for hands-on learning are limited (Lellis-Santos & Abdulkader, 2020). Since a significant part of science learning is based on application-based processes, it can be said that the features of mobile phones such as camera and sensors play an essential role in science experiments (Ürek & Çoramık, 2023).

### The Phyphox Application

A mobile tool that can be used for science lessons is Phyphox (Physical Phone Experiments), which is an add-free, publicly accessible application specifically designed for science education (Staacks et al., 2022). Operating through its connection with the sensors of a mobile phone, Phyphox makes it possible to record quantitative physical measurements (Stampfer et al., 2020). Phyphox contains many different features, as seen in Fig. 1. If these features are active on the smartphone to which they have been downloaded, their names appear in bold print (e.g., light, sonar); if inactive, the names appear in light print (e.g., pressure, elevator).

While operating via a mobile phone, Phyphox can also be remotely controlled by connecting to a computer, allowing the recording or sharing of data (Phyphox, n.d.). Phyphox can also process raw data and produce graphs (Staacks et al., 2018). This gives students the opportunity to visualize the actual size of what is being measured and how this size or quantity changes over time. It can further be said that Phyphox functions as a tool that helps students to associate science with the disciplines of technology and mathematics.



Fig. 1 Screenshots of Phyphox features downloaded onto an Android-based mobile phone

The literature reveals studies on how Phyphox can be used in experiments on various topics such as Faraday’s Law

(Andrianto et al., 2021; Eff-Darwich et al., 2023), the pendulum (Bernardini et al., 2024; Coramik & İnanç, 2023), the

bouncing ball (Bernardini et al., 2024), damped oscillation (Csernovszky et al., 2024), the kinetic friction coefficient (Çoramık & Ürek, 2021; Johansson et al., 2024), magnetic fields (Westermann et al., 2022), and solar panels (Pusch et al., 2021). On the other hand, there are fewer articles on how Phyphox impacts students' conceptual understanding or their skills and attitudes (Mayampoh et al., 2021; Nanto et al., 2022; Nkundabakura et al., 2024; Pierratos & Polatoglou, 2020; Saprudin et al., 2020; Ürek & Çoramık, 2023; Ürek, 2024). At the same time, it is striking to note that Phyphox has been included in few studies on STEM (science-technology-engineering-mathematics) education (Milner-Bolotin & Milner, 2024; Ürek & Çoramık, 2023). In this context, Milner-Bolotin and Milner (2024) discuss in their study the “smartphone-supported project-based science learning cycle” model which signifies the transition from traditional high school laboratories into science laboratories supported with Phyphox. Researchers report that besides the applications they use with high school students, they also use this pedagogy in physics teacher education. These types of evidence-based modern educational tools can make it possible to reach both current students and the teachers of the future, making STEM education more interesting and meaningful. Ürek and Çoramık (2023) report in their study on the STEM framework as pertains to final-year preservice teachers that the participants were first trained in the use of mobile phone sensors and the Phyphox app. In the following two weeks, the researchers presented the preservice teachers with a problem and asked them to find the solution with the help of their mobile phones and the different features of Phyphox. The participants then produced designs of swings, ending their swing-designing activity with very positive results.

## Science Teacher Education and Technology

In today's rapidly developing world of technology, teacher educators face the task of training teachers to make use of currently available innovative technological applications as teaching tools (Syh-Jong, 2008). The insufficient emphasis placed on technology in teacher education programs results in the concerning reality that teachers do not acquire the necessary competencies in using technology during their training (Admiraal et al., 2017). Instead, they are compelled to develop these skills only after entering the profession. Shulman (1987) delineates the types of knowledge that all preservice teachers must gain as content knowledge, pedagogical knowledge, and pedagogical content knowledge. Mishra and Koehler (2006) have stated that deliberative pedagogical uses of technology necessitate the creation of a complex body of knowledge that can be defined as “Technological Pedagogical Content Knowledge” (TPACK). From

the perspective of science education, the trio of subject matter, technology and pedagogy has been conceptualized as the means to learning science by performing meaningful experiments (Campbell & Abd-Hamid, 2013). It is thus believed that to ensure that preservice teachers are fully equipped, it is important that they learn the skills of incorporating technological applications into their lesson plans so that they can point to the associations between science and other disciplines. Since the Phyphox application is among the mobile apps that are currently being used in today's science education studies, it must be accepted that preservice teachers need to become competent in its use.

## Lesson Plans Supported with Current Technologies in Science Teacher Education

With the help of lesson plans that are based on current technologies and which incorporate interdisciplinary content, preservice teachers become more familiar with teaching strategies and resources, enabling them to draw up more productive lesson plans and gain the skills of using their time efficiently (Berlin & White, 2012). Indeed, Beschorner and Kruse (2016) assert that preservice teachers are open to incorporating new digital technologies into their lesson plans but have limited knowledge of the potential tools they can make use of.

The literature reveals various studies that report that preservice science teachers prepare lesson plans that are supported by current technologies. For example, Sungur Gül and Saylan Kırmızıgül (2023) studied how senior-year preservice science teachers use Algodoo simulations in their STEM activity lesson plans, and in this context, asked the preservice teachers to draw up lesson plans based on the 5E Model. Similarly, Namdar and Kucuk (2018) asked second-year preservice science teachers to prepare lesson plans based on the 5E Model, then to revise these plans according to the critiques of their classmates. Some studies associated the lesson plans prepared by the preservice teachers with their technological pedagogical content knowledge (Aktaş & Özmen, 2020; Canbazoglu Bilici et al., 2016; Haryanto et al., 2021; Syh-Jong, 2007). Some of these studies also covered microteaching applications (Aktaş & Özmen, 2020; Haryanto et al., 2021). In short, it is reported that the various applications have afforded preservice teachers numerous benefits. On the other hand, no study was found that centered on how the Phyphox app has been integrated into the process of lesson planning.

