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Investigation of Preferred Teaching Pedagogies of Preservice Science Teachers through Individual and Team Studies

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Abstract

The purpose of this research is to examine how working individually and as a team in solving pedagogical scenarios for teaching science subjects is reflected in the teaching preferences of preservice science teachers. This interpretive case study was conducted with 69 preservice science teachers studying at a university in eastern Turkey. The data of the study were collected using the teaching pedagogy preference form. The data analysis included descriptive analysis based on four instructional pedagogies: direct instruction, direct active, guided inquiry, and open inquiry. The research results revealed that preservice teachers did not sufficiently turn to inquiry-based teaching pedagogy for solving problem scenarios in both individual and teamwork. In addition, the results indicated that preservice science teachers' professional knowledge of teaching various science subjects is largely based on traditional teaching pedagogy. Based on these results, it is recommended that science educators use problem scenarios to reveal preservice teachers' inquiry-based teaching preferences.

Keywords: Science teaching pedagogy, Preservice science teacher, Inquiry-based teaching, Science Education

Introduction

Many nations, including Turkey, have utilized an inquiry-based approach to science education for decades. In science education, educators prioritize inquiry-based instruction over knowledge transfer (Wang, 2020). In line with this purpose, it is important for teachers to play an effective guiding role in science lessons so that students acquire scientific thinking habits based on inquiry (Osborne, 2014). However, many teachers face difficulties in teaching inquiry science because they believe they do not have the professional knowledge to do so (Gillies & Nichols, 2015). Teachers' knowledge or experience in science teaching obstructs inquiry teaching practices (Crawford, 2014). Aditomo and Klieme (2020) state that inquiry-based teaching is weakened by a lack of resources, a shortage of quality teachers, and the inadequacy of school culture to support inquiry-based science teaching. Studies have shown that teacher-centered teaching approaches cause students to have difficulty learning the complicated language of science (Kang, 2022; Sinatra et al., 2014). Therefore, it is necessary to use student-centered teaching approaches in which students will work in cooperation to increase their interest in science (Kang & Keinonen, 2018). Cairns and Areepattamannil (2019) reported that inquiry-based science teaching has a significant positive relationship with students' interest in learning science, future-oriented science motivation, and self-efficacy tendencies. Therefore, examining teachers' professional competencies and Pedagogical Content Knowledge (PCK) is important to increase academic success (Jüttner et al., 2013).

When science teachers have a high level of PCK, it is easier for teachers to facilitate students' learning (Abell, 2007; Gess-Newsome et al., 2011; Kirschner et al., 2015; Park & Oliver, 2008; Shulman, 1986). Teacher education should concentrate on identifying and developing preservice teachers' PCK (Coetzee et al., 2020). Some courses are very important in the professional preparation of pre-science teachers. It is thought that determining the teaching preferences of the preservice science teachers after taking the Principles and Methods of Teaching (PMT) course will directly affect the course content that science educators will conduct and the sample teachings they will cover in the courses. In addition, it is planned to be relevant not only to science educators, but also to the decisions of education policymakers about science teacher education. After updating the science course curriculum in 2013, it was designed based on the inquiry-based teaching approach and started to be implemented throughout Turkey. Therefore, the current research results will also contribute significantly to the preservice science teacher training processes within the framework of the science course curriculum.

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Current teacher education policies should give preservice teachers with opportunities to assess their teaching knowledge (DeMonte & Coggshall, 2018). One of the most important aims of science teacher education in universities is to enable preservice science teachers to have knowledge about effective and new teaching pedagogies (Cobern et al., 2014). Schuster et al. (2007) emphasize that teachers should direct the knowledge in science to a pedagogy acquired through inquiry, rather than presenting it as a product known to students. Although inquiry-based teaching is known to be important at every grade level, it cannot be applied successfully in science lessons (Capps et al., 2012; Meltzer & Otero, 2015). Effective inquiry-based teaching in science education is influenced by teachers' professional knowledge, attitudes, and beliefs (Lee et al., 2020; Lotter et al., 2018). Studies show that teachers' inability to grasp the inquiry-based teaching process correctly reduces their confidence in this approach and negatively affects their use in their lessons (Roehrig & Luft 2004; Yoon et al., 2012). Teachers face many challenges in how the inquiry should be taught (Gillies & Nichols 2015; Harris & Rooks, 2010). It is understood that a limited number of national (Feyzioglu et al., 2016; Sahingöz & Cobern, 2018) and international studies (Seung et al., 2014; Soprano & Yang, 2013; Wang, 2020) examined the inquiry-based teaching understanding of preservice science teachers. However, teamwork is also important in the preparation process of preservice science teachers (Peters-Burton et al., 2015). On the other hand, there is a significant lack of research on the use of teamwork to evaluate preservice science teachers' inquiry-based teaching pedagogies. An individual's experience working in teams in their university education makes it easier to adapt to business life (Kotlyar et al., 2021). Working as a team is more important than working as individuals (Van den Bossche et al., 2006). Working as a team leads to the emergence of better quality and efficient solutions (De Church & Mesmer-Magnus, 2010; Kwak, 2004). Masats and Guerrero (2018) also emphasize that both teachers and preservice teachers must have teamwork skills in order to facilitate their acquisition of professional knowledge. Therefore, it is very valuable to investigate the extent to which the preservice science teachers make sense of inquiry-based teaching pedagogy through individual and teamwork. Keys and Bryan (2001) emphasized the importance of understanding science teachers' perceptions and practices of inquiry to create a lasting reform in inquiry-based teaching. There is a great need for such studies in order to eliminate the weaknesses of the preservice science teachers' inquiry-based teaching understanding and competencies in the pre-professional period. In this context, it was aimed to examine the distribution of science teaching preferences of preservice science teachers within the scope of individual and teamwork. In line with this purpose, *"How is the distribution of teaching preferences (ready presented science or inquiry-learned science?) when prospective science teachers work on pedagogical problems individually and as a team?"* an answer to the research question was sought. This study aims to determine how the stage of second-grade science preservice teachers at a university in eastern Turkey influences their comprehension of inquiry-based teaching.

