Şahin-Kalyon, D. (2021). Teaching Science: Who am I? What do I plan. *International Online Journal of Education and Teaching (IOJET), 8*(3). 2150-2175.

Received : 24.03.2021
Revised version received : 23.06.2021
Accepted : 24.06.2021

TEACHING SCIENCE: WHO AM I? WHAT DO I PLAN?

Research Article

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Abstract

Achievement in primary school science courses has always been a field of interest by researchers in Turkey and other countries. For this reason, studies are conducted on science teaching at the primary school level. This study aimed to examine strengths and weaknesses of pre- and in-service primary teachers in science teaching. In addition, to overcome their weaknesses, the features that they imagined for a science classroom were revealed. Seventy-seven juniors, 78 seniors, and 87 in-service teachers participated in this study. The study data were collected through an opinion form called "I Teach Science," consisting of four questions. Findings were revealed following a descriptive analysis. The findings of the study revealed that the most frequently uttered strengths were the ability to do/design experiments, adoption of activity-based science teaching, application of different methods/technical knowledge, science process skills, and an interest in/attitude toward science. The most common weaknesses were found to be lack of field knowledge, lack of self-confidence, inability to do experiments, lack of laboratory knowledge, inability to design/use materials, and lack of interest in and attitude toward science. The most common ways they would apply to improve their weaknesses were found to be research, reviewing resources, obtaining help from experts or colleagues, designing experiments, researching/learning different methods, using different resources, and developing planning skills. While describing an ideal science classroom, the participants considered general characteristics of students and teachers and general/physical features of the classroom.

Keywords: science teaching, primary teachers, pre-service primary teachers, learning environments

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1. Introduction

Human life consists of making decisions, adapting to changes, and solving problems. Thus, how does a person decide among lots of choices, keep up with changes, or determine the accuracy of information? In short, which skills enable an individual to live a more active life in this world? These questions can generally be responded to by saying that skills such as research, inquiry, and problem-solving will help the individual lead a better life. People with these qualities realize the cause-and-effect relationship between the events and behave rationally in making decisions that will affect themselves and others. The answer to how to acquire these skills, which have an important place in daily life, lies under education given at an early age. Harlen and Qualter (2018) stated that education should prepare children for life in a world where their science and technology practices have key roles and lead them to acquire various skills and knowledge leading to understanding the scientific and technological aspects of the natural and artificial world around them. They also claimed that education should include the capacity to establish cause-and-effect relationships, to understand the nature of science and how scientific knowledge develops, and to include key ideas that will enable them to make rational decisions about how to survive and how they influence others' lives. In general terms, education - specifically science education – attempts to provide individuals with these characteristics, which will enable people to live a life with high awareness and understanding. The primary purpose of a science course, which includes subjects from disciplines such as physics, chemistry, biology, astronomy, and earth and environmental sciences, is to enable individuals to become science literate. Science literate individuals are those who are able to investigate and question events, make effective decisions, solve problems, be confident and open to cooperation, effectively communicate, learn throughout their lives with an awareness of sustainable development, use scientific knowledge for personal and social purposes, and use appropriate science processes and principles in individual decision making (American Association for the Advancement of Science [AAAS], 1990, pp. xvii-xviii; Milli Eğitim Bakanlığı [MEB], 2013; National Research Council [NRC], 1996, p.13). In addition, science education helps individuals not only develop reasoning and behavior that will enable them to live a physically and emotionally healthy and rewarding life but also guide personal preferences that affect their health and career choices. Science also arouses curiosity in both natural and science-created aspects of the world. It improves the learning skills needed in a rapidly changing world and the acquirement of an attitude to the use of evidence while making scientific or personal decisions. Science enables learners to be informed citizens who reject quackery and realize that evidence is used selectively to support arguments in favor of particular actions (Harlen & Qualter, 2018).

In a world where scientific and technological improvements are accelerating, the identification of accurate information is becoming increasingly complex, and it is necessary to make the wisest decision among several alternatives, individuals must have the above-mentioned characteristics to lead an active life. As these characteristics must be acquired from childhood, the science course aims to develop them starting from primary school. This course introduces the first steps to enable individuals to live a more satisfying life. Dawson

and Venville (2010) claimed that if young people have the understanding and skills to participate in public debates and make informed decisions about issues affecting their lives, this is the result of science education. However, it is possible to acquire such skills and knowledge only by creating appropriate learning environments. When it comes to learning environments, one usually thinks of classrooms where desks are traditionally placed one after the other with a blackboard on the opposite side. Nevertheless, a learning environment is more than a physical space. "A learning environment refers to various physical locations, contexts, and cultures in which students learn. This term is often used as a more accurate or preferred alternative to the classroom, which has more restricted and traditional connotations, as students can learn in various settings, such as out-of-school and outdoor environments" (Learning Environment, 2013). In addition to the physical environment, also classroom culture, teachers' learning approaches, digital technologies and materials, and teaching methods and techniques are included in the learning environment. The learning environment also covers learners' characteristics, learning-teaching goals, support activities, and assessment strategies to guide and measure learning (Bates, 2015, p. 490). A learning environment is built on the following five foundations: psychological, pedagogical, technological, cultural, and pragmatic. The psychological foundation reflects individuals' views about how they acquire, organize, and use knowledge and skills; the pedagogical foundation emphasizes how an environment is designed and what opportunities are provided by focusing on the activities, methods, and structures of the learning environment; the technological foundation shows how existing technologies can be optimized by creating appropriate tools for both the designer and the learner and affecting the design of learning systems; the cultural foundation affects the design of learning systems by projecting social traditions and values of the nature and role of education, as well as common beliefs about cultural values, education, and social roles of individuals; finally, the pragmatic foundation emphasizes whether a particular approach in a specific learning environment can be used (Hannafin & Land, 1997). Based on these characteristics and considering the community culture and what the learners know, a teacher chooses the appropriate teaching methods and techniques, determines the technological tools to be used, and designs the learning environment according to desired outcome, a subject, or a course. Such a design includes the whole teaching process of a course.

The basic purpose of science teaching is to educate an individual to become science literate; thus, it is essential to design learning environments effectively to achieve this goal. Just as science is an integral part of society, science education is an indispensable part of children's education. For this reason, effective science education should be ensured by balancing the excitement of scientific facts with the meticulousness of their explanations (Baird, 1988, p. 70). In other words, sufficient and relevant information should be taught by awakening students' curiosity about science subjects. Moreover, it is necessary to organize the subjects as contents that learners can use in their social lives. Thus, students who gain skills such as problem-solving, establishing cause-effect relationships, and reasoning, will also realize how much they contribute to their personal development by monitoring their own learning. To achieve these goals, science learning environments should be designed in such a way that students actively participate in the teaching process while gaining both knowledge and skills. Furthermore, knowing how children learn science and acquire certain science concepts can be used in designing effective environments (Vosniadou, Ioannides, Dimitrakopoulou, & Papademetriou, 2011). Nourishing science teaching will be ensured by creating learning environments where students are responsible for their own learning, actively participate in learning activities, assume the roles of seeking, inquiring, explaining, and discussing the source of information, contribute to expressing their own thoughts,

develop their reasoning and communication skills, and engage in practical cooperation and communication with their peers while researching and inquiring information (MEB, 2018).