## Aim and Significance of the Study

The aim of this study is to review in detail how senior-year preservice science teachers incorporate the Phyphox app

into their lesson plans. At the same time, the study seeks to determine the opinions and experiences of preservice teachers regarding the lesson planning process.

Although mobile tools are widely used in daily life, their use for teaching and learning is still unfamiliar in many schools (Chiu & Churchill, 2016). Haryanto et al. (2021) call attention to the fact that teaching science concepts can be more constructive with the help of pedagogies that benefit from technologies. Accordingly, sustained scholarly attention is being directed toward examining contemporary technological applications and their potential for effective integration into teacher education programs. As mentioned above, Phyphox is one of the current applications used in the field of science education. At the same time, just as mobile phones facilitate people's daily lives, the Phyphox app supports science instruction in many ways. Indeed, Stampfer et al. (2020) state that this app provides a lab in the pocket. On the other hand, no study was encountered among the limited number of studies on the use of the Phyphox app in teacher education (Nanto et al., 2022; Nkundabakura et al., 2024; Saprudin et al., 2020; Ürek & Çoramık, 2023; Ürek, 2024) that makes a detailed review of how preservice science teachers use this application in their lesson plans. The results of this investigation, therefore, can be expected to contribute to the field literature in the context of educating qualified science teachers who are able to make use of current technologies in their classes.

## Research Questions

1. How do preservice science teachers use Phyphox in their lesson plans?
2. What are the opinions and experiences of preservice science teachers regarding drawing up Phyphox-supported lesson plans?

## Method

### Research Design

This study was conducted as a qualitative holistic single-case study (Type 1). Single-case designs encompass only one unit of analysis; to test a hypothesis in holistic single-case designs, however, situations that do not match general standards or have not been previously investigated are considered (Yin, 2009). This study contains only one unit of analysis, constituting the process of how preservice science teachers use the Phyphox app for lesson planning. The investigation entails understanding the way in which preservice teachers make use of the Phyphox app in their lesson

plans, which refers to a set of circumstances that has not been previously investigated.

### The Study Group

The study group consists of 43 senior-year preservice science teachers in their seventh semester of a four-year science teacher education program in Türkiye. The group of preservice teachers was made up of 10 men and 33 women. The mean age of the participants is 22. The study was conducted on a volunteership basis, and the identities of the participants were kept confidential. The participants were identified by criterion-based sampling from purposeful sampling strategies. Criterion-based sampling identifies individuals who meet previously designated criteria and allocates these persons into the group sample (Palinkas et al., 2015). The main criterion for determining which preservice teachers would be in the study group was their completion of the required science field courses (fundamental physics, chemistry and biology) and their science teacher education courses (science teaching 1 and 2). All in the study group had successfully completed classwork in these courses. They had also taken the Interdisciplinary Science Teaching course offered in the seventh semester of the Science Teacher Education program. The participants were therefore prepared to teach basic topics of science and were familiar with STEM education. The study group had thus been selected based on the fulfillment of these criteria.

### The Study Process

The first action taken in the research was to provide the preservice teachers with a two-hour class instruction on using the Phyphox app. Following the participants' introduction to this app, they were asked to download the app to their mobile phones and start to use it by taking various measurements. Then, the participants were asked to prepare a lesson plan which meets the following criteria:

- Geared for middle school Science course learning outcomes (MoNE, 2018a),
- Connecting this course with the learning outcomes of the Mathematics (MoNE, 2018b) and Technology and Design courses (MoNE, 2018c),
- Being based on the 5E Model,
- Using Phyphox at any stage of the course.

Besides their theoretical content, the participants were instructed to include field activities in their plans and to add visuals to accompany the lesson plans. The preservice teachers were given two weeks to prepare their lesson plans. This completed the process of lesson plan preparation.

Finally, interviews with the participants were held to learn their thoughts and experiences regarding the activity.

### Data Collection Instruments

The study data were collected with the lesson plans, a lesson plan evaluation form, and a semi-structured interview form. As described above, the lesson plans were individually developed by each of the preservice teachers. To guide the participants in their lesson planning, they were provided with a template based on the literature (Çevik, 2020). The template first asks for the basic knowledge related to the course. This entails delineating the topic to be treated in class, the class level the course would be addressing, the number of class hours, key concepts and fundamental safety measures. The second part of the template requires the planned lesson to be linked with the Science teaching program, as well as the teaching programs for Mathematics and Technology and Design, along with a list of learning outcomes. The third section of the template is related to the treatment of the lesson in class. In this context, the template asks for the strategies, methods and techniques used in the course as well as the materials employed. Next, the preservice teachers are expected to detail exactly how they plan to conduct learning and teaching activities at each stage of the 5E Model. This includes a detailed description in their lesson plans of how the preservice teachers will set up their experiments and use Phyphox for measurements. The preservice teachers submitted to the researcher print-outs of the lesson plans they prepared following the template. The literature reveals that researchers have used the lesson plans that preservice teachers drew up as data collection tools (Haryanto et al., 2021; Namdar & Kucuk, 2018; Sungur Gül & Saylan Kırmızıgül, 2023).

