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A Case Study of Four Pre-service Science Teachers: What Do Teacher Reflections Tell Us?

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Abstract: Reflection requires someone to think in deep and express the impression of a phenomenon or an event. Reflection can be defined as a mirror to look at and see the personal insights, feelings, motivation, or purposes of individuals within a particular context and practice in a realistic way. This study examined the nature of pre-service science teachers' reflections during the last semester of the teacher education program. There were four cases as student-teachers attending science teacher education program in northwest region of Türkiye. The qualitative data, written reflections and researcher field notes were utilized and analyzed through inductive methods. The results indicated that even though pre-service science teachers learned scientific practices and inquiry, they were not able to implement due to some constraints: mentor teachers forced them to teach on a traditional basis. They could only complete the required four-hour teaching practice. Student teachers reflected on their learning as becoming a science teacher, but their actions were restricted, and they could not find supportive community in school and classroom context.

Keywords: *Pre-service teacher, reflective practice, science education, teacher education.*

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Introduction

Student teachers generally start the teaching profession with lack of experiences on pedagogical practices, knowledge of student conceptions and assessment as well as lack of content knowledge (Grossman et al., 2009; Shulman, 2015). They complain about the unrelated content between the university science courses and secondary school curriculum (Clarke, 2007; K. Zeichner, 2010). Student teachers are expected to be ready for teaching effectively in the classroom, and they need to be equipped with strategies and abilities to be able to adapt to different teaching contexts. A study by Barış and Hasan (2019) evaluated the teacher education system in Türkiye. The analysis of official documents showed that Türkiye had several policy changes in teacher training that might lead to limitations to the application of research. The study indicated that although teacher training philosophy was emphasized as progressive education, pre-service teachers could not get enough support from their practice schools to experience teaching more. According to Barış and Hasan (2019), a person should pass the national higher education exam to enter education faculties. Turkish Ministry of National Science Teacher Education is usually a four-year program including core science and education courses in the first three years and practicum and educational research courses in the last two semesters. They have practical training to practice teaching in cooperation with the Ministry of National Education. Teacher development starts while they are in the teacher education program and continues through seminars, professional development programs, or mentor teacher support. Having opportunities to practice science teaching aims to support the pre-service teachers' readiness to teach in a real classroom setting.

K. Zeichner and Liston (1987) suggest that traditional teacher education programs support teaching apprenticeship through transferring the body of knowledge for content and pedagogy. However, teacher educators need to collect more evidence of student teachers' experiences or practical activities through inquiry-oriented teacher education (K. M. Zeichner, 1994). Student teachers should be given opportunities to be conscious and self-directed to grow professionally and collectively. Altrichter et al. (2005) says that teachers should not forget the most valuable property, the knowledge born from their experiences and their actions to apply them in new situations. Teacher reflective practices can serve as a valuable and critical research tool to analyze pre-service teachers' learning and understand their actions while

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resolving problems in their practices. Teacher reflective practice is a purposeful act of inquiry and involves teachers' thoughtful thinking, planning, acting, and evaluating in a systematic manner (Altrichter et al., 2005). According to Brookfield (2017), teacher reflective practices encourage them to be conscious of the positive and negative aspects of the process of teaching and learning to make wise decisions on further practices; so, teachers should reflect on the teaching goals, beliefs, and strategies, students' conceptions, classroom management and assessment strategies to make evaluations and revisions.

Thus, teacher educators need to support pre-service teachers to understand their thinking of their professional activity and develop critical and analytical skills about teaching and learning processes. As pre-service science teachers begin teaching practicums at middle schools, they realize the challenges or realities of schooling besides their beliefs about teaching and learning. Teacher education should be aware of what pre-service teachers believe, how they teach, learn, and respond to different conditions at schools. This paper examines how Turkish pre-service science teachers characterize teaching and learning through reflective inquiry. The study aims to explore how student-teachers identify and reflect on legitimizing and demanding aspects of their teaching practices. Teacher reflections aimed to be used to study the individual and social aspects of the teaching process. The following question guides to the study: What characteristics of practicum experiences do pre-service science teachers identify and reflect as empowering and challenging aspects?