As teachers are considered fundamental designers of an effective learning environment, they play an important role in achieving the goal of science teaching. Baird (1988, p. 70) claimed, "The future of science education lies primarily in science teachers, not in curriculum or technology." Thus, it would be safe to say that teachers are the most compelling factor in science teaching and achieving teaching goals. In this direction, a science teacher is expected to encourage students in the science learning-teaching process and guide the integration of science, technology, engineering, and mathematics. Moreover, the teacher is expected to bring students to adopt higher-order thinking, develop products, and do invention and innovation by sharing the value of science and the responsibility and excitement of reaching scientific knowledge and leading the research process in the classroom (MEB, 2018). As science teaching is under the responsibility of primary teachers in primary schools, these roles are expected from the primary teachers, and they are required to perform such a task in the above-specified direction. Successful and competent science teaching by primary teachers will enable students to learn scientific facts and form a basis for their further learning. In a learning environment where students are not allowed to structure information, learning is achieved by establishing a relationship between the old and newly learned information. Students' ability to go through this stage accurately and effectively is related to the teaching process created by their teachers. The success of teaching, a complex activity that can be defined as helping students construct knowledge actively based on assigned tasks (Tynjala, 1999), is only possible if the teacher chooses suitable strategies and actions for the current classroom situation (Baird, 1988, p. 58). From this perspective, it would be asserted that successful science teaching can be realized through science learning environments designed by the teacher with appropriate and sufficient field and pedagogy knowledge. For this reason, primary teachers should ensure that students actively construct science knowledge while developing their problem-solving and reasoning skills and help them to collaborate and communicate practically with their peers. In addition, teachers see that science consists of ideas, innovations, and acts in daily life, upon realizing that the purpose of science education is more than providing information (Fitzgerald & Smith, 2016). Thus, they notice that they should provide students with both content-related information and knowledge and skills to use information in daily life.

In line with these roles and characteristics, teachers are expected to teach science effectively. However, another issue should be considered. Although all teachers are expected to fulfill the roles based on the presupposition of adopting these qualifications, it is unknown to what extent they internalize such qualifications, nor how much they can fulfill such roles. In the related literature, where the focus is rather on teachers' opinions and attitudes toward science courses than on how much they have the mentioned qualities, we can see that they are not confident and have difficulties in science teaching more than other lessons (Holroyd & Harlen, 1996). Teachers sometimes have problems while teaching the subjects within this course and cannot experience an efficient teaching process. To reveal the origin of such problems, it is necessary to determine how much teachers have the expected qualifications and roles and what impression they have of fulfilling these roles. Regarding science teaching, knowing why teachers have difficulties, how they see themselves in science teaching, and what their strengths and weaknesses can be considered as the first step in improving the teaching process. Teachers' awareness of their strengths and weaknesses will also affect the learning environment. A teacher who is aware of his/her weaknesses can better see where to start and look for different ways to strengthen these aspects. Therefore, s/he will create a richer science learning environment and enable students to be exposed to more effective

teaching. At the same time, s/he will definitely enrich the science learning environment by building the teaching processes on his/her strengths. Likewise, knowing the strengths and weaknesses will guide pre-service teachers in what they should pay attention to while teaching. In conclusion, in- and pre-service primary teachers achieve success in science teaching by gaining awareness of their strengths and weaknesses in science teaching. For these reasons, this study aimed to reveal the strengths and weaknesses of in- and pre-service primary teachers in science teaching and their ideal science learning environments.

This study aimed to reveal the strengths and weaknesses of in- and pre-service primary teachers in science teaching, their plans to improve their weaknesses, and the features of their dream science classrooms. For this purpose, we sought answers to the following questions:

1. What are the strengths of pre-service primary teachers in science teaching?
2. What are the strengths of in-service primary teachers in science teaching?
3. What are the weaknesses of pre-service primary teachers in science teaching?
4. What are the weaknesses of in-service primary teachers in teaching science?
5. What are the plans of pre-service primary teachers to improve their weaknesses in science teaching?
6. What are the plans of in-service primary teachers to improve their weaknesses in science teaching?
7. How do pre-service primary teachers depict a science teaching environment?
8. How do in-service primary teachers depict a science teaching environment?

2. Method

2.1. Research Design

In this qualitative study, a case study design was employed. A case study is noteworthy in qualitative research as it explains situations (events) that are difficult to explain with experimental research and attempts to define conditions where they occur (Büyüköztürk, Çakmak, Akgün, Karadeniz, & Demirel, 2010, p. 273; Yin, 2003, p. 15). Miles and Huberman (1994) defined a situation as a phenomenon that always happens in a limited context. This research focused on the participants' beliefs about science teaching and the environment in which they dream of performing science teaching. In- and pre-service primary teachers are the target participants. In other words, the data did not go beyond the participants' beliefs and the teaching environment they dreamed of.

2.2. Study Participants

Seventy-eight junior and 77 senior students studying Primary Education at a state university in the Black Sea Region and 87 in-service primary teachers serving in various cities of Turkey participated in the study. The seniority of teachers varied between one and 18 years, with a mean age of 37 years.

A criterion sampling method was used for sample selection. The criterion for pre-service teachers was to have taken the "Basic Science in Primary School," "Science Laboratory Practices," and "Science Teaching" courses. For in-service teachers, it was just "being a primary teacher." We paid particular attention to the voluntary inclusion of participants, who were informed about the purpose of the study.

2.3. Data Collection Tool

This study examined the opinions of in- and pre-service primary teachers. For this, an opinion form called “I Teach Science” was developed and used. We consulted expert opinions during the development of the form and structured the questions with respect to discourse and grammar.

The opinion form covered four open-ended questions in line with the research purpose. The first question was about the participants’ strengths in science teaching; the second question was about their weaknesses; the third question was about their plans, if any, to remedy their weaknesses. In the last question, the participants were asked to imagine and describe an environment where they desired to teach science. The pre-service teachers provided the data by writing their responses on the opinion form science teaching environment. In-service teachers, instead, filled in the opinion form on a computer through an online platform.

2.4. Validity and Reliability

To ensure the internal validity of the study, we consulted a subject-matter expert about the formulation of the study (peer examination). We used the data source to check some of the data collected online or face-to-face, and participant checks were provided through phone calls. For external validity, detailed description and typicality techniques were used. We utilized the evidence chain created through telephone interviews to increase the construct validity of the study. We planned and determined the process steps in advance before starting the study. After three-four months from the first analysis, we re-analyzed the data and started reporting based on similarities and differences between outputs. In addition, an academic expert checked the findings after the analysis. We have attempted to present the research report in as much detail as possible.

2.4. Data Analysis

In line with the descriptive analysis approach, we summarized and interpreted the data by the following pre-determined themes: (1) “Strengths in Science Teaching,” (2) “Weaknesses in Science Teaching,” (3) “Plans,” and (4) “My Science Classroom.” Pre-determination of the themes prevented data loss to a great extent and provided data organization. Among the data collected by the specified boundaries and brought together in a meaningful and logical framework, the ones that would be directly quoted for later were selected. While sharing the direct quotations, we used code names for the participants, such as ”S1” (for pre-service teachers) and “T1” (for in-service teachers). In “Findings” and “Discussion” sections, we proved cause-effect relationships and made comparisons with similar or different studies in the literature. This research scrutinized the strengths and weaknesses of the in- and pre-service primary teachers in science teaching, their plans for developing their weaknesses (if any), and how they wanted to shape their science classrooms. We hope that the study will raise awareness among in- and pre-service teachers in eliminating their existing shortcomings. With this study, we attempted to submit the opinions of a group of participants to the other interested groups (academicians, teachers, and teacher candidates). “Findings” section did not include frequencies of code repetition by the participants under the themes. We think that the obtained results will create awareness in science teaching at the primary school level. For this reason, even situations that were not very frequent were considered important issues to be addressed.

3. Findings

3.1. Strengths in Science Teaching

In this study, we asked the participants what their strengths were in science teaching. The categories and examples obtained from the analysis of the responses are presented in Table 1.