The lesson plan evaluation form was used in the analysis of the lesson plans. This form consists of five items. The following matters were addressed:

- i. For which class level was the lesson plan developed?
- ii. At which stage of the lesson plan was the Phyphox app used?
- iii. Who were the expected target users of the Phyphox app cited in the lesson plan?
- iv. Which feature of Phyphox was being utilized in the lesson plan?
- v. Which science topic was included in the lesson plan?

The first step in developing a lesson plan evaluation form entailed the preparation of a draft that covered the complete content of the lesson plan template. The evaluation process was aligned with the objectives of the research and conducted in accordance with the expert opinions of three

specialists in the field. Thus, in the context of the present study, the examination of the content of the lesson plans drawn up by the preservice teachers was limited to the scope of the above-mentioned five items. Thus, the items in the form focused on the first (i, v) and third sections of the lesson plan template (ii, iii, iv). The second part of the template enables preservice teachers to establish interdisciplinary connections in the course and therefore constitutes a prerequisite for aligning the lesson plans with the study objective. Accordingly, this section ensures the fulfillment of a prerequisite for preparing lesson plans in line with the intended purpose of the study. The items in the lesson plan evaluation form include various categories. These have been designated in terms of the grades targeted by the preservice teachers (i.e., grades 5–6–7–8) in their Phyphox-supported lesson plans, the stage of the lesson at which the app will be used (engage-explore-explain-elaborate-evaluate), and the Phyphox features (light-acoustics-motion stopwatch-pressure-inclination-roll-acceleration) to be employed by the user (teacher-student). Lastly, the evaluation of the topics treated in the lesson plans is based on the Science curriculum offered in the teaching program for middle school pupils in Türkiye (MoNE, 2018a). Similarly, the lesson plans were examined in terms of “time, activities, hardware and software use, type of technological app” as seen in the “Technology Observation Protocol for Science” developed by Parker et al. (2019) for high school teachers.

Another data collection instrument used in the study was a semi-structured interview form. This form was developed to determine the participants’ opinions and experiences regarding their lesson plan preparation. It contains four questions that focus on the following:

- i. Was the lesson plan preparation activity of benefit to you in any way? If so, please explain.
- ii. Would you think of using the Phyphox app that you used in this activity in the future? Can you elaborate?
- iii. What can the Phyphox app contribute to the learning-teaching process? Please explain.
- iv. Did you have any difficulty during this activity? Can you describe the difficulty?

The first version of the interview form was reviewed by three educators in the field who provided feedback. A change was made in Question No. 3 on the form according to expert opinion. The first version of the question asked about what contributions the Phyphox app could make to middle school students. The opinion of the experts, however, suggested that the study could produce more enriched data if the contributions could be discussed not only in terms of students but from the perspective of the entire teaching and instruction process. There are examples of similarly structured

interview forms in the literature. In a study by Sungur Gül and Saylan Kırmızıgül (2023), for example, the researchers discuss the advantages, disadvantages and intended uses of these sorts of activities in the context of preparations for an Algodoo-supported STEM activity. Other articles in the literature also report on the opinions expressed by preservice teachers in their interviews regarding the creation of lesson plans (Aktaş & Özmen, 2020; Beyer & Davis, 2009; Strangis et al., 2006). In the present study, each participant's interview took about 12 min. The discussions were held face-to-face in an office setting.

## Data Analysis

Descriptive analysis and content analysis were employed in the data analysis. The lesson plans that the preservice teachers had prepared were analyzed with descriptive analysis based on the items contained in the lesson plan evaluation form. Descriptive analysis can be used to distill datasets into meaningful dimensions to uncover patterns to inform and improve decision-making (Loeb et al., 2017). Thus, this analysis identifies patterns in data that answer questions on who, what, where, when, and to what extent. In the study, each meaningful category identified in the lesson plan evaluation form was analyzed in terms of frequency and percentage distribution. Similarly, the literature reports on lesson plan evaluations that are presented in terms of frequency (Namdar & Kucuk, 2018) and percentages (Beyer & Davis, 2009; Blömeke et al., 2008; Namdar & Kucuk, 2018).

The data obtained from the semi-structured interviews were transcribed and then analyzed with content analysis. According to Krippendorff (2004), content analysis is a research technique for making replicable and valid inferences from texts (or other meaningful matter) in terms of the context of their use. The analyses were carried out manually without using any software. This process was executed based on the steps recommended by Saldana (2009). Accordingly, the meaningful units revealed in each response to each question were first identified. Then corresponding codes were assigned. Similar codes were combined to form categories. Finally, themes were extracted from each category. The code-category and themes were expressed with frequencies and percentages to facilitate interpretation.

To increase study validity, the findings were collected with different collection techniques (triangulation). At the same time, the study sample, setting and the research process were defined in detail to facilitate comparisons with other samplings. The reliability of the results of the data analysis was confirmed by an external researcher who was invited into the data analysis process. The interrater consistency coefficient was computed according to the formula introduced by Miles and Huberman (1994). Thus, the

consistency coefficients calculated between two analysts for each item in the lesson plan analysis were found to be above 0.95. In the analysis of the data obtained from the interviews, the researcher of the present study submitted the identified codes to the external researcher, asking to place the obtained data into these codes. The consistency coefficients found in this way were above 0.85. The results of the interview analysis were also supported with excerpts from the preservice teachers' own statements (coded as P1, P2 etc.), which increased the reliability of the study.