Literature Review

Reflection is an active process of noticing one's experiences to explore the details of it in greater depth (Amulya, n.d.). Reflection requires someone to think in deep and express the impression of a phenomenon or an event. In other words, reflection can be defined as a mirror to look at and see the personal insights, feelings, motivation, or purposes of individuals within a particular context and practice in a realistic way (Dewey, 1933). Reflection gives rationality and continuity to a situation to make it clear and coherent for future practices (M. Clarà, 2015). Reflection differs from one person to another; each person may bring different insights to a problem: Reflective practices may provide several inferences about an observation or experience in a holistic way (M. Clarà, 2015). Reflective practice aims to develop teachers' theoretical and practical knowledge through guiding them to analyze what they learn, observe, and practice, the purposes and consequences of their actions in both individual and social processes (Fund, 2010). Reflective practice aims to encourage teachers to think and understand their work from a multidimensional perspective: teachers need to understand the strengths and weaknesses of their instructional practices and the factors facilitating and inhibiting their work in the classroom, school, and society. Teachers also need to be aware of other teachers' experiences. As O. McGarr et al. (2019) suggests, "Gaining the perspectives of colleagues and peers can provide alternative perspectives on one's practice and can facilitate deeper conversations and insights about practice that may not emerge through more personal forms of reflection" (p. 246). Teachers' individual and collective thinking and reflecting process would help them to develop pedagogical knowledge in theory and practice and contribute to the work of educational policy makers for assistive improvements. Teachers should engage in sharing and discussing ideas on specific situations from multiple perspectives to address preconceptions in their own insights and plan the goals of future practice.

According to Dewey (1933) and Schön (1983), reflective practice requires an ongoing, systematic process for teacher professional development. Teacher learning continues through the entire teaching career: Teachers develop knowledge of content and pedagogy in the teacher education program and continue to learn from their practices, experiences, and collaboration with other teachers, students, parents, and policy makers. Teacher education programs help pre-service teachers understand their responsibilities, disposition, and abilities in becoming a teacher (M. Clarà, 2015). Teacher reflection individually or within a community guides them to analyze their beliefs, knowledge, and practices to become conscious of actions and observations to make decisions for future practices. Teacher reflections serve as a learning journey of becoming a reflective practitioner. Teacher reflection is a process of inquiry or mindful consideration of professional actions to understand and explain dilemmas or possible solutions in the context of different problems. Schön (1983) explains two types of teacher reflection related to experience: First, teachers can gain insight on their own teaching through examining the practice during action to achieve the learning outcomes (reflection-in-action). Second, teachers reflect on a particular situation in practice after the lesson is completed to learn from experience and make revisions (reflection-on-action). This process includes an individual and collective analysis and synthesis to make sense of actions in different contexts in a continuous thinking process (Felton & Kuhn, 2007; D. Kuhn, 2018). Teachers' reflective experiences help them learn from their practices and develop the knowledge of evidence from their teaching to utilize and address in future. Teachers can bring their previous experiences in new situations or problems to develop new practical knowledge.

Pre-service teachers need guidance from mentor teachers or teacher educators in realizing their prior knowledge to reflect and change for effective teacher learning. They need to regulate their learning through realizing the strengths and weaknesses of their actions. Allas et al. (2020) aimed to explore the role of student teachers' reflections on teaching videos for the development of teacher knowledge. The study found that student teachers could select the important moments of their practices from the videos and reflect on the qualities of events to develop practical knowledge. Meijer et al. (2002) suggested that teachers should be guided to reflect in and on their practice to develop teacher knowledge. The authors referred to stimulated recall interviews and concept mapping in a personal or group activity to express

teachers' actions and learn from others' experiences. Husu et al. (2008) utilized guided reflection procedure to encourage pre-service teachers in revealing their experiences through critical incidents on video lessons. The guiding questions supported teachers to express and elaborate on their previous experiences and make revisions through thinking and acting in a pedagogical context. Tripp (2011) focused on critical incidents to capture beliefs, perceptions, valuable and challenging aspects of teaching practices. Critical incidents were used to analyze, interpret, and shape teacher thinking and action in reference to empowering and challenging situations. Huff Sisson (2016) also argued that critical incidents gave teachers opportunities to develop professional identity through acting, thinking, and judgment of their own teaching and students' learning in real classroom context. López-de-Arana Prado et al. (2019) examined the patterns of pre-service teachers' reflections from their practicum experiences during the analysis of dilemmas and solutions in a collective manner. Fund's (2010) research also involved final-year pre-service teachers' written reflections on their learning experiences and peer feedback for alternative, reinforcing, and explanatory comments. Toom et al. (2019) aimed to investigate the quality of pre-service teachers' reflections on the critical aspects of their teacher learning experiences to develop practical knowledge. The study found that student-teachers' reflections were based on the assessment of what was happening at the beginning, but towards the end, they made evidence-based explanations about their actions. Clarà et al. (2019) supported the use of collaborative reflection to support teacher learning. The study aimed to utilize diverse experiences (e.g. tensions or dilemmas) of pre-service teachers through collaborating with the teacher educator to clarify, explore, focus, and interpret different aspects of their practices. This process also included the open or directive facilitation dynamics for discussion, analysis and synthesis of the events through framing, oppositional voice, problematization, alternative claims, and modelling.