In Table 1, categories consisting of the responses of both in-service and pre-service teachers are included in the first 10 rows; those of only pre-service teachers are given in rows 11 to 15; while those of in-services teachers are located between rows 16 to 18. In the "Other" category, responses of in- and pre-service teachers are given mixed. The strengths of the participants were clustered under 18 categories.

Table 1. *Categories created for the strengths of in- and pre-service primary teachers*

Categories	***Sample Quote***
Doing/designing experiments	*S8: I like to research . . . I like to deal with experiments . . . I feel vigorous in this field because these activities make me closer to this lesson.*
Adopting activity-based science teaching	*S30: . . . based on research, I can find new experiment and activity ideas from available books and journals, and I can teach a practice-based lesson in my classes. . .*
Applying different methods/technical knowledge	*S15: . . . while teaching science, I can apply the methods and techniques that can appeal to students . . .*
Having science process skills	*S16: I think that I can make robust predictions about the given situations and can easily reach the desired result with proper and correct research.*
Having an interest in/attitude toward the science	*S41: I am more interested in science. That's why I enjoy taking related courses and explaining them.*
Being curious	*S55: Wondering and investigating what I wonder are among my strengths . . .*
Being a master in field knowledge	*S89: I think that I am better at science subjects thanks to the activities introduced by our professors at the university.*
Designing/using material	*S84: My strengths include being able to create any material and present them in the class.*
Motivating/attracting attention	*S32: I can attract and motivate students.*
Ability to ask questions	*S46: I ask questions about how events that will arouse students' curiosity occur around us; thus, guiding them to research and inquiry.*
Researching	*S1: I like to do research to teach the lesson with different methods . . . That's why I feel strong.*
Laboratory knowledge	*S71: I can use the microscope easily. I follow the laboratory rules and know how to behave in a lab environment.*
Questioning/being critical	*S46: Among my strengths in science, I think the most important ones are curiosity and success in inquiry and research.*
Regarding the lesson	*S11: I know what the science lesson brings to students, its importance and place in their lives.*
Curriculum knowledge	*S2: I know the curriculum and what it expects from me.*
Being able to associate science with daily life	*T35: In the science lesson, the topics are linked to the events we encounter in daily life. Literally, this is a lesson from life. So, I give examples from daily life to children while explaining the subjects, which helps my students learn the subjects permanently and meaningfully.*
Being able to teach the lesson at the student level	*T7: Being able to teach the lesson at the student level and embody the subject.*
Being able to utilize technology	*T15 . . . I try to make use of technology as much as I can.*
Other	*Having nature intelligence, patient, creative, problem-solving, following current issues and resources, and having a different perspective*

Most of the participants reported that they were able to do experiments and made the science lesson more effective by designing experiments. Primary school science lessons generally include subjects related to life. Teachers should introduce in their classes' different activities to establish a relationship between daily life and classroom practices. For this reason, a science class can be potent as long as practice-oriented teaching is adopted. When it comes to practice in science, the first thing that comes to mind is undoubtedly experimentation, because science naturally bears experiment and observation. Due to its place and importance in the science lesson, pre-service teachers may also have frequently mentioned the ability to do/design experiments among their strengths.

> *S127: I believe that I have succeeded in . . . the experiments that have been done before. I think I have achieved this success with the precise results of the experiments.*
> *T1: I search for the experiments and activities that can be done in the classroom and have the students do these experiments by separating them into groups.*

The science lesson is taught in the third and fourth grades at the primary school level. Considering the developmental characteristics of the students, teachers should propose them concrete activities and concepts. Table 1 indicates that the in- and pre-service primary teachers adopted activity-based teaching among their strengths. Teachers frequently emphasized that their students were included in the learning process by doing and experiencing through activities.

> *S27: I like to introduce different activities.*
> *T27: I have a try-and-do and an activity-based understanding.*

While the in- and pre-service teachers talked about their strengths, they often highlighted that they had different methods and technical knowledge and could apply these methods and techniques correctly. The frequently mentioned methods by participants were drama, argumentation-based teaching, problem-based teaching, the 5E model, and inquiry-based teaching.

> *S118: Since I know different methods and techniques suitable for science lesson, I can teach the subjects by applying different methods.*
> *T81: I make use of materials, plays, and creative drama. I frequently include these methods in my science classes, which is my strength.*

Science process skills are used by scientists in their studies, but they also help students gain an understanding of the world and find solutions to problems. Therefore, although these skills are related to other courses, they are among those that are mostly touched in a science course. The participants included adopting these skills among their strengths. Regarding science process skills, they mostly mentioned observation, guessing, experimenting, and inference.

> *S20: Observation, inference, inquiry . . .*
> *T45: Observation skill*

Although the word "curiosity" literally refers to enthusiasm and affection, it also means the desire to deal with something or to learn it. The participants mostly expressed their curious nature as a strength. Their interest in and positive attitude toward the field of science are among their strengths. In addition, the pre-service teachers stated that they knew how important the science course is for primary school students in terms of required skills.

> *S40: I always have a sense of wonder.*
> *T56: My curiosity about many things . . . about experiments, scientific studies, man, nature, etc . . . increases my interest in the science lesson.*

The participants reported that they had fundamental knowledge in fields such as physics, chemistry, and biology, which makes them have robust field knowledge. However, only the pre-service teachers expressed that having a good command of the curriculum was a strength.

> *S13: I have the background information and knowledge about experiments and know what method and strategy I should practice while teaching.*
> *T14: I have a robust background and capacity to do experiments.*

In general, teachers plan a 40-minute lesson in primary schools, including the science lesson, and try to include activities that will attract students' attention and motivate them to the lesson during this time. In the process, teachers use materials that make the subject matter concrete and ask questions to make students active in the class. Considering the strengths of participants, it was noteworthy that the above-mentioned issues were commonly uttered. The participants reported that they felt influential about motivating/drawing attention to the lesson using materials and asking questions.

> *S33: I can grab the attention of my students and motivate them to the lesson.*
> *S16: I think I can ask thought-provoking questions.*
> *T34: By asking questions that I do not know the answers to, I encourage children to become aware of the simplicity of not knowing something and asking conscious questions.*

Individuals need to conduct research to solve the problems they encounter in their lives or increase their available knowledge capacity. Pre-service teachers considered research skills as their strengths. They generally reported that they searched for resources, methods/techniques to make science teaching more potent. They also conducted research to follow innovations. They emphasized that they conducted research to follow current topics and to enrich the knowledge accumulated during their undergraduate education. However, in-service teachers did not mention any strengths within this category.

> *S94: . . . being able to observe, research, and comment on the subject.*

Experimental practices are of great importance in science lessons because teachers aim to provide their students with different skills through experiments. Teachers have to guide students in doing experiments in the science lesson. For this reason, teachers should know about laboratory materials or rules. Table 1 shows that pre-service teachers felt competent about the laboratory and included laboratory knowledge among their strengths. Nevertheless, in-service teachers did not utter any strengths related to laboratory use.

> *S54: The lab courses that we engaged in both semesters of the second year contributed to me a lot. I know how to make students question an experiment, how to get their attention, what to do before, during, and after experiments.*

Pre-service teachers expressed that questioning and critical thinking skills were their strengths in science teaching. The participants adopting such skills also reported that they would gain these skills for their students. They felt being one step ahead in science teaching thanks to their inquiry characteristics.

> *S48: I can think critically, and I have an inquiry-based perspective.*

In-service primary teachers, unlike pre-service ones, expressed their strengths the ability to associate science with daily life, to teach the lesson at the student level, and to benefit from technology.

> *T67: In the science lesson, the topics are linked to daily life events; it is literally a lesson from life. So, I give examples from daily life to children while explaining the subjects, which helps my students learn permanently and meaningfully.*
> *T35: I try to make use of technology as much as I can.*

Table 1 presents that the strengths of the participants are gathered under 18 categories. Ten of these categories contain strengths indicated by in- and pre-service teachers. While five strengths are mentioned only by pre-service teachers, three are mentioned only by in-service teachers.