Theoretical Framework

Inquiry-Based Teaching and Science Education

It is important for teachers to have the right content knowledge and to choose appropriate teaching approaches for students to teach science subjects permanently (Ramnarain & Schuster, 2014). PCK is considered an essential knowledge base for effective teaching of science subjects (Henze & Barendsen, 2019). Moreover, PCK represents specific knowledge about teaching specific content that teachers have and has developed over time (Bertram & Loughran, 2012; Coetzee et al., 2020). Students' interest in science is significantly related to the teacher's professional knowledge and the quality of teaching (Clarke & Fournillier, 2012). Dudu and Vhurumuku (2012) state that traditional science education has been heavily criticized for not including skills that represent the work of real scientists, such as making observations, collecting data, organizing, and making inferences. This situation has revealed the necessity of teaching approaches that encourage students to think at a higher level, solve problems, experience science practices, and make sense of the nature of science (NRC, 2012; Zhao et al., 2021). With this in mind, the inquiry-based teaching approach has been incorporated into international science education curricula (Akuma & Callaghan, 2019; Furtak et al., 2012). According to the Next Generation Science Standards (NGSS), questioning science involves formulating a question that can be answered through research, which is the foundation of scientific practice (NGSS Lead States, 2013). Inquiry-based teaching has been promoted in science classrooms to develop students' scientific thinking and problem-solving competencies (Gillies & Nichols, 2015; Pease & Kuhn, 2011). According to Areepattamannil (2012), the fundamental features of inquiry-based teaching include student teamwork, research, and access to scientific knowledge. Teachers can conduct inquiry-based teaching in harmony with different teaching methods using modern teaching practices (Furtak et al., 2012; Kuo et al., 2019; Marshall et al., 2017; Minner et al., 2010; Peters-Burton & Frazier, 2012). NRC (2000, 2012) stated that when children participate in inquiry science learning, they notice scientific problems, value evidence, evaluate and make appropriate decisions. Inquiry learning refers to the learning process in which students construct knowledge by interpreting scientific research results rather than transferring scientific knowledge directly from teachers or textbooks (Lee et al., 2020; Lotter et al., 2018). With this approach, students are asked to ask questions; model development and use; plan and conduct research; analysis and interpretation of data; create descriptions; argue over the evidence; and be involved in acquiring, evaluating, and communicating information (Lotter & Miller, 2017; Zhang & Li, 2019). This process facilitates students' interaction with complex science ideas and participation in scientific activities (Gillies & Nichols, 2015; Harris & Rooks 2010; Wang, 2020; Zhang & Cobern, 2021). Situations in which teachers place more emphasis on students' active thinking and drawing conclusions from data contribute significantly to students' understanding of science content and development of attitudes compared to traditional passive approaches (Kang & Keinonen, 2018; Sadeh & Zion, 2012; Seung et al., 2014). NSES defined five key features of inquiry-based teaching as follows (National Research Council [NRC], 2000, s. 29):

1. Engaging in scientifically oriented questions,
2. Prioritizing evidence when answering questions,
3. Formulating explanations from evidence,
4. Linking explanations to scientific knowledge and
5. Communication and justification of disclosures.

Inquiry-based teaching presents students with real-life problems and teaches them the practical skills they will need to become productive citizens (Fitzgerald et al., 2019; Tseng et al., 2013; Zhang, 2016). define inquiry-based learning in science education to cover four levels (confirmatory inquiry-structured inquiry-guided-inquiry open inquiry). Martin-Hansen (2002) emphasizes that open inquiry, the most complex form, represents real scientists' work. Teachers play a critical role in teaching practices that facilitate learning (McLaughlin & MacFadden, 2014). Teachers should try to support the accuracy of students' scientific thinking and explanations by checking students' understanding (Colley & Windschitl, 2016; Kim, 2020; Kim, 2021; Tytler & Aranda, 2015). Science teachers' use of inquiry-based teaching approaches in their lessons will increase students' interest in science (Seung et al., 2014). To increase students' interest in the lesson, future science teachers should be familiar with inquiry-based science processes applied by scientists (McLaughlin & MacFadden, 2014; Walan et al., 2017).

There is a need for new assessment tools to evaluate the professional knowledge of science and preservice science teachers about inquiry-based teaching, which is today's contemporary teaching approach. In recent years, pedagogical problem scenarios have come to the fore in science teacher education studies (Cobern et al., 2014; Goodnough & Hung, 2009; Sizer et al., 2021; Skilling & Stylianides, 2020; Weizman et al., 2008). Pedagogical problem scenarios include a short teaching story that prospective teachers may encounter in any science lesson in the future. The use of pedagogical problem scenarios is very important. Because pedagogical problem scenarios are a way to catch the deficiencies and weaknesses in the professional knowledge structures of preservice science teachers during the preparation period, it is an opportunity for teacher educators to follow up and shape the current professional knowledge of prospective teachers when faced with such a situation. These pedagogical problems are also an effective way to reveal teachers' mental images of how to teach a particular science topic in a real classroom context. Pedagogical scenarios are used to reveal epistemic decisions that a teacher must make (consciously or unconsciously) in designing and implementing science teaching to teach scientific content on a particular subject (concepts, principles, relationships, and explanations), (Cobern et al., 2014). Schuster et al. (2006) explain several important purposes of pedagogical problems as follows: i) pedagogical problem scenarios are very realistic and original tools in revealing teachers' professional knowledge, ii) teachers or preservice science teachers working on problem scenarios related to such teaching cases serve to catch the deficiencies in existing professional knowledge schemes. In the related literature, the effects of science teachers and preservice teachers working as a team on pedagogical problem scenarios were determined by various studies. Among these studies, Hume and Berry (2011) conducted exploratory research based on teamwork to improve the professional knowledge of preservice science teachers. In this study, preservice teachers worked on CoRe forms in small teams to improve their professional knowledge and select appropriate teaching activities related to their students' learning about atomic structure and bonding. The research results revealed that including these preservice teachers in collaborative tasks had positive results in acquiring professional knowledge. El Nagdi, Leammukda, and Roehrig (2018) concluded that teachers' educational experiences could be positively affected by their interaction with their peers. Based on this result, they encouraged the team teaching model. In this model, teachers work together and can maintain the epistemological foundation of their discipline. In this study, researchers revealed that collaborative work is a very important theme that characterizes and develops a teacher professional identity. Professional collaboration between teachers or preservice science teachers may not always be beneficial, even if the effects are generally positive. Educational leaders today take a keen interest in engaging teachers in collaborative work for strategic reasons. However, these collaborative efforts go far beyond the professional goals and activities that teachers themselves can initiate. Therefore, the desired efficiency cannot always be obtained

(Andy Hargreaves, 2019). In this context, one of our research's main areas of interest was to test whether cooperative preservice teacher training is always effective.

Method

Research Design

The present research was conducted with the intertwined multi-case pattern of the case study. The intertwined multi-case pattern is a type of design in which more than one situation is studied by dividing it into separate sub-units, and then a comparison is made between the situations (Yin, 2003, s.40). Each case is divided into units. The results from these units allow for a comparison of situations (Yildirim & Simsek, 2008). In this study, the teaching preferences determined by the science teacher preservice science teachers studying in two different classes, individually and as a team, over different problem scenarios formed the intertwined situations of this research. The methodological design of the research is shown in Figure 1.