## Findings

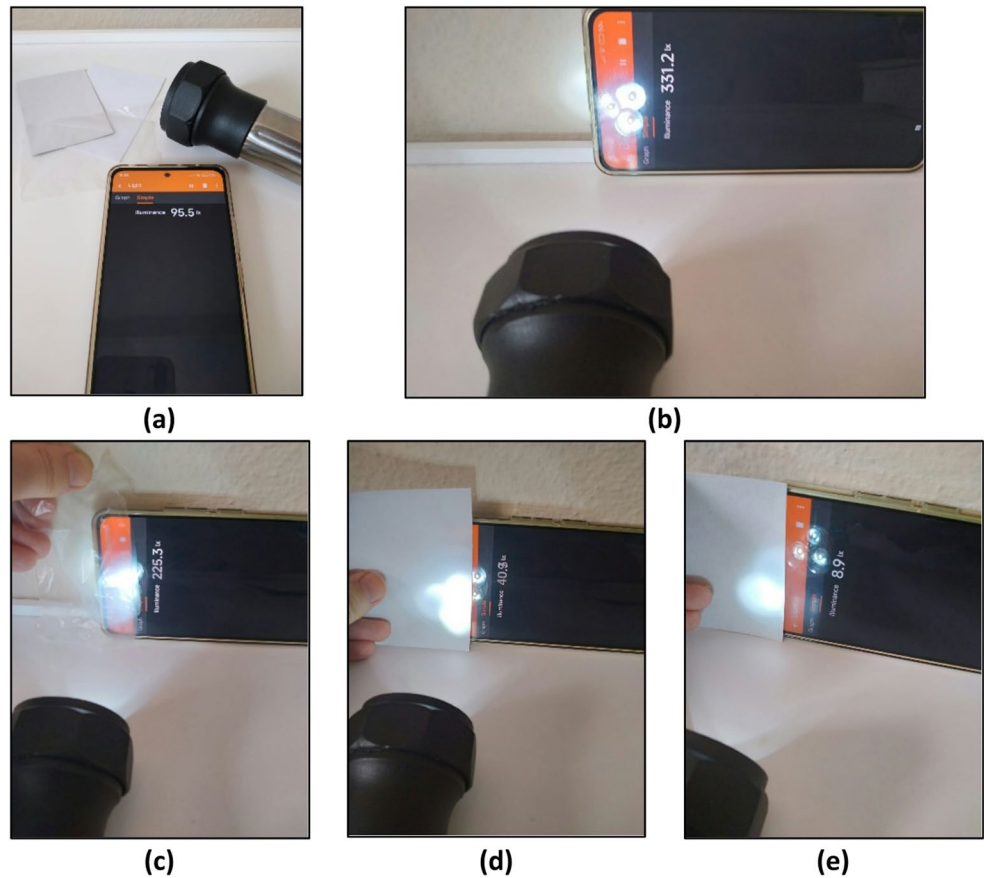
### Findings Related To Preservice Teachers' Use of Phyphox in Lesson Planning

The findings culled from the lesson plans prepared by the preservice teachers indicate that in terms of grade level, 19 participants prepared lesson plans for the fifth grade (44.2%), followed by 14 lesson plans prepared for the sixth grade (32.6%). Six lesson plans were prepared for the seventh (13.9%) and four lesson plans were prepared for the eighth grades (9.3%). In terms of Phyphox users, it was observed that 22 participants included teachers (51.2%) and 21 participants included the students (48.8%) in their lesson plans. In terms of the stages of the 5E Model, Phyphox was used by 29 participants in the Explore stage (67.4%), followed by 14 participants in the Elaborate Stage (32.6%). While there was only one participant who planned to use the app in the Explain phase (2.3%), none of the participants chose to use it for the Engage or Evaluate stages. Additionally, one of the participants (P21) planned to use Phyphox in two of the phases of the lesson (both in the Explore and Elaborate stages).

A look into which applications in Phyphox had been used in the lesson plans showed that "light" was the most popular feature. Twenty-two participants used the light feature in their lesson plans (51.2%). This was followed by "acoustics." It was observed in the context of acoustics that the applications that most popular among 12 participants were the tone generator, audio amplitude and frequency history features (27.9%). Following these came the motion stopwatch used by four participants (9.3%) and the pressure app by three participants (7.0%). It was noted that the acceleration, inclination and roll were each used only once (2.3%). Except for P32, it was found that all the participants used only one application in their lesson plans; P32 used both a motion stopwatch and an inclination. Figure 2 provides an example showing how Phyphox was used in the lesson plans prepared by P14.

The activity shown in Fig. 2 is performed using Phyphox's light feature. Here, the amount of illuminance is

**Fig. 2** Measurement of illuminance with materials which have different light transmission



determined using the light sensor of the mobile phone. The materials used in the activity in part a of the figure are a piece of plastic bag, A4 paper and cardboard, a mobile phone, and a flashlight. Also, in part a, the ambient illuminance was measured to be 95.5 lx using the front camera of the mobile phone. In part b of the figure, when a flashlight was shined on the phone's front camera, the illuminance increased to 331.2 lx. Then, in parts c, d, and e of the figure, materials with varying light transmission, such as a piece of plastic bag, A4 paper, and cardboard, were placed directly in front of the phone's front camera, and the illuminances were measured as 225.3 lx, 40.8 lx, and 8.9 lx, respectively. Thus, the activity allows students to learn that various materials interact with light differently in an experimental way and support their learning by providing numerical data.