3.2. Weaknesses in Science Teaching

In the study, participants were also asked what their weaknesses were in science teaching. Table 2 presents the categories and examples obtained from the analysis of responses. In Table 2, the categories consisting of the responses of both in- and pre-service teachers are included in the first eight rows. Categories consisting of the responses of only pre-service teachers are given in rows nine to 11, while those of only in-service teachers are presented in rows 12 to 16. In the "Other" category, the responses of in- and pre-service teachers are given mixed. As shown in Table 2, the weaknesses of the participants were clustered under 16 categories.

Most of the participants stated that they had deficiencies in fields such as physics, chemistry, and biology. To teach the main concepts in basic science (physics, chemistry, and biology) and to make students discover the equivalents of these concepts in daily life are among the specific objectives of science lesson. The lack of basic knowledge makes the participants weak in science teaching. As a matter of fact, the participants accepted that they were not able to do experiments and had problems in generating activities due to their knowledge gaps, which adversely affected their attitudes and self-confidence during the classes. Besides, the participants also felt weak mastering the concepts of science.

> *S27: Actually, I'm creative, but I cannot deploy it in classes. It may be because my knowledge and prior learning are lacking in this field. If I had had a good education, I would have been good at this field.*
> *S87: I think I have some gaps regarding the terms and names of experiment equipment. I think there are topics that I do not have enough knowledge on.*
> *S91: I don't think I have enough science knowledge.*
> *T62: Science is a field that requires very comprehensive and technical knowledge. I may have weaknesses in these technical and information-demanding parts of the field.*

Pre-service teachers associated their lack of field knowledge with the insufficiency of courses taken in pre-university periods. In-service teachers, in contrast, generally associated this situation with inadequate and unqualified undergraduate courses.

Participants also mentioned a lack of self-confidence among their weaknesses. Pre-service teachers related to the lack of self-confidence to the lack of basic science knowledge and the inability to plan a lesson. However, in-service teachers associated it with misconception due to lack of knowledge. Furthermore, the participants identified their laboratory knowledge gaps as weaknesses. Pre-service teachers reported that this situation also affected their self-confidence in being able to do experiments.

> *S101: I have problems with self-confidence since this course is in the scope of quantitative concept courses.*
> *S73: I have gaps in the field knowledge, and, therefore, I may fall short during experiments or lectures, which worries me.*
> *T4: I am afraid of causing misconceptions in children because I may misuse the concepts like melting-dissolving.*
> T29: Not being able to distinguish some laboratory materials and to conduct experiments in the laboratory.

Table 2. *Categories created for the weaknesses of in- and pre-service primary teachers*

Categories	***Sample Quote***
Lack of field knowledge	*S18: I'm afraid that I won't be able to teach it if the subject is based on experiments or biology and chemistry because I have poor background knowledge of such subjects.*
Lack of confidence	*S19: My unconfidence and fear of not being useful to students.*
Inability to do experiments	*S102: I think my ability to do experiments is not very good; I am insufficient.*
Lack of laboratory knowledge	*S67: I know that I cannot use some tools and equipment in laboratory classes, but I can solve this problem.*
Inability to design/use materials	*S84: Not being able to develop enough materials . . .*
Lack of interest in and attitude toward science	*S154: My weakness is that I don't like science, so I quickly forget the information I have learned.*
Not knowing science concepts	*S104: I do not understand some abstract concepts. I know that they will ask the questions I want to ask while explaining the concepts I do not understand to children. I have no idea about the answers.*
Inability to plan a lesson	*S19: . . . I cannot prepare a generally well-organized lesson plan . . .*
Problems in determining/practicing methods/ techniques	*S145: Sometimes, I cannot use different methods in this lesson because time may not be enough.*
Inability to determine appropriate experiments for students	*S2: I cannot predict whether the experiments I will do are suitable for the student level.*
Lack of science process skills	*S37: I have shortcomings in some of the science processes.*
Going off the subject	*T34: I can be extremely lost in and go off the topic, which leads to unnecessary - albeit a little - waste of time and information pollution.*
Problems in concretizing the lesson	*T86: Sometimes, I find it difficult to concretize abstract topics since there is no lab at our school.*
Not being aware of developments	*T7: Also, I am unable to review the latest science resources and miss the developments. Therefore, I need to read more.*
Insisting on traditional methods	*T51: I can sometimes have time problems, so I only use traditional methods in some of my classes.*
Having misconceptions and confusion	*T24: Misconceptions and not knowing the conceptual definitions . . .*
Other	*Use of technology, motivation, relating, inability to ask appropriate questions, classroom management, use of games, inability to respond to the question asked, and inability to identify misconceptions.*

Primary teachers are responsible for supporting student development in science by considering their cognitive development characteristics. While fulfilling this responsibility, they benefit from diverse teaching practices. One such a practice is experimenting. Pre-service teachers stated that they felt weak in determining appropriate experiments for their students. Some also felt weak about experimenting. Some in-service teachers touched upon the same issue, stating that they did not have enough experimenting practice and in addition, unlike pre-service teachers, they could not conduct experiments due to the lack of materials or laboratories in their schools.

S24: I may not be able to set experiments to be done by the age level.
S14: I do not see myself as competent enough to design and implement an experiment in a classroom.
T13: I can't do every experiment because of inadequate facilities.
T38: Everything would be better if there were a niche lab environment.

The participants highlighted lack of interest in or negative attitude toward science as their other weaknesses. They believed that they would not be able to teach science properly due to a lack of interest or attitudes.

S99: . . . since the lack of interest and knowledge will cause me to miss something in teaching science, which is my weakness.
S17: I have difficulty understanding and teaching science because I am not interested in it.
T1: When enrolling in the department of classroom education, we had already not had significant success in science. I do not find undergraduate science education sufficient. After the appointment, I realized having difficulty with some questions that students asked about science. I sometimes find it difficult to find answers to these questions that I am not interested in due to my poor background.

A science lesson is impressive only with a well-planned teaching process and the use of effective materials. The participants mentioned their weaknesses in planning the lesson and designing/using materials. While pre-service teachers generally stated that they had difficulties in designing materials, in-service teachers referred to not being able to find appropriate materials. While pre-service teachers talked about their shortcomings in preparing lesson plans, in-service teachers highlighted planlessness.

S19: . . . I cannot prepare a well-supported lesson plan in general . . .
S24: I try to find and do something on the internet, but I cannot be creative in an environment with limited opportunities and cannot make materials suitable for science teaching from the materials used frequently around us.
T24: Not being able to make a multidimensional lesson plan in advance.

In a science lesson, primary school students discover, research, inquire, and discuss arguments using their science process skills. In order for students to take on all these roles in the learning process, the teachers must include different methods and techniques in this process. Despite this, pre-service teachers reported that they felt weak in determining appropriate methods, techniques, and practices. They generally associated this situation with not knowing different methods and techniques, having troubles with time, and having problems in determining appropriate methods for the outcomes. Nevertheless, in-service teachers did not mention any weaknesses related to this situation.

S57: I don't know exactly how to use the 3E, 5E, and 7E models while teaching my lesson.
S64: I am not able to implement the 5E and argumentation-based learning models fully.

Pre-service teachers also emphasized their weaknesses in science process skills. However, in-service teachers did not mention any weaknesses in this situation.

S36: Sometimes, I cannot write the result of my observations. That is, I cannot report while experimenting and observing.
S130: I may not be able to comply with science process skills.