These studies showed that pre-service teachers could notice the strengths and weaknesses of their practices through observation, reflection, and interviews on problematic situations or critical incidents. In these studies, teachers' participation in reflective practice guided them to improve their learning through acting, thinking, and judgment. Teacher knowledge included the knowledge of pedagogy, content, curriculum, assessment, and student conceptions as well as educational context, goals, and values (Grossman et al., 2009). These studies suggested that student-teachers should develop prior knowledge about teaching at real-school settings through observing and experiencing several teaching practices of mentor teachers as well as from collaborating with other pre-service teachers and teacher educators. Teacher voice should be given more emphasis to understand how they reason their pedagogical practices and to support teacher learning. Teacher education programs should aim to develop pre-service teachers' analysis and synthesis of their actions through reflections. Pre-service teachers' development may differ based on the context of their experiences, so it is important to pay attention to how student-teachers develop practical knowledge in different contexts. Pre-service teachers should be supported to analyze and interpret the critical incidents in teaching practices. Teacher reflections on observations, practices or documents can address the process of teacher learning for practical actions.

Methodology

Research Context and Participants

In Türkiye, in a research university, teacher education programs train pre-service science teachers through focusing on courses on science content knowledge, science methods and practicum courses to guide them to develop pedagogical teacher knowledge. These courses include theoretical and practical studies, laboratory investigations, educational research experiences, and small group activities. The science education methods and practicum courses aim to engage pre-service science teachers to develop knowledge of inquiry processes, observe mentor teachers, analyze teaching episodes, practice microteaching activities and engage in reflective inquiry in a personal and collective process.

This study aimed to explore how Turkish pre-service science teachers understand and characterize their practicum experiences through a qualitative case study design (Stake, 1995). The study was conducted during the Spring 2019 semester at a public university in northwest region of Türkiye. This study was conducted as part of a practicum experience of pre-service science teachers, who were required to make observations of science teaching and learning activities at schools, design lesson plans to practice science teaching in a real classroom setting. Students were expected to plan and implement science teaching at least four 50-minute lessons. Referring to their practicum observations and teaching practices, they wrote reflections on what had happened and how to address challenging situations for resolution.

A group of eight pre-service science teachers took "Practice Science Teaching" course, attended classroom observations and taught four science lessons. The researcher asked for these pre-service science teachers' voluntary participation to reflect on their internship experiences. A total of four pre-service science teachers (Audrey, Dorothy, Lena, Jane- all pseudonyms) accepted to be part of the study. They were conveniently and purposefully selected while they were attending their last internship course that lasted twelve weeks. The participants were between 22-25 years old; four student-teachers were female.

Table 1. Guiding Questions for Pre-service Science Teachers' Reflections on Practices

1. Please identify a critical classroom issue and describe the strengths and weaknesses and discuss what a teacher should respond to the situation.
2. What kinds of things did you take into consideration in planning this lesson? What did you learn about planning?
3. What did you learn about teaching?
4. What did the students learn? How do I know that?
5. What went well with the lesson?
6. What went wrong with the preparation and implementation of your lesson?
7. What will you do to improve this lesson - grow professionally?
8. How does learning occur?
9. What is your role as a science teacher?
10. What type of instructional strategies do you usually use in teaching science?

Data Collection

The data collection during the Spring 2019 aimed to identify the pre-service science teachers' educational experiences, their science teaching orientations, and teaching practices. The data collection included four lesson plans for each teacher, written reflections on their observations and experiences in a 12-week period, and researcher field notes. One reflection focused on the most critical point for discussion at their school. Pre-service teachers were suggested to write critical questions and explanations about their experiences. Student teachers wrote a two-page summary paper on the summary of critical incidents, their reflection on the incident, and a discussion of how to overcome this kind of an incident. Student teachers' other reflections focused on different aspects of their internship experiences. Sample guiding questions for reflections are provided on Table 1.