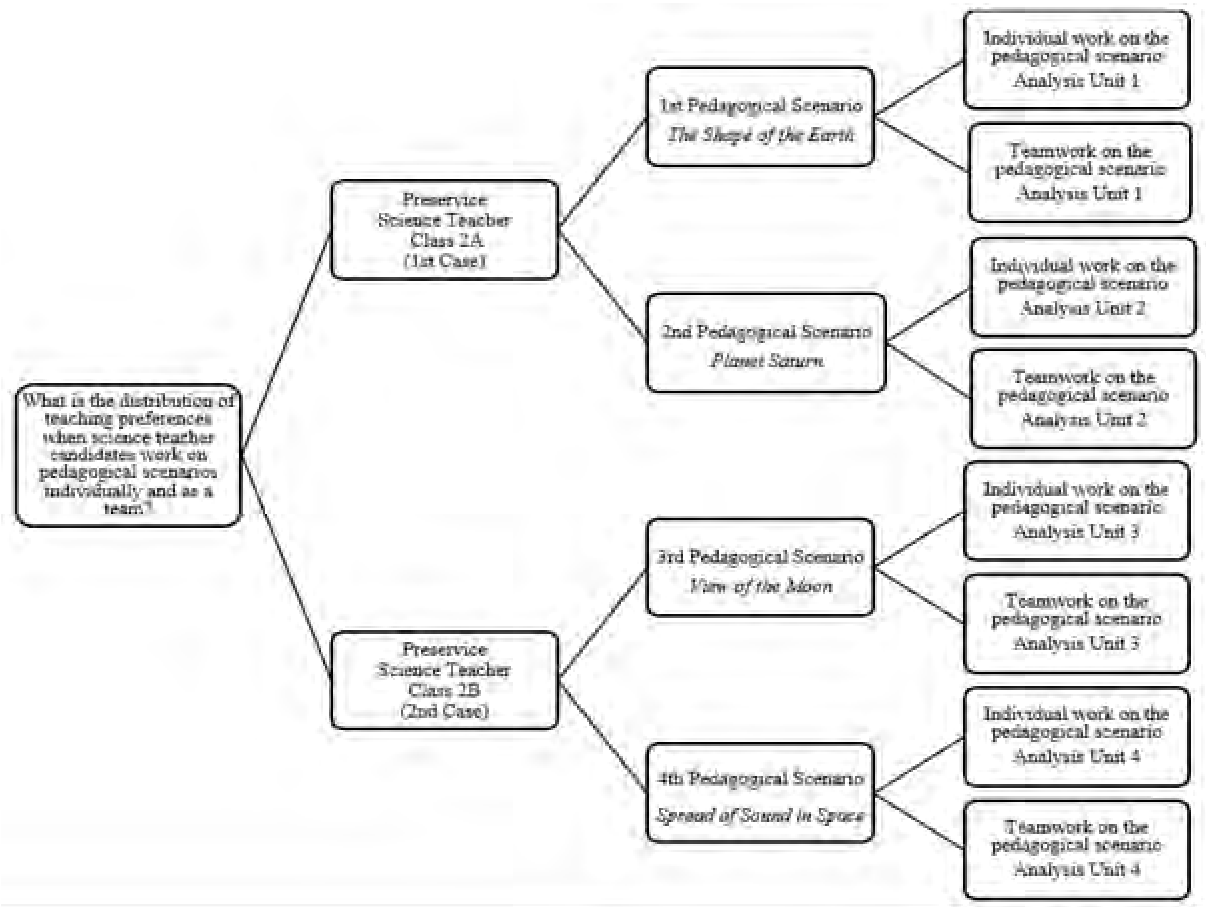


Figure 1. Intertwined multiple case design of the research

When Figure 1 is examined, it is seen that there are comparative situations in this study. Comparative case study research provides in-depth insights into processes, outcomes or relationships (Krehl & Weck, 2020). Comparative research is needed to inform those responsible for teacher education about alternative approaches. This research compares the teaching approaches that emerged as a result of the individual and teamwork of preservice teachers in solving problem scenarios related to teaching various science subjects.

Participants and Context

This study includes 69 second-grade preservice science teachers studying at a public university in Turkey (Class A: 35, Class B: 34). Preservice science teachers in both classes were divided into 14 teams by researchers.

Research teams are coded as T1, T2…T14. The ones coded as T12 in the text represent preservice science teacher number 2 of team number 1. T5 consisted of four preservice science teachers and the other teams consisted of five teacher preservice science teachers. T22 and T92 are foreign preservice science teachers. Preservice science teachers in the Classes A and B were randomly distributed by the relevant student affairs officer in the order of enrollment in the university. The preservice science teachers went through the same academic processes until the research was conducted. The research was conducted with second-grade preservice science teachers at the end of the fall semester because the preservice science teachers took the Principles and Methods of Teaching (PMT) course. The feature of this course is that it has the first professional knowledge course content that will affect the preservice science teachers' teaching pedagogy preferences. Preservice science teachers have previously taken the courses of introduction to educational sciences and educational psychology as professional knowledge course. However, these courses do not have course content that will directly affect the teaching pedagogy preferences of the preservice science teachers. The course content of the PMT course taken by the preservice science teachers is as follows:

> Basic concepts; teaching-learning principles, models, strategies, methods, and techniques; setting goals and objectives in teaching; content selection and editing; teaching materials; instructional planning and instructional plans; theory and approaches; effective school teaching, learning, and success in learning; evaluation of classroom learning (The Council of Higher Education, 2018, s.7)

Data Collection Tool

In the relevant literature, it is emphasized that working with pedagogical problems in the preparation of preservice science teachers can contribute significantly to their professional development (Cobern et al., 2014). The steps taken to identify and correct the current pedagogical deficiencies of the preservice science teachers through sample teaching scenarios are critical in helping them gain effective science teaching habits in the future. In this context, in the present study, the Teaching Pedagogy Preference Form (TPPF) was used to determine preservice science teachers' inquiry-based science teaching preferences. The inspiration for this form was Schuster et al. (2007) developed the Pedagogy of Science Teaching Test (POSTT). This test has been used in various studies (Cobern et al., 2013; Cobern et al., 2014; Feyzioglu et al., 2016; Ramnarain & Schuster, 2014; Schuster & Cobern, 2011; Schuster et al., 2012; Sahingoz & Cobern, 2018). Moreover, it is a handy measurement tool that is preferred to examine the orientation of teachers and prospective teachers in teaching science subjects. We adapted the POSTT from Cobern et al. (2014), Schuster et al. (2007), and Ramnarain & Schuster (2014). The POSTT is shown in Figure 2.