Pre-service teachers also expressed their weaknesses in technology, motivating the students, asking appropriate questions, classroom management, games, responding to students' questions, and identifying misconceptions.

In contrast to pre-service teachers, in-service teachers reported that they sometimes went off the subject, had problems in concretizing the lesson, preferred traditional teaching methods for compulsory reasons, and realized to have misconceptions. There were also teachers not aware of current developments. By reporting that they had problems in concretizing the lesson and preferred traditional teaching methods, the teachers generally associated this problem with the lack of materials or laboratories in schools. Teachers with misconceptions mostly experienced this while explaining any subjects to students.

> *T45: Sometimes, I have a lack of knowledge or confusion in some subjects. For example, I sometimes find it challenging to respond to simple questions, like "Is fire a natural or artificial source of light?"*
> *T72: Inability to concretize the subject due to the lack of experimenting materials.*

Table 2 shows that the weaknesses of the participants are clustered under 16 categories. Ten of these categories contain weaknesses indicated by in- and pre-service teachers; 3 are mentioned by only pre-service teachers; 5 are mentioned only by in-service teachers.

3.3. Plans for Science Teaching

In the study, participants were asked what plans they had to overcome their weaknesses in science teaching. Table 3 presents the categories and examples resulting from the analysis of their responses: the categories consisting of the responses of both in- and pre-service teachers are shown in the first 12 rows; those including responses of only pre-service teachers are in rows 13 to 16; in the "Other" category, responses of in- and pre-service teachers are given mixed. As shown in Table 3, the plans of the participants were gathered under 16 categories.

Research is a systematic search for information to clarify or reveal some facts and situations. The participants reported that they planned to conduct research to obtain the necessary information about their weaknesses. In the study, the most frequently reported plans were reaching information, teaching better by eliminating knowledge gap, finding materials and activities, eliminating the lack of field knowledge, being able to understand the developmental periods of the students, being able to master the curriculum, following the changes, knowing different methods/techniques, finding various experiments, understanding what science is, and conducting research to reach scientific knowledge.

> *S47: I will get scientific knowledge by doing more research.*
> *S32: Based on my research, I will learn about teaching and learning models.*
> *T48: I plan to conduct research to eliminate my weaknesses and reach the necessary information before explaining the subject.*

In addition to conducting research, the participants reported that they had plans to overcome their weaknesses by reviewing different sources. By reading and reviewing more, they aimed to obtain new information, compensate knowledge gaps, follow developments, and develop self-confidence. Books, journals, and scientific articles were mentioned as reviewing resources. They also stated that they should check different sources (e.g., videos) besides reading printed or electronic resources. They perceived watching the videos as learning different methods/techniques, obtaining different experiments, or improving their material preparation skills.

> *S6: I follow programs and read books that relax me and improve my self-confidence.*
> *S88: . . . I can watch videos on manual skills . . .*
> *T73: Reading scientific studies on misconceptions.*
> *T80: Learning different methods and techniques by watching various videos.*

Table 3. *Categories created for the plans of the in- and pre-service primary teachers*

Categories	***Sample Quote***
Research	*S40: We have already been taught about sub-branches of science for three years. I think there are a lot of differences in my current knowledge and capacity when compared to these in the first enrollment in the university. If I have been able to progress like this in three years, I think that I can learn more by conducting research in the coming years and accumulate enough field knowledge for my students.*
Resource reviews	*S132: . . . I think I can maximize my knowledge by researching and reading more.*
Expert or colleague assistance	*S9: I can get help from professors specializing in science.*
Doing/designing experiments	*S91: I will improve myself in science and learn new experiments and practices.*
Researching/learning different methods/techniques	*S134: . . . I also want to learn more about different teaching methods.*
Utilizing different sources	*S48: Watching videos on laboratory practices.*
Developing the ability to make plans	*S19: I need to research more lesson plan examples to improve my lesson plan writing . . .*
Mastering the curriculum	*S5: Considering and reviewing learning outcomes more . . . Producing activities that can improve these outcomes gains . . .*
Training support	*S143: I want to attend training organized in the field of education.*
Seeking for conferences/seminars	*S131: . . . I plan to attend conferences, seminars, and training summits to improve my weaknesses*
Improving self-confidence	*S66: I will be confident engaging in discussions.*
Increasing interest in and attitude toward the lesson	*S43: I should always come prepared for the lesson to be more willing and interested.*
Practice	*S28: I will try to put my theoretical knowledge into practice and identify my weaknesses to eliminate them.*
Observation	*S42: To make my teaching more effective, I have to observe teachers who are component in this job well and implement their methods myself.*
Learning by teaching	*S106: To strengthen my weaknesses . . . learning with my students, moving forward by both teaching them, and learning by myself . . .*
Developing science process skills	*S37: I will study the science process skills and understand them better in the future.*
Other	*Postgraduate education, additional field-oriented works, academic development, designing a practice class, increasing motivation*

The participants were willing to get help from experts to improve their weaknesses. The expert group they wanted to get help from included academics, experienced teachers, and colleagues from the same or different branches. Only pre-service teachers reported that they would improve by observing experienced colleagues and utilizing their experiences, and by getting direct help from their colleagues.

> *S42: I should observe competent teachers ensure the effectiveness of my teaching.*
> *S68: Or I will have conversations with my colleagues in science teaching about it.*

T25: I have to do research and exchange ideas with my colleagues to make my teaching more efficient.

Pre-service teachers asserted that they could remedy their weaknesses with practice. The practice referred to experimenting and implementing teaching plans. Some also believed that they would eliminate their weaknesses over time when they entered the teaching process with their students. Nonetheless, in-service teachers did not mention any weaknesses in this situation.

S30: I think I can overcome my weaknesses by preparing more lesson plans . . . by lecturing in the classroom.
S33: As a pre-service teacher, I want to make a fruitful observation and then teach students.

The participants were overall aware of the importance of the science lesson. Therefore, they had different plans to improve their weaknesses and enrich their classes. Researching and learning about different methods/techniques were among their plans. Another plan was to master the curriculum. They also reported that they wanted to do or design experiments to improve themselves. In addition, they aimed to make their teaching effective by enhancing their planning skills. Only pre-service teachers stated that they wanted to develop their science process skills.

S107: I will try to learn and generate new and original techniques.
S134: . . . I also want to learn more about teaching methods.
T32: I'm trying to learn new teaching methods and techniques.
T6: For this, it is necessary to review the curriculum constantly.

Scientific meetings, such as conferences and seminars, held in the field of educational sciences are organizations where academics and teachers share studies and knowledge. Teachers, as well as academics, benefit from these meetings. The participants reported that they thought that they could overcome their shortcomings by attending such scientific meetings and training.

S9: I can improve myself by reading science journals or attending conferences.
S131: I plan to attend conferences, seminars, and training summits to improve my weaknesses.
T11: Participating in seminars and training that will be useful for me . . .
T17: I can strengthen my weaknesses with in-service training and seminars.

While individuals are making observations, they identify the similarities and differences between the observed situations. Pre-service teachers believed that they should make observations to strengthen their weaknesses. They thought that they would overcome their shortcomings by observing other competent teachers.

S33: As a pre-service teacher, I want to attend a class in a primary school, make a good observation, and then teach on my own.
S72: I have to observe more to eliminate my weaknesses.

Considering the categories and examples given in Table 3, in- and pre-service teachers talked about common plans. Unlike in-service teachers, pre-service teachers stated that they could improve their weaknesses through observation.

Table 3 presents that the participants' plans are gathered under 16 categories. Twelve of these categories include the plans indicated by in- and pre-service teachers; four cover the plans mentioned by only pre-service teachers.