Lastly, a review of the topics included in the lesson plans indicated that the topics chosen were compatible with Phyphox apps. Table 1 shows the distribution of the topics addressed by the participants in their lesson plans.

As shown in Table 1, most preservice teachers used the "light" feature of Phyphox. The preservice teachers who made use of the "light" feature in Phyphox included the topics of light transmission/absorption, seed germination, and bulb brightness in their lesson plans. Another frequent feature of Phyphox utilized in the lesson plans was "acoustics".

**Table 1** Distribution of the topics addressed in the preservice teachers' lesson plans

Phyphox Feature	Topic	Sub-topic	f (%)
Light	Light	light transmission	11 (25.6)
		light absorption	2 (4.6)
	Electricity	bulb brightness	8 (18.6)
	Reproduction and Growth in Plants	seed germination	1 (2.3)
Acoustics	Sound	sound insulation	7 (16.3)
		sound propagation	4 (9.3)
	System in the Human Body	sensory organs (ear)	1 (2.3)
Motion Stopwatch	Force	frictional force	3 (7.0)
Roll		frictional force	1 (2.3)
Acceleration		distance-time-speed	1 (2.3)
Motion Stopwatch, Inclination		simple machines	1 (2.3)
Pressure	Pressure	open air pressure	3 (7.0)

The preservice teachers who used the "acoustics" feature in Phyphox included the topics of sound insulation, sound propagation, and the ear. Besides these, the "pressure" experiment was employed in the topic of atmospheric pressure, the "motion stopwatch" was used in the topics

of frictional force and simple machines, while “roll” was utilized in the topic of frictional force, “inclination” experiment was employed in the topic of simple machines and the “acceleration” in the topic of distance-time-speed.

### Findings Related To Preservice Teachers’ Opinions and Experiences on Phyphox-supported Lesson Planning

The findings concerning the preservice teachers’ gains from the lesson planning activity are summarized in Table 2.

Table 2 indicates that the lesson planning activity was beneficial to the participants in many ways. It was first seen that the activity was useful in that it added benefits to the preservice teachers in terms of the use of Phyphox. Using Phyphox promoted learning how Phyphox could be integrated into science classes, how measurements and observations could be expressed quantitatively with Phyphox, and how topics could be made more concrete and tangible. In this context, P15 commented: “*I found the answer to my question as to how technology could be used in science class using Phyphox. It was also very useful to be able to observe quantifiable values in the activity I designed. At the same time, I learned that I could easily make concrete observations of topics that I had learned abstractly but had not been able to experiment with.*” The second benefit of the activity was related to their professional life. In this context, the preservice teachers mentioned their future careers, associating science with other disciplines, and setting up a lesson plan following the 5E model in this context. P38 commented on this in this way: “*As I was preparing this lesson plan, I felt I was learning an application that I could use in the activities I will introduce my students to in my future teaching career.*” Thirdly, the preservice teachers gained from the activity in terms of learning creative skills, time management, and improving thinking skills. As

**Table 2** Opinions of the preservice teachers about their gains from the activity

Theme	Categories	Codes	f (%)
What the pre-service teachers gained	In terms of using Phyphox	integrating the app into lesson plans	19 (44.2)
		taking measurements and making observations	16 (37.2)
		making subject matter more concrete	5 (11.6)
	Professionally	future careers	15 (34.9)
		forming interdisciplinary relations	5 (11.6)
		preparing lesson plans in line with the 5E Model	1 (2.3)
		creativity	5 (11.6)
	In terms of skills	thinking skills	1 (2.3)
		time management	1 (2.3)

P39 expressed it: “*Using Phyphox in this activity made me learn how to think more comprehensively. I also saw how a single activity could connect science with mathematics and technology.*”

When the preservice teachers were asked whether they would include Phyphox in their future lesson plans, all of the participants answered in the affirmative. P39, for example, said: “*I would like to use this application in the future. After I graduate as a teacher, I will think of enriching my lesson plans with Phyphox and making the lessons more productive for my students.*” The participants mentioned various advantages of the app in this context. In Table 3, it is seen that the participants expressed their views on what the app contributed to the learning/teaching process in three categories: their gains in terms of the lessons, their students, and performing the experiments.

Table 3 demonstrates that with regard to what Phyphox-supported lesson plans can contribute to students, the preservice teachers stated that Phyphox would offer students the opportunity to participate actively in class, learn how to use technology to their benefit, acquire permanent learning, learn by doing and experiencing, make interdisciplinary associations, feel like a scientist, and develop their higher cognitive and creative skills. P32 had this to say: “*Students will be encouraged to engage in active participation in class.*”

**Table 3** Opinions of the preservice teachers about the contributions of the app to the learning/teaching process

Theme	Categories	Codes	f (%)
The contribution of Phyphox to the learning and teaching process	In terms of the students	permanent learning	13 (30.2)
		learning by doing and experiencing	11 (25.6)
		using technology to their benefit	11 (25.6)
		encouraging active participation	7 (16.3)
		forming interdisciplinary associations	3 (7.0)
		feeling like a scientist	2 (4.6)
		developing higher cognitive skills	2 (4.6)
		developing creativity	1 (2.3)
		In terms of performing experiments	accessing easily observable numerical data
	eliminating the cost problems of tools/equipment		7 (16.3)
	removing limitations of time and place		7 (16.3)
	finding the opportunity to tackle different experiments		3 (7.0)
	In terms of the lessons	interesting	17 (39.5)
tangible		9 (20.9)	
entertaining		4 (9.3)	