Analyzing of Data

The analysis of the data sources involved inductive method: open-coding process began with reading the data based on the purpose, comparing and contrasting codes to classify them based on similarities and differences, making logical relationships among categories to determine the themes and assertions of the study (Corbin & Strauss, 2015). Theory-driven themes were used to identify the nature of pre-service science teachers' reflections on their practices after conducting in-vivo coding of raw data to iteratively construct and synthesize categories and then into themes through comparison. The coding of student-teachers' reflections was categorized based on Clarà et al. (2019) to focus on "problematizing, action, explanatory, and evaluation" aspects of reflective thinking. The definitions for these themes are presented in Table 2. For example, student-teachers' approach to lecturing was considered problematic. Their suggestions to resolve the problem were addressing 21st century skills as an action to address this problem. In addition, student-teachers' lesson implementation and beliefs about teaching and learning science were categorized as explanation. The participants also evaluated their role as a teacher in society. In this study, pre-service science teachers' professional and practical knowledge aimed to be modelled by systematically comparing teacher reflections and field notes to answer the research questions. To establish the trustworthiness, the author used triangulation techniques through participants' extensive reflections. Codes were compared with one participant's coding to establish member-checking; differences were resolved through discussion.

Table 2. Themes Developed for Participants' Reflections

Theme	Description
Problematizing	Teachers describe a problematic situation in the practice
Action	Teachers describe the actions to handle a problem
Explanation	Teachers explain a situation in the practice
Evaluation	Teachers evaluate the situation considering political, moral, ethical factors

Note. Adapted from M. Clarà et al. (2019)

Findings/Results

The participants practiced teaching at their internship schools and reflected on how they should become a teacher within a community. The results indicated the participating pre-service science teachers' educational experiences that they problematized, took action to resolve problems, evaluated the situations in different ways, and explained what happened in practice. In their experiences, they referred to teaching approach, student thinking, teacher attitudes, and physical environment of the classrooms as well as lesson planning and implementation, community practices, and orientations to science teaching.

Problematizing Situations and Actions to Address

Jane problematized lecturing and aimed to resolve the problem through peer learning. She suggested that 21st century skills supported the use of effective laboratory practices through cooperation but teaching for standardized tests and curriculum created discrepancies to address science and engineering practices and nature of science and left little room for scientific inquiry. She added that science teachers tended to rely more on lectures, and students became passive receivers of knowledge in the teacher-centered teaching and became dependent on supervising authority for their learning needs. Jane stated,

> *Science is approached as strict, content-based, teacher-centered with time restriction to cover the suggested topics. Even though we learn the applications of science in the laboratory and science methods courses, it is not possible to use our knowledge during the internship. In real classroom settings, we do not observe much group work activities. Science teachers are forced to prepare students for national standardized tests through solving a lot of questions and focusing on the practical strategies to solve the problems.*

Jane addressed the difficulty of planning and enacting student-centered strategies as suggested by reform movements. She thought that science teachers had to teach exam-focused lessons and transfer the curriculum rather than addressing students' diverse needs. Jane explained her observation as more focused on traditional instruction, and she thought that this kind of instruction was boring for students as students needed to engage in more meaningful experiences to understand how science works in their environment. Jane thought that at schools, individual learning has been supported; students were afraid of providing answers, so they usually imitated their answers based on others' responses. Jane suggested that peer instruction could help students learn from each other and share their success for common purposes. Jane's solution to this problem was that science teachers should utilize peer learning strategies in a collaborative and communicative learning atmosphere, where students worked in groups to work on the exploration activities such as experiments and observations. Jane suggested that science teachers should act as a guide and utilize effective scaffolding strategies to promote student learning through asking guiding questions, giving feedback, controlling the students' level of frustration, and comparing different explanations along with good classroom management strategies.

Audrey discussed the problem of alternative conceptions. She observed that some teachers tended to use lecturing or cookbook laboratory activities with directions or instructions to complete. She suggested that science teachers should be aware of the common misunderstandings on the topic. Audrey referred to possible alternative conceptions that could occur during an activity and stated,

> *In the simulation, you can alter the liquid density. As the density is increased the liquid turns to honey and takes the color of yellow. When the density is decreased the liquid turns to gasoline and takes the color of grey. Students' answers were about the direct propagation between the pressure and density. However, when the teacher asked for another liquid which was olive oil, the students' response was "Because olive oil is yellow, it must be denser than water, so its pressure is higher than water." The teacher realized the current misconception, so she asked, "What can you say about mercury's density and pressure?" The students' answer was "Mercury is grey! It is like gasoline and it's both density and pressure are lower than water."*

Audrey explained how science teachers could reveal and address students' alternative conceptions during the instruction. She thought that learners' previous experiences and cultural factors might affect their thinking, and science teachers should be aware of and utilize instructional strategies that could engage students in scientific practices and nature of science while understanding the scientific conceptions. She stated that science teachers should be aware of students' thinking process as they were not empty vessels, and they brought several prior ideas based on their past experiences; students might develop alternative conceptions related to a science concept, which should be resolved for a meaningful learning experience.