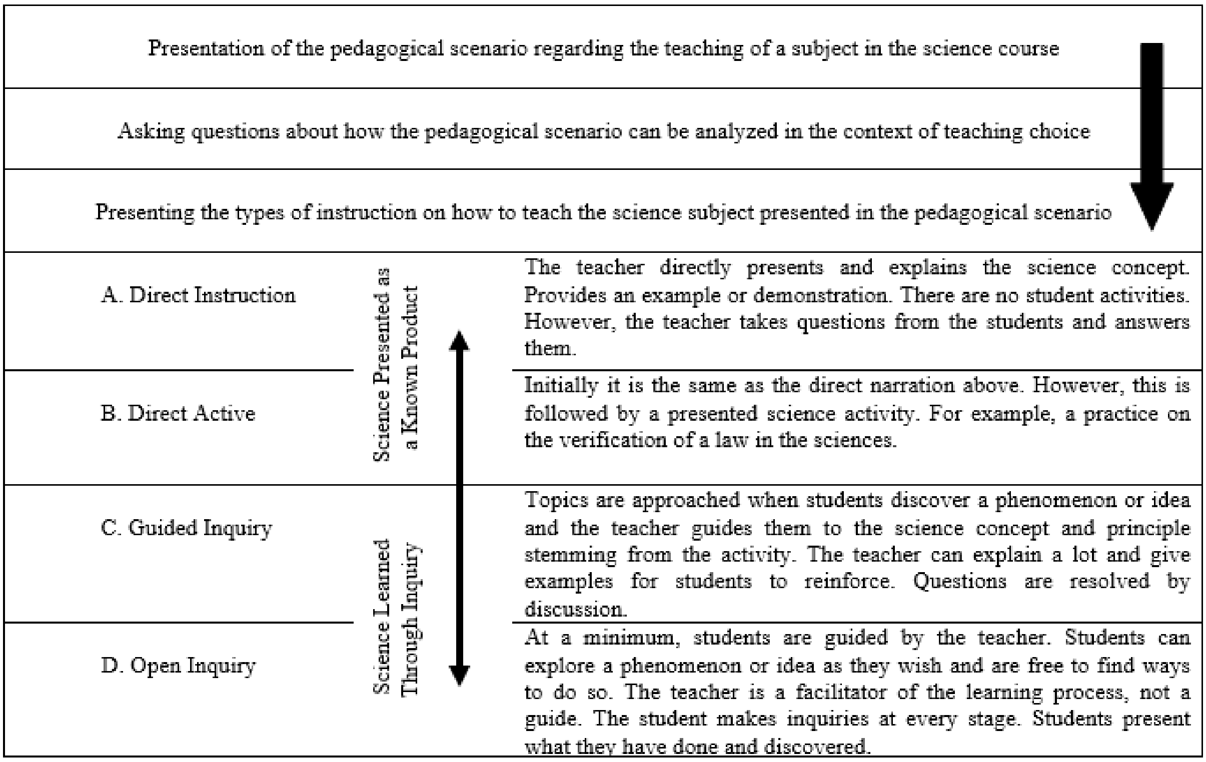


Figure 2. The design of each item of the POSTT (Adapted from Cobern et al., 2014; Ramnarain & Schuster, 2014; Schuster et al., 2007)

Schuster et al. (2007) ask for an explanation for each item in the POSTT design as to why teachers preferred the teaching approach they chose and why they did not choose other options. Rather than aiming to find the right or wrong option, this test presents different pedagogical options for teaching choices. After the problem scenarios are presented in the test, four various teaching preferences are presented in an elegant format, and the candidate chooses the one that best fits his or her needs. The aim here is to encourage the respondent to envision themselves in a particular teaching situation, to play the role of the decision maker, and respond accordingly (Cobern et al., 2014; Schuster et al., 2007). In the POSTT, there is a possibility that the multiple-choice presentation of the teaching preferences will lead the respondent. The TPPF prepared within the scope of this research has some differences from the existing POSTT. Each item of the TPPF, like the POSTT, contains a pedagogical problem scenario for teaching a specific science topic. In addition, as in the POSTT, this teaching scenario is followed by a section where preservice teachers are asked their opinions on how they can teach the expressed science subject. On the other hand, in TPPF, as in POSTT, there are no teaching approach options to reveal preservice science teachers' science teaching preferences.

We have prepared TPPF in four sciences: The shape of Earth, Planet Saturn, Moon Appearance, and Sound Propagation in Space. The form prepared on these subjects was applied to 24 students studying in the 3rd year of science teaching of the same faculty, where the main study was conducted, to confirm its validity before the study process. After this application, interviews were held with the preservice science teachers on the intelligibility and usefulness of TPPF. The form was sent to three faculty members from different universities, and their opinions were sought on both the pedagogical scenarios' suitability and the items' intelligibility. In this context, we gave the TPPF its final form by making some adjustments to the items in the form in line with the feedback of the 3rd-grade preservice science teachers and the suggestions of the faculty members. The data obtained as a result of applying the form to third-grade preservice science teachers were analyzed to ensure reliability. In this context, we created a scoring system for the teaching preference section in each item of TPPF, acting according to the logic in POSTT. Each question in the POSTT includes four different preferences Direct Instruction (DI), Direct Active (DA), Guided Inquiry (GI), and Open Inquiry (AI) instruction types. The answers to be written for the teaching preference section of each item in the form were scored as DI (1 point), DA (2 points), GI (3 points), and AI (4 points). In addition, "0" points were used in the meaningless answer and the teaching preference section that the preservice science teachers left blank. In this context, the researchers mutually scored the teaching preference answers regarding the "Shape of the World" item in the draft form of the TPPF applied to third-grade students. A good level of correlation was found between the scores given by the researchers ($r = .78$, $p < .05$). These results showed that the prepared TPPF is a valid and reliable tool for the main application. In the present study, TPPF consists of four different pedagogical scenario-type items, two for the Class A and two for the Class B. While answering the pedagogical scenarios, preservice teachers could choose as many different teaching pedagogy as they wanted. In this way, it is thought that it will be more reliable to reveal what kind of teaching pedagogy preferences are formed in the minds of preservice science teachers. Two different pedagogical scenarios are used in each class because the preservice science teachers can exchange information during the application. The designed pedagogical scenarios (PS) areas in Table 1:

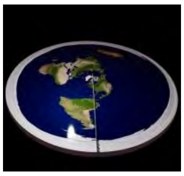
Table 1. PS items in the TPPF

Class 2A	1st PS	*"A science teacher wants students to learn conceptual information about the shape of the world. During the lesson, one student said that the world was in the shape of a tray, and another said that it was in the shape of a cube. The teacher considers the most effective way to learn conceptual information about the subject. If you were in this teacher's place, what kind of teaching preferences would you suggest for learning conceptual information about the subject? Please explain in detail."*
	2nd PS	*"A science teacher wants students to learn conceptual information about planets and their properties. During the lesson, one of the students said, "If we leave Saturn in the water, will it sink?" posed a question. If you were in this teacher's place, what kind of teaching preferences would you suggest for learning conceptual information about the subject? Please explain in detail."*
Class 2B	3rd PS	*"A science teacher wants students to learn conceptual information about the movements of the Moon. During the lesson, one of the students asked, "Can we see all sides of the moon?" If you were in this teacher's place, what kind of teaching preferences would you suggest for learning conceptual information about the subject? Please explain in detail."*
	4th PS	*"A science teacher wants students to learn conceptual information about sound spread. During the lesson, a student said that sound can spread in space. This teacher considers the most effective way to learn conceptual information about the subject. If you were in this teacher's place, what kind of teaching preferences would you suggest for learning conceptual information about the subject? Please explain in detail."*

Each item in the TPPF begins with a pedagogical scenario representing a real teaching situation for a particular science subject. These scenarios contain sentences that emphasize the teaching purpose of the chosen science topic (concepts and principles) and the way out of teaching this topic to students effectively. Then comes a sentence asking what kind of pedagogy they can teach the chosen science topic to the student.

For the questions in the interview forms used in the case studies to be understandable, the researchers make preliminary experiments and take the experts' opinions. The researchers of this study also conducted a pilot study on the content structure of TPPF. They sought the views of both third-year preservice teachers and science educators. Feedback from third-year preservice science teachers was on the text structure and intelligibility of pedagogical scenarios. Some of the preservice science teachers only commented on one or more of the four scenarios included in this feedback form. In line with the feedback given, the researchers made adjustments to the intelligibility of the texts in a way that would not disrupt the original structure of the POSST for all scenarios. For example, the 1st pedagogical scenario structure in the first draft form of TPPF and the feedback of some of the 3rd-grade preservice science teachers are as in Table 2.

Table 2. Feedback from preservice science teachers for the 1st pedagogical scenario

Draft 1st pedagogical scenario		Feedback
Are we on a tray? Gamze, who is a science teacher in a middle school, teaches the 6th grade students the subjects of astronomy and space unit in the 7th week. As the first lesson, teacher Gamze wants the students to understand what the shape of the Earth is like and the information that proves this correctly. Teacher Gamze thinks what would be the most effective approach to achieve this. If you were in place of teacher Gamze, what would be your suggestions regarding the teaching approaches that ensure that the students best understand this subject?	  *Note: Explain the teaching approaches you will prefer by associating them with the information that proves the shape of the world.*	*I think the pictures can affect the preservice teacher's choices. Instead, it would be more accurate if only the paragraph should remain.* (preservice science teacher 5) *I think it would be better if a story could be written about the shape of the Earth in a way that highlights the problems in students' learning. Also, the expression of teacher Gamze constantly disrupts the flow of the text.* (preservice science teacher 16)

Examples of the feedback given by science educators are as in Table 3.

Table 3. Feedback from science educators for the 3rd pedagogical scenario

Draft 3rd pedagogical scenario	Feedback
Years later, teacher Fatih met his university friends Yılmaz and Kemal at a meeting. Each of these teachers worked as a science teacher in different schools. After the meeting, the three of them came together and started to talk about teaching science subjects. At the end of the lesson, teacher Fatih came to one of the students and said, "Does the whole moon look the same to us, teacher?" He said he asked a question. Teacher Fatih stated that he had studied the subject of the world and our planet in this class one lesson before and that he never thought such a question would come to the students' minds. Teacher Yılmaz said, "Now that I think about it, it is a really interesting question; how did you answer it? said. Teacher Kemal said, "While planning our lessons, I think we should be prepared for these questions and structure the science experiences in the classrooms that will enable students to find the answer to this question posed to my teacher Fatih." If you were the fourth teacher involved in this conversation, what would be your teaching advice to these teachers so that they could answer the above question?  Note: Explain the teaching approaches you will prefer by associating them with the information about the Moon.	*I would like to point out that there are some shortcomings. First of all, when I think about the pedagogical scenario logic in POSST, a section from a section in the course should be scripted. However, this question contains excerpts from the conversation in a free time outside of class. So the script reflects a real classroom context. Therefore, this situation needs to be reviewed in scenarios. It would be helpful if the scenario was simpler.* (science educator 1) *The feedback I thought to have when I reviewed the script is as follows: 1. The pedagogical text is too long as it is, it should definitely be shortened, 2. The scenario should have a pedagogical purpose by including a classroom context and teacher-student interaction in it, 3. I think the section given as a note at the bottom of the scenario is unnecessary.* (science educator 3)

The used version of the data collection tool after it was arranged in line with these views is given in Table 1.

Data Collection Process

The lecturer conducting the PMT course divided the course into three parts, each consisting of five weeks. In the first part, basic concepts, teaching-learning principles, models, strategies, methods, and techniques; setting goals and objectives in teaching; content selection and editing, in the second part, teaching materials; instructional planning and instructional plans; theories and approaches and in the last part; effective school teaching, learning and success in learning; evaluation of classroom learning. While teaching the course, the lecturer firstly directed the preservice science teachers to the questions that they should research and question about the acquisitions they should have related to the subject. The lecturer guided the preservice science teachers when they had difficulty in learning or researching but did not directly indicate the solution to the problem. Preservice science teachers presented what they learned about their achievements in the classroom environment. The information presented was discussed in the classroom environment, and the information obtained by the preservice science teachers was finalized with the suggestions of the lecturer. The inquiry-based teaching approach is covered in the second part. For example, in this section, the following problems related to inquiry-based teaching were given to the preservice science teachers:

1. What teaching pedagogies are based on direct instruction, directly active, guided, and open inquiry?
2. Create a separate lesson plan based on these teaching pedagogies.
3. A science teacher wants students to learn conceptual information about density. During the lesson, a student asked how hot air balloons fly. This teacher considers the most effective way to learn conceptual information about the subject. If you were in this teacher's place, what kind of teaching preferences would you suggest for learning conceptual information about the subject? Please explain in detail.
4. A science teacher wants students to learn conceptual information about physical-chemical change. During the lesson, a student asked how weight loss is a change. This teacher considers the most effective way to learn conceptual information about the subject. If you were in this teacher's place, what teaching preferences would you suggest for learning conceptual information about the subject? Please explain in detail.
5. A science teacher wants students to learn conceptual information about the particulate nature of matter. During the lesson, a student asked how the milk overflowed. This teacher considers the most effective way to learn conceptual information about the subject. If you were in this teacher's place, what teaching preferences would you suggest for learning conceptual information about the subject? Please explain in detail.