3.4. My Dream Science Classroom

In the study, the participants were asked about the features of their future science classrooms. We created categories by considering the sub-themes "Student," "Teacher," "General Features of the Classroom," and "Physical Properties of the Classroom." Table 4 shows the categories and examples obtained from the analysis of the participants' responses: the categories consisting of the responses of both in- and pre-service teachers are included in the first six rows; those of only pre-service teachers are given in rows seven to 11; responses of in- and pre-service teachers are given mixed in the "Other" category. There are 10 categories under the "Science Classroom" theme in Table 4.

Table 4. *The categories created for the dream science classroom of pre-service teachers: student and teacher*

	Categories	***Sample Quote***
Student	Researching	*S23: I want to raise my students as individuals who are curious about science and life, research, and questioning.*
	Inquiring	*S48: . . . A classroom full of students who wonder. . . . ask questions . . . question something.*
	Curious	*S60: I want students to have a strong sense of curiosity in my future science classroom.*
	Active	*S63: I will ensure that my students . . . be active.*
	Experimenting	*S66: Students in my dream science classroom . . . will be able to experiment and discuss.*
	Asking	*S71: I want to have students who ask questions, wonder, and research.*
	Science literate	*S74: My future science classroom . . . should be one with science-literate students.*
	Gained science process skills	*S3: I would like to have students with strong observation skills.*
	Other	*Having good communication skills, arguing, cooperative, self-confident*
Teacher	Guiding	*S62: A classroom environment where they are active while I am guiding them.*
	Attention-grabbing/Motivating	*S12: Being an exceptional teacher that does not distract children.*
	Other	*The best, having remarkable science process skills, competent, decisive, well-educated*

Teachers and students are the two main factors shaping the teaching process. The participants also drew the profile of students and teachers in their dream science classrooms. According to the participants, students in a science classroom should be able to research, inquire, be curious, do experiments, be active, be science-literate, have gained science process skills, be self-confident, discuss topics, and be cooperative. The participants desired to educate students with these characteristics. Pre-service teachers believed that a teacher should acquire science process skills, be the best in the field, attract/motivate the students, and introduce these characteristics to their students. Table 4 includes categories commonly mentioned by in- and pre-service teachers under the "Student" sub-theme. However, only pre-service teachers discussed the characteristics that a teacher should have. As shown in Table 4, there are a total of 10 categories within the "Student" and "Teacher" sub-themes under the "Science Classroom" theme: Six of these categories include student characteristics mentioned by in- and pre-service teachers; the remaining four contain the student-teacher characteristics mentioned by only pre-service teachers.

Table 5 includes situations discussed by the participants under the "General Features of the Classroom" sub-theme. In the table, categories consisting of the responses of both in- and pre-service teachers are given in the first six rows, while those of only pre-service teachers are shown in rows seven to nine. As shown in Table 5, there are nine categories under the "Science Classroom" theme.

Table 5. *My Dream Science Classroom: General features of the classroom*

Categories	***Sample Quote***
Experiment place	*S4: As a person who likes to do experiments, I would like to teach theoretical knowledge to my students first and then have them do several experiments.*
Out of school environment	*S23: Of course, since the classroom is not an area surrounded by walls, I want to take my students to out-of-class places related to the subject area.*
Practice-based	*S38: I want my future science classroom to be a practice-based place. That's why this lesson is fun.*
Fun/Happy classroom	*S26: I believe it will be a classroom full of fun and students who are free and can express their thoughts comfortably.*
A place where different methods/techniques are used	*S51: Being able to use all the teaching methods I have learned as much as I can.*
Democratic environment	*S56: A democratic environment where creativity is supported and respectful to different ideas.*
Active participation	*S1: I wouldn't want to teach in a highly theory-based system. That's why I want to have a classroom where students and I are always active.*
Constructivist environment	*S28: My basic philosophy will be the constructivist approach.*
Free environment	*S14: It is vital for me to create a free and comfortable environment where students can express their opinions.*

According to the participants, a dream science classroom should be a fun and democratic environment with happy students taught with diverse experimental practices, methods, and techniques. Such an environment can be created inside as well as outside the school. However, in dream science classroom descriptions, only pre-service teachers emphasized a free environment, on which the constructivist philosophy is based, and students' active participation in experiments and practices.

Table 6 depicts the situations discussed by the participants under the "Physical Properties of the Classroom" sub-theme. In the table, categories consisting of the responses of both in- and pre-service teachers are given in the first eight rows, while those of only pre-service teachers are shown in rows nine to 12. As shown in Table 6, there are 12 categories under the "Science Classroom" theme.

The participants reported that the science lesson materials must be present in an ideal classroom. They believed that such materials would initiate activity-based teaching and related experiments. They mentioned the necessity of a laboratory corner in the classroom if there were no school laboratories. The participants also emphasized the need for a different seating arrangement in their dream classrooms. In addition, some participants also included plants and animals in their classrooms because they were suitable for the content of the science lesson. At the same time, some participants would like to place a board to exhibit written products generated after classroom practices. Some others described a colorful classroom with walls and ceiling painted with suitable science outcomes (solar system, scientist pictures, and formulas) and technological teaching tools. Based on all these

depictions, the participants generally would like to teach science lessons in a classroom with science lesson materials, experimental aids, different seating arrangements, plants and pets, science boards, and technological tools.

Table 6. *My Dream Science Classroom: Physical properties of the classroom*

Categories	*Sample Quote*
Science materials	*S84: I will have all the experimental equipment in my classroom. . . . There will be materials through which I can concretize and teach the lesson.*
Lab corner	*S92: . . . I will arrange some corners in my classroom, like science corner, math corner . . .*
Board	*S136: I'll definitely create a science board.*
Different seating arrangements	*T42: The only things to be missed in my classroom are the desks. In my classroom, students will be constantly active and seeking new things and learning.*
Technological tools	*S110: I try to create a classroom with . . . technological tools and abundant materials that students will be interested in.*
Plants	*T56: One corner of the classroom is full of plants we grow, the other is full of up-to-date science resources.*
Pets	*T81: A complete laboratory with all the opportunities of technology . . . Outside, an ecological garden or even a garden with animals would be great.*
Painted walls/ceiling	*T9: It has several plants. There may even be fish in an aquarium. There are pictures on its walls. It could be pictures of scientists, formulas, or living things.*
Creative design	*T67: A large laboratory with glass walls, suitable for all seasons, and intertwined with nature in the natural environment of lots of animals and gorgeous trees reaching the sky or in a forest adorned with fragrant scents and all the beauty of the world of colors . . . Inside the laboratory, the experiment equipment placed in the white cabinets . . . A long white table in the middle . . . My students who work together or individually around the table, wear white coats with experiment glasses in their eyes and gloves in their hands, and have an expression of excitement, curiosity, and happiness on their faces . . . It is beautiful to dream of a spacious, peaceful, nature-intertwined science teaching environment in which meaningful learning takes place by doing, living, observing, and examining in nature or a laboratory environment . . . I cannot imagine it to be real . . .*
Curriculum	*T3: First of all, I would like to include the science lesson in the curriculum from the 1st grade.*
School Administrator	*T69: And I really want to work in a school where I have an independent classroom and a large number of teachers and administrators who always support teachers.*
Family	*T29: I do my best and come to class with intriguing content. Despite this, it is not possible to attract the attention of some students. The underlying reason for this is the family factor. I rarely see a child with an ignorant family researching, starting a hobby, wondering about extracurricular issues, and doing studies.*

Unlike pre-service teachers, some in-service teachers included the curriculum, administrator, and family elements in their dream classrooms: science teaching should start

from the first grade, and administrators and families should support the practices in science classrooms.