Since they will be experiencing the process themselves, their learning will be permanent. They will be learning through doing and experiencing as they use the application." Among the contributions of Phyphox to the process of experimentation, it was noted that the app allowed the easy observation of numerical data, eliminated the tools/equipment cost dilemma, avoided the limitations of time/place and brought new opportunities for carrying out different experiments. According to P5, "Phyphox provides students with numerical data, giving them data for proof. The students can also easily use the app in any setting they are in outside of the school environment." With respect to the lessons, the participants said that the Phyphox application could help them make lessons more entertaining, interesting, and tangible for the students. P3's comments in this context are as follows: "Since the Phyphox app is used over mobile phones, it might catch the interest of middle school pupils and increase their curiosity about technology. I think that this way, they will find their lessons more entertaining."

Lastly, the findings obtained from preservice teachers' opinions and experiences on what difficulties they encountered in their lesson plan preparations, are presented in Table 4.

In Table 4, it is seen that most participants did say that they had various in the lesson planning activity. With regard to using Phyphox, they had problems about how to use Phyphox and had to do with choosing and using a Phyphox feature that would be appropriate for middle school topics. The participants also said they experienced some difficulties when the Phyphox app did not work on the phone. For instance, P20 said, "I had a hard time at the beginning when I was first starting to use the app. I figured it all out later. Then my first goal was to find a good topic and an activity where I could use the app. I had a little trouble here too. But later, I was able to continue smoothly without any more trouble." Another aspect that gave the participants trouble was related to preparing the lesson plans. The preservice teachers said that they had trouble finding appropriate learning content, deciding at which stage of the lesson they should make use of Phyphox, and with preparing a lesson plan in line with the 5E Model. In this context, P29 said

the following: "It was a challenge to link the learning outcomes with the lesson. The learning outcome for the science class was ready but I had trouble linking the learning outcomes in the technology and design class with appropriate experiments." Additionally, few participants said they had difficulty with the equipment they were using, specifically stating that they had trouble setting up an electrical circuit. P37 said, "I had trouble with setting up the circuit. In connecting the cables." On the other hand, about one third of the participants said they had faced no difficulties at all. P5 for example said: "No, I didn't encounter any difficulty. Just the opposite. The features Phyphox offers enabled me to complete my lesson plan easily and quickly."

## Discussion

The researcher in this study explored how a group of preservice science teachers drew up their lesson plans for teaching the topic of their choice in a middle school "Science" course using the Phyphox app. Further exploration was devoted to learning the preservice teachers' opinions and experiences related to this process. In addition, the preservice teachers were asked to associate the topic treated in their lesson plans with the "Mathematics" and "Technology and Design" courses. Thus, as Chittleborough (2014) has suggested, the objective here has been to examine how an innovative application such as Phyphox can be used in fostering a culture in the schools whereby technology is explored with a mobile phone, an already widely available technological device. By encouraging the preservice teachers to prepare their lesson plans by incorporating learning outcomes not only in "Science" but also in "Mathematics" and "Technology and Design," the goal in this study of promoting the current widely favored interdisciplinary approach was also achieved.

The outcome of the study was firstly the observation based on the review of the preservice teachers' lesson plans that there was a decrease in the number of lesson plans corresponding to the higher grades. This finding may be interpreted to mean that the preservice teachers found themselves more prepared to teach lower class levels in terms of making associations with technology. It may be that they felt less competent to teach the science topics in the seventh and eighth grade curriculums. This is perhaps why Phyphox appeared less in the lesson plans for the upper grades. Novak and Wisdom (2018) state that preservice elementary school teachers generally have limited science content knowledge. At the same time, this result may have been a consequence of the preservice teachers' limited experience in teaching. Indeed, at the time the study was conducted, the participants had not fully completed the practical training although they

**Table 4** Opinions and experiences of the preservice teachers on the challenges of the activity

Theme	Categories	Codes	f (%)
Challenges experienced in the activity	There was some difficulty	in using Phyphox	19 (44.2)
		in preparing the lesson plan	7 (16.3)
		in using the materials	2 (4.6)
	There was no difficulty	easily performed	16 (37.2)

had taken the field courses in previous semesters. It is useful therefore to note that the preservice teachers were in the seventh semester of their program and did not have sufficient teaching experience and practice. In this context, Ronfeldt et al. (2014) reported in their large-scale study that taking more methodology courses and engaging in more practical training better prepared preservice teachers for their professional lives. On the other hand, this outcome conflicts with the results of the study conducted in the Netherlands by Admiraal et al. (2017) in which the authors declared that preservice high school teachers integrated different technologies into their higher-level classes. The conflicting outcomes in the present study and the study by Admiraal et al. (2017) may be associated with the differences in the backgrounds of the participants, the students the lesson plans were drawn up for (middle school vs. high school) and consequently, the specific science topics being taught. The results of Lei's (2009) study in the U.S. also assert that preservice teachers should limit the use of technology in lower grades since they believe that there are other fundamental elements of knowledge that students in these grades should be learning. However, when it is considered that articles in the literature generally reflect the use of Phyphox-supported teaching at the university (Mayampoh et al., 2021; Nanto et al., 2022; Nkundabakura et al., 2024; Saprudin et al., 2020; Ürek & Çoramık, 2023; Ürek, 2024) and high school levels (Pierratos & Polatoglou, 2020), it is believed that the present study carries significance in that the lesson planning executed by the preservice teachers for the lowest grade at middle school can be expected to prepare students to use this application with ease in their science classes at higher levels of learning.