Lena emphasized the role of science experiments. Lena suggested that science teachers should be trained to create a suitable environment to make students active participants of their learning through collaboration. From her experiences, she realized that teachers were not ready for an unexpected situation in their lesson through appropriate planning; teachers should have a back-up plan to address the problems and continue the learning process. She was aware of teacher self-efficacy to resolve a problem during the instruction. Lena addressed teachers' attitudes towards science experiments, and she stated,

> *Teachers think that science experiments are entertaining and attract students' interest. Science experiments should be integrated into science instruction to help students develop scientific abilities to collaborate effectively with their peers as well as engage in scientific practices through observations, data collection and analysis, and scientific explanations.*

Lena expected teachers' tendency to use science experiments to enhance students' scientific abilities rather than only focusing on the enthusiasm to do the experiments. On scientific experiments, Lena stated:

> *The questions that I am interested in is, "What is scientific experiment? What is normal experiment?" Think about the experiment done at CERN and in a classroom, "What are the similarities and differences between students' experiments at the school level and scientists' (scientific) experiments in research?"*

Lena discussed the meaning of experiment including procedures to carry out such as observations, variables (dependent and independent), hypothesis, data collection and analysis. Lena thought that experiments done at schools took short time, scientific experiments at research institutions were conducted in more suitable experiment environments with sensitive instruments and interdisciplinary teams through following detailed scientific methods. Lena emphasized that middle school students did not understand the scientific method and were not able to ask research questions since the experiments in middle schools included the replication of former experiments. She argued that science teachers should know how to plan and guide the experimental process to identify variables; most science teachers approached science as true and never changing and science experiments to prove the hypothesis. She added that science teachers should integrate science experiments to improve students' scientific thinking skills and understanding of nature of science rather than dealing with technical problems or instrumental errors.

Dorothy focused on the role of physical conditions in teaching and learning science. Dorothy stated,

> *I observed the physical problems in the classroom. When I came to the classroom, there was a disorder. Especially, students who sat at the back side of the classroom and felt uncomfortable since there were hangers and lockers at the back. Students hang their coats in the classroom. There was chaos when students wanted to take their books. Physical conditions are important for creativity and motivation, and learning.*

Dorothy explained that the physical environment was important for learning to feel comfortable enough during the lesson. She suggested that teachers should consider the temperature and light of the class, the organization of the desks, and free space to walk around the classroom; science laboratories and their characteristics were important for teaching and learning process. Dorothy also referred to less laboratory instruction in schools due to lack of materials, financial problems, unsatisfactory lab environment, considerable number of students in each class and lack of teacher interest. She added that if school administration did not support teachers for laboratory instruction with sufficient equipment such as running water or source of electricity, teachers should conduct some experiments with their own resources and home-made materials in the classroom environment. She stated, "For instance, teachers can show how gas molecules behave by using a pot of hot water, balloon, and empty bottles." However, Dorothy indicated that most teachers were unaware of scientific safety procedures to take precautions; teachers should be aware of the safe use of equipment, storage of harmful chemicals and actions to take in the case of emergencies. She thought that teachers were not able to teach laboratory courses since they have not been trained well in science laboratory instruction. She added that the national curriculum supported the traditional instruction, so teachers focused on showing demonstrations to spend more time on covering the content for test preparation.

Explanation of Lesson Planning and Implementation

Pre-service science teachers described their lesson planning and teaching practices by reflecting on their own actions and their interactions with other student teachers and their mentor teachers. Student teachers were expected to teach four 50-minute lessons at their internship schools. Mentor teachers selected the topic of each lesson according to the annual curriculum plan and learning objectives, and they suggested the pre-service science teachers to use the examples from the national science textbook. Even though mentor teachers were restricted to follow the national curriculum, pre-service science teachers were suggested by their teacher education program to use additional resources to accommodate students' learning and enact student-centered instruction. Student teachers prepared the lesson plans following the learning objectives as a guide from the curriculum for a 50-minute lesson.