4. Discussion

The task of determining the quality of teaching in learning environments is always shared between teachers and students; therefore, it would not be wrong to assert that the leading roles belong to teachers and students in the learning process. In addition to the mentioned roles, the features of the teaching environment are also among the factors affecting teaching quality. Ultimately, we determined the strengths and weaknesses of in- and pre-service primary teachers in science teaching. Moreover, we sought their plans about how they would improve their weaknesses - if any - and shape the science learning environment to enhance science teaching. The findings obtained from teachers' responses revealed the situations making a primary teacher feel strong or weak in science teaching and listed what could be done to overcome weaknesses. Finally, they depicted how a science teaching environment should be. Figures 1 and 2 present the statements that were most frequently yielded by the participants.

As we privileged what the teachers emphasized in the study, we have not included the frequencies of repeated categories (numerical data). However, we determined a sequence from the most repeated to the least repeated when sorting categories. Under each theme, we first presented the categories composed of common statements of the participants, then those of only pre-service teachers and only in-service teachers, respectively. In this regard, Figure 1 shows the most frequently mentioned strengths: doing/designing experiments, adopting activity-based science teaching, and applying different methods/technical knowledge. The strengths emphasized only by pre-service teachers appeared to be: ability to do research and having laboratory knowledge. The strength statements belonging only to in-service teachers are the ability to associate science with daily life, teaching the lesson by students' level, and the use of technology.

Effective science teaching helps students develop conceptual understanding and investigative skills needed to be active citizens and science learners (Davis, 2008, p.1). In primary school science teaching, emphasis is placed on conceptual learning through various learning processes, including contemporary teaching techniques, practice-based activities, and group works (Appleton & Kindt, 1999; MEB, 2018; Tobin et al., 1994). To be able to conclude with conceptual learning, the teacher should guide meaningful and permanent learning in the student cognition by recognizing the achievements in the curriculum and using professional knowledge (Apaydın & Kandemir, 2018). Teaching methods and techniques have an important place in such guidance. In the study, the participants pointed out the strengths of having different methodological/technical knowledge and applying these methods/techniques. In addition, the term "experimenting" corresponds to laboratory-based science teaching. Therefore, we can state that the participants felt competent in experimenting as well. In the national literature, there are a plethora of studies in which in- and pre-service teachers indicated using different teaching methods and techniques in science teaching (Apaydın & Kandemir, 2018; Avcı & Ketenoğlu Kayabaşı, 2019 Kınık-Topalsan, 2019; Şahin & Güven (2016); Taşkaya & Sürmeli, 2014; Şimşek, Hırça, & Çoşkun, 2012;).

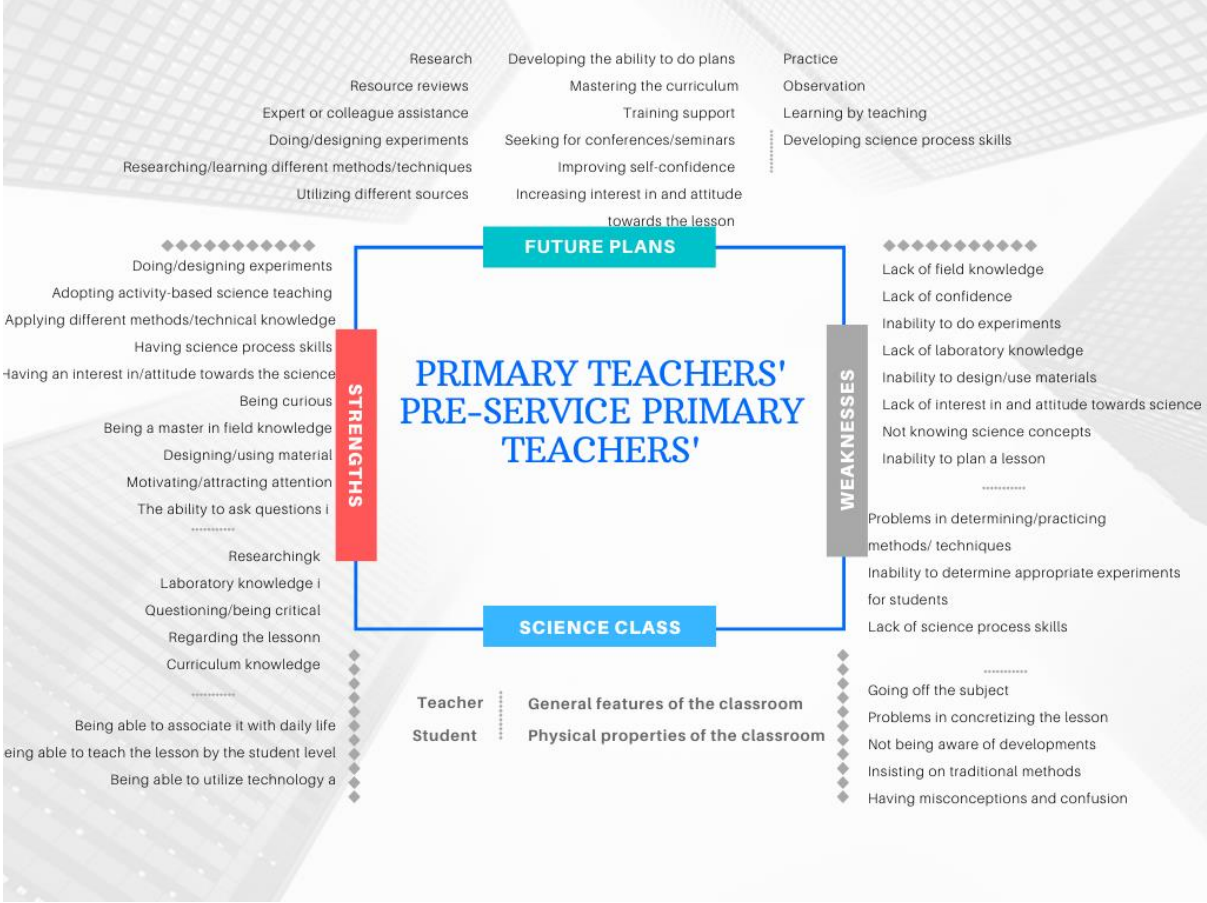

Figure 1. Strengths, weaknesses, and plans of the participants

The national and international literature shows us that primary teachers have had difficulties in science teaching from past to present. For example, Weiss (1994) reported that only about one-third of primary teachers thought they were eligible to teach science. When asked about teaching science, several teachers felt unqualified and uncomfortable (Abell & Roth, 1991). Primary teachers are less confident in their ability to teach science and technology because of their lack of background knowledge (Appleton, 1991). Pre-service and in-service primary teachers have only a rudimentary understanding of the subject matter they would be teaching (Mullholland & Wallace, 2000). The findings of a study by Ersoy and Anagün (2009) revealed that the teachers did not include homework where students could exhibit their creativity. It is well-known that pre-service primary teachers have shortcomings in conceptual knowledge included in the science curriculum and that they face some problems since they do not have a substantial command of it (Anagün et al., 2015; Tekbıyık & Akdeniz, 2008). It is also reported that they have gaps in how to use a laboratory (Yıldırım & Akgün, 2015). In this study, the participating teachers reported that they suffered from the above-mentioned situations, consistently with previous findings.

Teachers with strong subject knowledge, pedagogical knowledge, pedagogical material knowledge, and positive subject attitudes are essential for effective teaching (Ahtee & Johnston, 2006). However, while referring to their weaknesses, the teachers often reported that they lacked field knowledge in science. The category “being a master in field knowledge” ranked sixth among the strengths. In other words, only some participants felt competent in their field knowledge. Therefore, they may have difficulty in creating learning environments that allow students to take charge of their own learning (Ahtee & Johnston, 2006). It has long been known that teachers’ lack of subject knowledge hinders successful

science teaching at the primary school level. We also know that a poor attitude toward science is a major impediment to successful science teaching (Appleton, 1991; Harlen & Holroyd, 1997; Johnston & Ahtee, 2004).