Another outcome of the study was that the teachers and students using Phyphox were approximately equal in number as users of the app while implementing lesson plans. This means that the preservice teachers approached the use of the Phyphox app in lessons equally, regardless of whether it was being employed by the teacher or the students. When it is considered that the target group in this case is middle school pupils, it must be said that classroom teachers need to provide students with effective guidance in the use of this application. Indeed, the Turkish Ministry of National Education (MoNE, 2023) has put regulations into effect that stipulate that students should not be allowed to use their mobile phones at school or in the classroom in ways that disrupt lessons. Teachers therefore need to exercise caution in the classroom or laboratory setting when students are using the Phyphox app to make sure that students do not use their mobile phones for purposes other than classwork. The researcher in the present study discovered that the preservice teachers believed that the learning process related to this app would be both educational and entertaining for

students. In fact, Ürek and Çoramık (2023) revealed in their study conducted with preservice teachers that this application was found to be quite entertaining. It might be safe to say that these features of the application may indeed provide motivation for students working with Phyphox in the classroom and prevent them from using their mobile phones for extraneous purposes.

The preservice teachers used Phyphox the most during the Explore stage of preparing their lesson plans. This gave the students the chance to make relevant observations regarding the topic at hand and to explore by collecting and interpreting the data. For example, P20 indicated that the students were divided into groups and asked to test the sound insulation of cartoon boxes by using the audio amplitude feature of Phyphox in the Explore stage of the lesson. This preservice teacher wanted the students to use three types of cartoon boxes, one of which was empty and the other two were isolated using different materials such as cotton, sponge etc. Afterwards, P20 asked the students to place the same sound source in the box and close its cover. Then, the students measured the audio amplitude in equal distances to the box in dB for each case. Thus, the objective of the exercise was to give the students the opportunity to explore sound insulation. Besides, Namdar and Kucuk (2018) have reported that preservice science teachers are generally unable to include enough 5E-based activities in their lesson plans to engage students. This shortcoming can be overcome with the use of Phyphox. P6 said in this context, *"The various features of this application (e.g., graphics, collecting numerical data, and other features) enabled me to complete the activity quickly and easily. I have no doubt that the features Phyphox offers will greatly contribute to the experimental design and application process of science teachers like me. I would like to use Phyphox actively in the future."* P15 stated, *"This application turns abstract concepts into concrete notions and makes learning much more meaningful. For example, although atmospheric pressure is discussed in science classes, its exact measurement at the students' current location cannot be exactly demonstrated. In the lesson plan I designed, I measured atmospheric pressure with Phyphox and presented the students with the exact numerical value. I didn't need any other tool for this. This way, Phyphox helped me to plan a more entertaining lesson."* In the present study, the other stage of the model in which Phyphox was used the most was the Elaborate step. Besides, Sungur Gül and Saylan Kırmızıgül (2023) found in their study that preservice teachers mostly used Algodoo for the Elaborate stage of their lesson planning. The next most common stage at which this application was used was the Explore stage. While these researchers also reported that the preservice teachers in their study were ready to use Algodoo for the Engage and Evaluate steps as well, albeit not as much

as for the other steps, the present study did not reveal such an outcome. This different result may be because of how the different features of the Phyphox and Algodoo applications impact the learning process.

In the study, it was found that the Phyphox features to be most selected for the preservice teachers' lesson plans were the "light" and "acoustics" features. The preservice teachers may have chosen these features because they operated on easier setups. This finding is corroborated by the participants themselves. For example, P12, who was preparing a lesson on sound propagation, said the following: *"At first, I thought I would have problems with this application since I didn't know how to use it. I saw later that it was easy to use."* Similarly, P25, who was preparing a lesson plan on the interaction between light and matter, said, *"To be frank, before I started working on the lesson plan, I thought that using Phyphox would be difficult. But when I started to work with it, I realized it wasn't hard at all. After I read through the training program, ideas started coming to me and I used these ideas to create my lesson plan."* It was seen that the Phyphox features were compatible with the topics included in the lesson plans. The light feature, for example, was used in the topics of light transmission and absorption. It was also observed that the topic of light bulb brightness was associated with the light feature in the lesson plans even though it is more related to the topic of electricity. The lesson plans incorporated physics topics, and these topics too were by nature compatible with Phyphox (Stampfer et al., 2020). A few preservice teachers used a creative approach by applying the light feature to biological topics such as "seed germination" and "the ear." In this context, it might be said that no study has been encountered in the literature on integrating Phyphox into a subject outside of physics. While Phyphox has been more commonly used for the topic of kinematics (Bernardini et al., 2024; Coramik & İnanç, 2023; Çoramık & Ürek, 2021; Johansson et al., 2024; Pieratos & Polatoglou, 2020), the present study showed that the preservice teachers used the motion stopwatch, inclination and other similar features to a lesser extent. This may have stemmed from the participants' degree of readiness to make use of these features, and also from the target group that the lesson plans addressed.