In this way, the course process was terminated. In this context, it is possible to say that the lecturer uses open inquiry-based teaching in his class. After the course process, 1st PS was first applied for the Class A. Preservice science teachers first wrote down the instructional pedagogies that they individually created in their minds. Sufficient time has been given to the preservice science teachers for this application. There was a 20-minute break after the application. Afterward, they worked in teams and discussed. Their work as a team lasted between 50-and 60 minutes. The same process was followed for the 2nd PS on a different day. The research process applied for Class A was repeated in Class B at different times. Individual and team practice times for Class B were approximately the same as for Class A.

Data Analysis

The answers given by the second-grade science teacher preservice science teachers to the pedagogical scenarios were analyzed according to their representation of the characteristics of the following instructional pedagogy preference types. The explanations in Table 4 are briefly summarized by adapting from the study of Sahingoz and Cobern (2018, p.1376).

Table 4. Teaching preferences and characteristics used in the analysis of the scenarios

Instructional Preference Type (category)	Features (cods)
DI	- The teacher presents the topic orally and explains - Students only listen to the teacher - Teacher gives examples within the scope of the subject - If students have questions, the teacher answers - Teacher asks questions
DA	- Teacher communicates information directly to the student - The teacher explains the topic with a presentation or example - The teacher does an activity to validate the information presented to the students. - Teacher provides limited active participation of students
GI	- It is ensured that the key concepts related to the subject are discovered through activities under the guidance of the teacher - Afterwards, a statement can be made on the subject - A discussion environment is created - The teacher provides the students with various activities to comprehend the desired information under his/her guidance - The teacher guides the students in the emergence of scientific concepts through various activities - The teacher gives more examples to reinforce the topic - The teacher maintains a learning environment where everyone shares the responsibility - Teacher makes students experience the processes of identifying and solving problems - The teacher creates the necessary environment for the students to use the materials and tools themselves and guides them.
OI	- Students can explore key concepts in any way they want - The teacher should have very little guidance on the subject. - Giving theoretical information about the science subject in the scenario - The teacher gives information to a minimum - Teacher facilitates the process that students determine to discover knowledge, does not participate actively in this process - Students are free to devise ways to explore an idea or phenomenon. - Students explore how the natural world works by following their interests - The teacher takes student interest into account - The teacher determines learning activities based on students' questions - Students explain and present the information they discovered in their scientific ways.
Meaningless Answer (MA)	- The answer given does not comply with the features as mentioned above - Irrelevant answers

In this study, the meaningless MA response category was included in addition to the teaching pedagogies used by Sahingoz and Cobern (2018). This category was added as it was felt during data analysis. Two researchers analyzed preservice teachers' teaching preferences at different times within the framework of the characteristics in Table 4. The results were then compared. In the study, the teaching preferences of preservice teachers working individually on teaching pedagogy scenarios were compared with the teaching preferences of preservice teachers working in teams. The obtained data were analyzed through content analysis. The code list for the teaching pedagogy of science teachers, which constitutes the conceptual basis of the research, was prepared (Cobern et al., 2014; Magnusson et. al., 1999). Strauss and Corbin (1990) state that the researchers' use of coding according to predetermined concepts while performing content analysis will provide a significant convenience in the analysis of data. The code list we created was later published by Schuster et al. (2007) examined four teaching approaches in the science teaching spectrum (Direct Instructor, Direct Active, Guided Inquiry, and Open Inquiry) and under the themes of "meaningless answer" that we identified. Also, another consideration in data analysis is that researchers are open to additional codes that emerge throughout the analysis, as they use a pre-formed coding scheme. Because Creswell (2013, p.185) emphasizes that using a pre-shaped code structure may limit the reflection of participants' views, so researchers should be open to additional codes throughout the analysis. Taking this matter into account, a reliable structure was created for the analysis of the data. While classifying the answers of the preservice science teachers according to their teaching pedagogy, a complete agreement was sought among the researchers. A total of six responses that were not agreed upon emerged. Three different science educators coded these answers. The resulting classifications were compared and the teaching preference with higher frequency was chosen and reflected in the findings.

In the findings section, firstly, the frequency distributions (analysis units 1 and 2) of the teaching pedagogies preferred by the preservice science teachers in the Class A are presented to the reader in tabular form. Table 4 presents the total frequency values of DI, DA, GI, OI, and MA directed by preservice teachers in their team and individual work. Afterward, the percentage distribution of the types of teaching pedagogy preferred by the preservice science teachers (Case 1) is given. The values in the table were calculated as follows: first, the frequency values of each of the individual or team answers given by the preservice science teachers in the total direct tutorial/direct active/guided inquiry/open inquiry and meaningless answer categories were determined. Then, the ratio of the number of each teaching choice to the total number of answers was found and multiplied by one hundred. This way, the percentage of an item preference in the total number of responses was found and reflected in the tables. The same findings were presented in the data obtained from Class B (analysis unit 3, 4, and Case 2). The fact that this research, which was carried out with an intertwined multiple-case design consisting of two different situations and eight different units, required the data obtained to be transferred to the findings in this way. In this context, the science teaching preference distributions of the preservice teachers were obtained for each situation.

Results

The frequency distributions of the teaching pedagogy types preferred by the preservice science teachers in Class **A (Case 1) for the 1st and 2nd PS are presented in Table 5.**

Table 5. Frequency distributions of instructional pedagogy types for Case 1

Case 1	Answer Type	Analysis Unit 1						Analysis Unit 2					
		DI (f)	DA (f)	GI (f)	OI (f)	MA (f)	Total (f)	DI (f)	DA (f)	GI (f)	OI (f)	MA (f)	Total (f)
T1	Team	2	-	-	-	1	3	1	-	1	-	1	3
	Individual	8	-	1	-	7	16	2	-	-	-	9	11
T2	Team	2	1	-	-	1	4	1	1	-	-	2	4
	Individual	8	-	1	-	10	19	6	1	1	1	7	16
T3	Team	1	-	1	-	1	3	2	1	-	-	1	4
	Individual	9	-	2	-	6	17	4	5	-	-	6	15
T4	Team	2	1	-	-	-	3	-	1	-	-	1	2
	Individual	12	-	-	-	5	17	1	3	-	1	8	13
T5	Team	-	1	1	-	1	3	-	1	1	-	1	3
	Individual	4	2	-	1	2	9	1	3	1	-	5	10
T6	Team	2	2	-	-	-	4	-	1	-	-	2	3
	Individual	7	3	3	-	-	13	1	5	-	-	1	7
T7	Team	1	-	-	-	-	1	-	-	-	-	1	1
	Individual	8	1	-	-	6	15	3	1	-	-	4	8

When Table 5 is examined, it is seen that the teams did not choose teaching pedagogy for OI. However, it is noteworthy that individually, one preservice science teacher in the 1st PS and two preservice science teachers in the 2nd PS made an OI type of teaching preference. The total number of preferences for teaching pedagogy of the teams is close to each other in 1st PS (f=21) and 2nd PS (f=20). However, it is seen that the total number of preferences of the preservice science teachers individually in teaching pedagogies decreased in the 2nd PS (f=106 for the 1st PS, f=80 for the 2nd PS). Sample responses from the preservice science teachers are as in Table 6.