Unlike pre-service teachers, some participating in-service teachers reported that they had problems in concretizing the lesson. Additionally, they reported that they had difficulty in conveying the subjects to students due to misconceptions or confusion. In addition to these undesired situations, they generally preferred to use traditional teaching methods due to lack of field knowledge, inability to do experiments, not knowing scientific concepts, and lack of laboratory knowledge. When teachers are not confident in teaching science, they tend to use teaching strategies that allow them to maintain control of the information flow in the classroom. Still, regarding the contemporary science curriculum, these strategies are not appropriate ways to engage students in science (Appleton, 2003).

Misconceptions prevail among the weaknesses emphasized by the teachers. The reason why pre-service teachers did not touch upon this situation might be that they have not noticed their misconceptions yet. In- and pre-service teachers tend to have similar misconceptions with their students (Hope & Townsend; 1983; Tunç et al., 2012; Kwen, 2005). Therefore, considerable efforts are needed to uncover and eliminate such misconceptions.

The findings of a study examining pre-service science teachers revealed the importance of practicing the Science and Technology Teaching course during undergraduate education to enable them to use methods and techniques based on the strategies envisaged in the science curriculum and to gain self-confidence while using such strategies (Akben, 2018). We believe that the results of Akben's study are noteworthy for eliminating the weaknesses of primary teachers. Besides teachers' negative attitudes toward science, based on their bad science experiences, have been previously shown to have an impact on their instructional practices (Avery & Meyers, 2012; Menon & Sadler, 2018). Until 2018, pre-service primary teachers took two courses, called Science and Technology Teaching I-II, in two semesters during undergraduate studies. The change of the undergraduate program implemented in 2018 included only one of these two courses. Therefore, we deem the "practice" component of this course was neglected due to the change. For this reason, while preparing the undergraduate classroom education program, it is necessary to consider the criteria determined in student admission and the number and quality of the courses to be taught, considering the academic background of the students to be enrolled in this program.

We concluded that the most common ways the participants would apply to improve their weaknesses were to do research, review resources, seek expert or colleague assistance, design experiments, research/learn different methods, utilize different resources, and develop their planning skills.

Considering the features of a science classroom described by the participants, this classroom should bear the following features: "Students in the science classroom should be science literate and active in the course, have the ability to ask questions, and adopt science process skills. The teacher should attract the students' attention to the subject and guide the class. The learning environment can be a classroom, a laboratory at the school, or an out-of-school environment. The teaching environment should be a fun, free, and democratic place where different methods and techniques are used, a wide variety of experiments are conducted, and practices are emphasized." Besides, such a learning environment must have some physical properties: the participants claimed that experimental equipment and all other science-oriented materials should be available. It should be a place with a different seating arrangement, technological equipment, and even plants and animals under the students' responsibility.

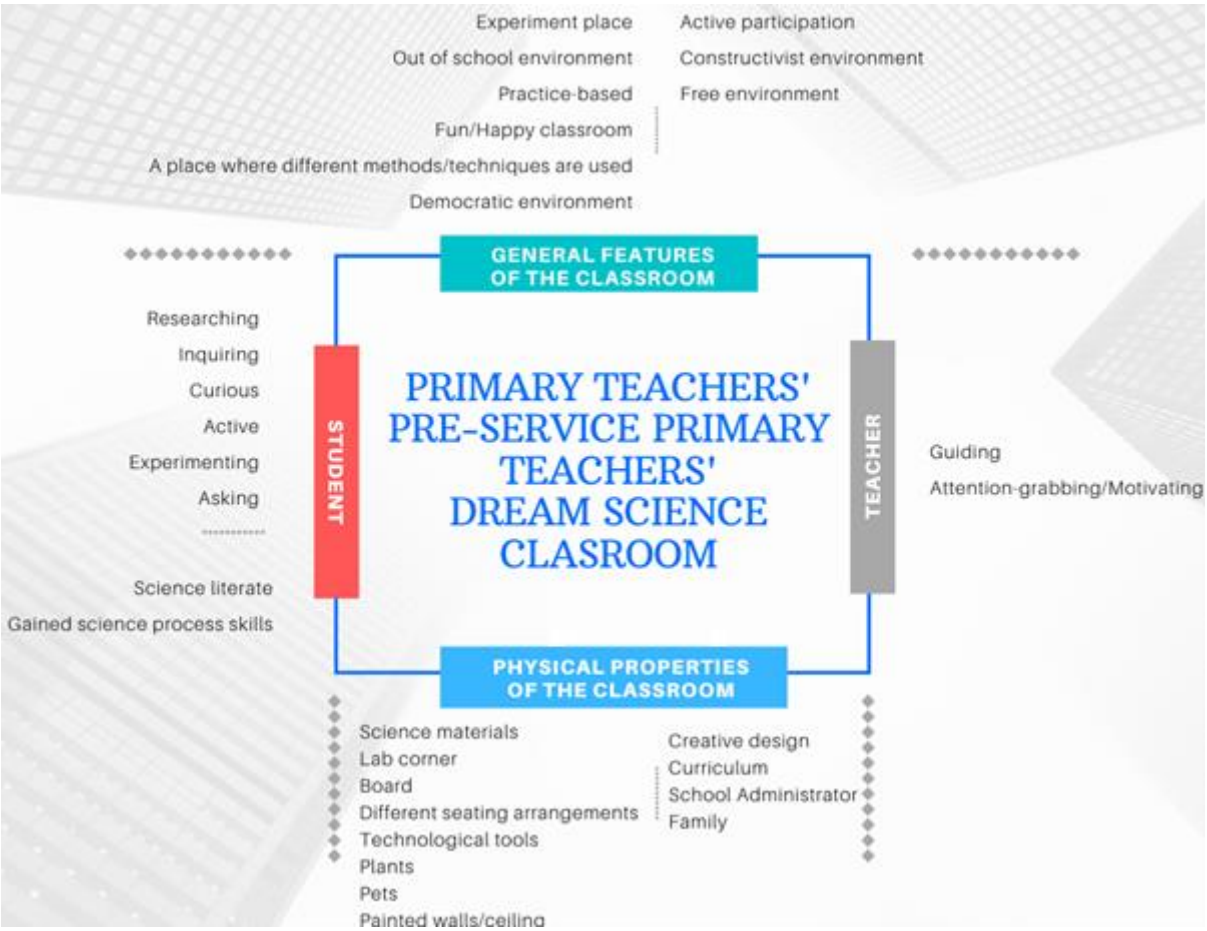

Figure 2. Science classroom depictions of the participants

Regarding the teachers' strengths and depictions of a dream science classroom, it is not prudent to indicate that they adopted a constructivist teaching philosophy. They used the word "constructivist" when talking about the properties of such a classroom. In their study about pre-service teachers, Can and Çelik (2018) found that the participants generally adopted a constructivist approach.

The study has some limitations. We did not consider some variables such as gender and seniority. Therefore, further studies may include these variables to bring a diverse perspective to the topic.

Teachers' behaviors, values, and will act may be cultivated or inhibited during their early careers. Identifying factors that motivate science teachers to persist and become effective will help improve pre-service and in-service teacher education programs (Ginns & Watters, 1999). This study uncovered the situations in which the participants felt weak in science teaching. Relevant measures can be taken to eliminate such weaknesses among pre-service teachers.

5. Conflict of Interest

The author declares that there is no conflict of interest.

6. Ethics Committee Approval

The researcher obtained the necessary ethical permissions from the Tokat Gazioamanpaşa University ethics committee.

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