It can be seen from the study that the lesson planning activity that the preservice teachers engaged in contributed to their development in many ways, preparing them professionally, improving their skills, and using Phyphox. Since preservice science teachers primarily need a good knowledge of their field, along with the ability to associate field knowledge with daily life and develop a rich repertoire of experiments (Nilsson, 2009), Phyphox thus helps preservice teachers to better structure their lesson content. In keeping with these conclusions, it was determined that all the

participants expressed their intention to use the application in their future classes. Similarly, Sungur Gül and Saylan Kırmızıgül (2023) reported at the end of their study that all the preservice teachers wished to use Algodoo in their own classes in future, stating that the lesson plans they had prepared on the basis of this application contributed to their development in many ways. Researchers reporting their results in other studies have noted that preservice teachers registered increased self-confidence regarding their technological and pedagogical field knowledge (Canbazoglu Bilici et al., 2016), the use of technology (Adamy & Boulmetis, 2005), feeling empowered to take meaningful strides in their attempts to integrate technology into science teaching (Rehmat & Bailey, 2014). Thus, the positive effect of having preservice teachers incorporate technology into their lesson plans goes beyond teaching the subject matter, reaching a wider scope of learning that includes communication, evaluation, and the preparation of materials.

With respect to the contribution of Phyphox to the learning and teaching process, the preservice teachers pointed to the positive effects the application had on their lessons, on students, and on the process of experimentation. Zhou et al. (2017) assert that the concept of having preservice teachers include technology in their lesson plans was not necessarily born out of the arrival of new technologies but because the teaching process stood to benefit from being helped in creating more effective experiments. The fact that the preservice teachers in this study espoused the same approach, especially in emphasizing the advantages Phyphox presents in the experimentation process, reflects a similar insight. P28 made the comment, *"Students can perform experiments using this application in subjects they have not fully conceptualized or are not sure of."* P30 said, *"Since students will be arriving at mathematical results when they perform experiments with Phyphox, all their doubts will be dispelled."* Meanwhile, Polly and Binns (2018) point to the necessity of focusing on technologies that science teachers can use to reinforce higher thinking skills and make lesson content more engaging for students. It is evident in this context that the preservice teachers' views in this study about how they found the opportunity to develop higher cognitive skills and creativity in their students and carry out different kinds of experiments are in keeping with the viewpoint of the mentioned researchers. In connection with this point, P20's comment was the following: *"Phyphox can enable middle school pupils to think multidimensionally. This application gives them much more than they can receive in a classroom lecture. They will thus gain a broader perspective and be able to synthesize new knowledge."* P39 said, *"Students learn how to think more comprehensively. They think about where else they might use this application. This fosters creativity."* There is a similarity between these views

and the positive opinions previously expressed by Ürek and Çoramık (2023) about the way lessons encouraged permanent learning, made use of creativity, and facilitated observational skills when they reported on a Phyphox-supported activity that they had conducted with preservice teachers. In short, the preservice science teachers' views on how Phyphox could contribute to the learning and teaching process is consistent with what is reported in the literature.

Finally, regarding the challenges faced by the participants in their preparation of lesson plans, it was found that about one-third did not report having any difficulty, while a greater percentage did state that they had trouble with lesson planning, using Phyphox, and working with the various materials. The difficulties faced in preparing the lesson plans involved determining expected learning outcomes and deciding in which stage of the lesson Phyphox could be used. Similar difficulties were also reported by Strangis et al. (2006). The fact that the participants spoke of experiencing various difficulties in the present study is understandable when it is considered that they worked on the lesson plans from both a theoretical and a practical outlook. Meanwhile, Aktaş and Özmen (2020) have reported that in their transition from the “lesson planning” stage to the “school application” stage, preservice science teachers display development in different fields. It can be considered therefore that the practical experiences preservice teachers engage in during their training will help them overcome such challenges.

### Limitations

Lastly, this study is limited to the qualitative data obtained from a group of senior-year preservice science teachers in their seventh semester in the context of preparing Phyphox-supported lesson plans. At the same time, the preservice teachers performed their planning theoretically and on paper. Although they used the experimental setups and took quantitative measurements, they performed these on their own. Thus, the study does not include practical experimentation in the actual class setting related to the grade the preservice teachers will be teaching. This is another limitation of the study. It may be recommended that this process is taken up in the eighth semester of education, at which time preservice teachers may apply their learning to middle school students. The effectiveness of extending the learning process in this way can thus be analyzed, providing a means of contributing more enriched data to the literature.

### Conclusions, and Suggestions

To conclude, this article reports a summary of the opinions and experiences of a group of preservice science teachers who prepared their lessons plans based on the 5E Model

and with the support of Phyphox. Besides the many positive benefits the participants gained from this activity, it is believed that some of the outcomes may be related to the preservice teachers' limited teaching experience and should be examined more thoroughly in future studies. It is recommended that the results obtained should guide future studies in that:

- The attitudes, approaches and other perspectives of preservice teachers reflected in these types of lesson planning activities should be explored quantitatively,
- How preservice teachers can integrate Phyphox into topics outside of physics and creativity levels related to this should be explored,
- Preservice science teachers should be encouraged to use Phyphox in their teaching practice for their lessons with middle school students. The effect of this instruction on different variables in the teaching process (content knowledge of the preservice teachers, their self-efficacy) can be explored in more detail with mixed research methods.

**Funding** The author did not receive support from any organization for the submitted work.

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

### Declarations

**Ethical Approval** Ethical approval was taken from Science and Engineering Ethics Commission of Balıkesir University (E-19928322-100-459526).

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

**Competing interests** The author has no competing interests.

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