Table 6. Example responses for case 1

Preservice science teacher / Team	Example answer
It's one of T4's answers for the 1st PS. It has been evaluated in the DA category.	*"After explaining the subject to the students, the experiment can be done. For example, a spherical world model and a tray with a world map can be used. We give the student a toy car. We want him to move forward from the starting point and reach the starting point. Thus, it has to take a second path in the tray to return to its destination. In the sphere, there is no need for this. When it moves in the same direction on the sphere, it will return to the point where it started."*
It is one of T5's answers for the 2nd PS. It has been evaluated in the GI category.	*"Students can be divided into teams of five. The following questions are directed to the teams: 1- Observe the movement of the Sun throughout the day. What did you achieve? 2- Observe that the ship is coming from afar. What are your observations? The answers to these questions can be discussed in class. The teacher can correct the deficiencies or mistakes."*
It is one of $T1_1$'s answers for the 2nd PS. It has been evaluated in the DI category.	*"First, I tell students about Saturn. For example, I would say it is the second-largest planet and has a ring. I would say its density is smaller than Earth. I would say that the Earth is 70 percent water, while Saturn is mostly made up of gases. I would say that Saturn does not sink, just as ice does not sink in water."*

The findings obtained from the percentage distribution of the total number of preferences of the preservice science teachers studying in the Class A according to the types of teaching pedagogy are as in Table 6.

Table 7. Percentage distribution of preferred teaching pedagogies for Case 1

Case 1	Analysis Unit 1					Analysis Unit 2				
Answer Type	DI (%)	DA (%)	GI (%)	OI (%)	MA (%)	DI (%)	DA (%)	GI (%)	OI (%)	MA (%)
Team	47.6	23.8	9.5	-	19.1	20	25	10	-	45
Individual	52.8	5.7	6.7	0.9	33.9	22.5	22.5	2.5	2.5	50

When Table 7 is examined, it is seen that the DA, GI, and OI values of the number of preferences of the preservice science teachers according to the types of teaching pedagogy are close to each other for the 1st PS and 2nd PS. However, the preservice science teachers preferred more in the DI type in the 1st PS as a team. It is seen that they give more MA in the 2nd PS. When the preservice science teachers work as a team in 1st PS, it is seen that the number of preferences in DA and GI types increases according to their individual studies. It is noteworthy that when the preservice science teachers work as a team in the 2nd PS, the number of preferences in DA, GI, and MA types increases according to their individual studies. The frequency distributions of the types of teaching pedagogy preferred by the preservice science teachers in the 3rd PS and 4th PS in Class A (Case 2) are presented in Table 8.

Table 8. Frequency distributions of instructional pedagogy types for Case 2

Case 2	Answer Type	Analysis Unit 3 DI (f)	DA (f)	GI (f)	OI (f)	MA (f)	Total (f)	Analysis Unit 4 DI (f)	DA (f)	GI (f)	OI(f)	MA (f)	Total (f)
T8	Team	-	1	-	-	-	1	1	1	-	-	-	2
	Individual	-	1	-	-	7	8	-	3	-	-	3	6
T9	Team	1	1	-	-	1	3	-	2	-	-	-	2
	Individual	1	1	-	-	6	8	2	3	-	-	5	10
T10	Team	1	-	-	1	-	2	-	1	-	1	-	2
	Individual	7	1	1	1	4	14	3	4	1	2	3	13
T11	Team	1	-	1	-	-	2	-	2	1	-	-	3
	Individual	6	2	3	-	-	11	2	3	-	-	3	8
T12	Team	-	1	-	-	-	1	-	1	-	-	-	1
	Individual	1	2	1	-	2	6	1	5	-	-	1	7
T13	Team	2	-	-	-	-	2	1	-	1	-	-	2
	Individual	2	2	-	-	2	6	5	-	-	-	1	6
T14	Team	1	2	-	-	1	4	1	1	-	-	1	3
	Individual	5	3	-	-	1	9	6	4	1	-	2	13

When Table 8 is examined, it is seen that only T10 and the preservice science teachers belonging to the team made a preference for OI. The total number of preferences in the teaching pedagogies of the teams is equal in PS 3 and PS 4 (f=15). It is seen that the number of preferences of the preservice science teachers according to their individual teaching pedagogies (f=62 for the 3rd PS, f=63 for the 4th PS) is close to each other. Sample responses from preservice science teachers are presented in Table 9.

Table 9. Sample responses for Case 2

Preservice science teacher / Team	Example answer
It is T13₃'s only response for the 3rd PS. It has been evaluated in the MA category.	*"I would talk about the moon's phases and how the moon goes around the earth. I would explain the subject broadly."*
It is one of T10's answers for the 4th PS. It has been evaluated in the OI category.	*"We test their prior knowledge by asking questions such as "What is sound? In which media does sound spread?". We collect the answers given by the students. We question on what basis they give such answers. Then we ask them to research relevant questions and find their answers. We ask them to compare their preliminary information with the information they obtained at the research's end."*

The findings obtained from the percentage distribution of the total number of preferences of the preservic e science teachers studying in Class B according to the types of teaching pedagogy are as in Table 10.

Table 10. Percentage distribution of preferred teaching pedagogies for Case 2

Case 2	Analysis Unit 3					Analysis Unit 4				
Answer Type	DI (%)	DA (%)	GI (%)	OI (%)	MA (%)	DI (%)	DA (%)	GI (%)	OI (%)	MA (%)
Team	40	33.3	6.7	6.7	13.3	20	53.3	13.3	6.7	6.7
Individual	35.5	19.3	8.1	1.6	35.5	30.2	34.9	3.2	3.2	28.5

When Table 10 is examined, it is seen that the preservice science teachers in the Class B mostly preferred the DI type in the 3rd PS and the DA type in the 4th PS as a team. Preservice science teachers individually focused on their DI and MA teaching preferences in the 3rd PS. In the 4th PS, it is noteworthy that the preservice science teachers mostly focused on the DA teaching preference. When the preservice science teachers work as a team in the 3rd PS, it is seen that the number of preferences in DI and DA types increases according to their individual studies. It is noteworthy that when the preservice science teachers work as a team at the 4th PS, the number of preferences increases in the DA, GI, and OI teaching pedagogy types compared to their individual studies.

Discussion

The purpose of this study was to investigate the preferred teaching pedagogies of second-grade preservice science teachers through individual and group work. According to the findings of the study, preservice science instructors favoured DI and DA instructional pedagogies over GI and OI. Preservice science teachers' working individually or as a team affected their teaching pedagogy choices. Working in teams increased the choice of DI teaching pedagogy while reducing the percentage of MA they provided. The teamwork of preservice science teachers mostly increased the percentage of choosing GI teaching pedagogy. However, the rate of preservice science teachers (individual or team) generally preferring this teaching pedagogy is low. The teamwork of the preservice science teachers decreased the OI teaching pedagogy choice in Case 1 and increased it in Case 2. It is noteworthy that as the science topics in the pedagogical scenarios faced by the preservice science teachers change, the type of teaching pedagogy they prefer also changes. Sahingoz and Cobern (2018) revealed that the teaching preferences of science teachers vary according to the subject. In this study, teachers may have preferred different types of teaching, taking into account the difficulty and nature of the subject. However, in the current study, it is seen that the preservice science teachers mostly concentrate on DI and DA teaching pedagogies and MA giving. Solving the encountered problem scenarios correctly depends on the team's ongoing scientific discussions (Nutt, 2008; Steele et al., 2007). Therefore, the preservice science teachers may not have been able to produce inquiry-based teaching ideas within the scope of solving pedagogical scenarios because they could not carry out teamwork effectively. Preservice science teachers are expected to produce inquiry-based teaching ideas because the currently used science course curriculum recommends using this teaching preference. Another cause for the current research findings could be the lack of preservice science teachers' professional knowledge and skills. Ramnarain and Schuster (2014) found that physics teachers in regions with a good economic situation in South Africa use GI orientation, and physics teachers in regions with poor economic situations use DA orientation. Teachers using DA orientation attributed the reason for this choice to crowded classrooms and students' inability to obtain resources. On the other hand, teachers using GI orientation associated their teaching preferences with school culture, parent expectations, and teachers' professional competence. It was in 2005 that Turkey started to use the constructivist approach in science lessons. The compulsory inclusion of the research questioning strategy in the science curriculum took place in 2018. The prospective teachers who participated in the current research completed the primary and secondary school processes in the revision processes of this program. Therefore, they experienced learning environments in which DA and DI teaching preferences were made in the classrooms. They may have reflected DA and DI teaching preferences in the activities they designed by being influenced by these learning environments. Kang and Keinonen (2018) state that Finnish science teachers prefer GI more when their 2006 PISA results are taken into account, and they are less likely to use the practice of OI and discussion. They explain the reason for this situation as teachers are not equipped with sufficient professional knowledge during their candidacy or service period. This explanation supports the result of our current research. Lee et al. (2020) emphasize that for teachers to use inquiry teaching, they must have confidence that this pedagogy positively impacts teaching science concepts. This may be one of the reasons why preservice science teachers in the present study were poor in choosing teaching pedagogies based on GI and OI. In order to reveal this situation scientifically, different studies are required in which interviews will be conducted. If science teachers are needed to choose and implement instructional pedagogies based on GI and OI, they must be equipped with the requisite professional knowledge throughout their candidacy (Luft et al., 2008). Seung et al. (2014) emphasizes that it is not sufficient to provide preservice teachers with only theoretical information on inquiry-based science teaching, and it is necessary to have discussions on exemplary practices. The result of this research was considered, and discussions were carried out on sample activities while conducting the relevant course. Despite this educational process, it is seen that the preservice science teachers do not focus enough on inquiry-based teaching. It is possible to say that the duration of the education given within the research framework is insufficient. Wang (2020) designed a training program to provide inquiry-based pedagogical instruction to prospective science teachers. As a result of this study, it was emphasized that science educators should be able to correctly convey inquiry-based pedagogical instruction so that preservice science teachers can construct it correctly. In addition, Wang (2020) also stated that science educators should be trained for inquiry-based teaching. The result of Wang's (2020) research, Seung et al. (2014) is in line with the research result and the current research result. As a result of the related research, another reason why preservice science teacher tend to choose DI and DA teaching may also be due to the teachers they have taken as role models. Because the education system in Turkey started to adopt the research-inquiry teaching strategy in 2013. The preservice teachers in which the research was conducted were mostly exposed to the training of teachers based on direct instruction until the university. Therefore, the observations of the preservice science teachers so far may have prevented them from adopting an education process for inquiry-based teaching. To summarize, it may have adversely affected the new professional knowledge of the preservice science teachers that they will acquire prior knowledge about the profession. This situation can be investigated with qualitative studies based on interviews. However, in order to solve this issue, study should begin at the start of the candidacy training. Internship courses can also help science instructors and preservice science teachers choose inquiry-based teaching pedagogies. Lederman and Lederman, 2019; Faikhamta et al., 2018). The internship course in the first year was eliminated with the redesign of the scientific teaching undergraduate program in Turkey in 2007. This change removed opportunities for preservice science teachers to observe inquiry-based classrooms. As a result, one may argue that this environment makes it difficult for preservice science teachers to gain professional expertise regarding inquiry-based teaching.

Conclusion

When presented with pedagogical scenarios, second-grade preservice science teachers prefer DI and DA teaching pedagogies both individually and in teams. The preservice science teachers tended to give the correct answer from DI to DA and MA when the subject shifted, while generating answers to the educational scenarios they experienced in both individual and group work. One criticism of science teacher education in Turkey is that it does not provide instructors with the support they require to develop novel teaching methods.

Recommendations

The findings of the study can be used as teaching material in teacher education classes. These findings are interpreted using qualitative data. Working with additional preservice science teachers allows for comparative investigations. It is advised that science professors and educators focus on more notable and diverse instances. Science teacher educators must either update their inquiry-based professional expertise or seek training. Education officials can expand the number of internship courses to lengthen relevant course durations and boost the professional competence of preservice science teachers. This proposal is especially significant in terms of allowing students to apply or observe the professional information they have learned in school.

Limitations

This study was conducted with a limited number of preservice science teachers who were at the beginning of their education at a university. Interviews could have been used to substantiate the results. More pedagogical scenarios on different topics could have been used.

Conflict of Interest

The authors declare that there is no conflict of interest.

Author (s) Contribution Rate

Each of the authors contributed equally to this work.

Ethical Approval

Ethics committee approval was received for this study from Kafkas University Social and Human Sciences Ethics Committee (Date: 19.10.2020, No: 43).

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