After the selection of learning objectives, student teachers searched for possible alternative conceptions from the literature that students might have related to the concept. During their internship practices, student teachers met the same students once or twice; they were not familiar with students' academic background and personal needs. They were suggested to prepare the possible questions in their lesson plans that could guide the flow of the lesson to maintain student attention smoothly. They only aimed to address students' pre-knowledge and possible alternative conceptions through questioning from the previous units. For example, Audrey stated, "I asked questions to check students' familiarity with the concepts." She aimed not to give direct information, but she aimed to ask questions to make students predict and use daily life or historical examples as well as visual resources such as video and pictures to make them visualize.

Student teachers aimed to link students' old concepts with the new ones through making students predict and express their ideas, using analogies, and experimentation. Most student teachers used effective questioning techniques to probe students' pre-knowledge, detect students' anticipated conceptions and to promote peer interactions in classroom by using multiple teaching materials (videos, animation, pictures, news, and maps) with a worksheet. Some pre-service teachers did not have a chance to integrate science experiments in their lesson plans since the classroom that they were using was not appropriate for experimentation. In a classroom with desks in linear order, Lena and Jane attended the same internship school and practiced teaching with 25-34 students. These student teachers, after introducing with open-ended questions to reveal students' pre-knowledge, mostly utilized PowerPoint presentations to show visuals such as diagrams, pictures, or videos related to the concepts. For example, Lena preferred to show a demonstration at the beginning of the class to show the propagation of sound in a solid medium with daily materials (hitting metal spoon to

the desk and to another metal spoon) or show three-dimensional eye model. Her worksheet included the questions that could build every concept in an order through following the demonstration and PowerPoint presentation. Jane had prepared a presentation to follow on the smartboard, but due to technological difficulties, she explained the topic by drawing the CO_2 cycle on the board, and she led a whole class discussion. Dorothy worked with a different mentor teacher at another school and could use a smartboard to show a simulation on the board. The class was not available for integrating group work, and students were completing the worksheets while the pre-service teacher was demonstrating the electric circuit on the simulation.

Different from other teachers, after revealing students' ideas, Audrey integrated experimentation in the classroom: she asked students to predict and design the experiment to observe, record, and classify their results with the given materials. Her lesson plans included the possible activities to use in the classrooms: after the introduction part, students joined group work on separate rectangular tables and conducted experiments to answer the questions on the worksheets. She walked around the room to see what the groups were doing. However, completing an experiment was difficult in a 50-minute lesson; the student teacher had difficulty in time management to summarize the lesson at the end.

These pre-service teachers completed the lessons by ensuring that students completed the worksheet by the end of the lesson. Even though the lesson plans included all the activities and emphasized the scientific practices and nature of science concepts, pre-service teachers couldn't address scientific process skills and characteristics of science explicitly due to time and equipment limitations.

Explanation of Orientations to Science Teaching

The participants' explanations on the role of the science teachers focused on teachers' responsibilities and autonomy in science classrooms. Student teachers discussed that teachers have a role in students' science-based academic life, so they should develop basic knowledge including science process skills, students' conceptions, abilities, and needs for learning. Student teachers argued that teachers were also responsible for productively navigating the curriculum to plan and enact the instruction. They believed that teachers should be autonomous to integrate various assessment types based on students' needs.

Participants' responses also focused on teachers' role to create a safe, comfortable, and supportive learning environment, in which they could utilize variety of instructional strategies and integrate technology to empower student voice. Student teachers claimed that teachers should be aware of students' needs, expectations, and prior knowledge to prepare an effective lesson plan; the lesson plan should be flexible based on students' needs and include various activities and back-up planning. They stated that teachers should be aware of students' existing conceptions, ask questions to reveal and address their pre-knowledge to build scientific conceptions through exploration. However, Lena focused on transferring correct scientific facts through direct instruction: Lena stated, "I prefer teaching through step-by-step instructions including pre-determined questions and expected responses to ensure students get correct information." Lena believed that teaching the correct information was necessary through student-centered models, she suggested the integration of collaborative activities or peer learning to create a discourse environment during the experiments. She also supported the development and use of modelling to make students visualize concepts.

Avoiding traditional knowledge, participating teachers argued that teachers should enact student-centered lessons where students were provided experiences, and students' ideas were shared and discussed. Student teachers' responses focused on scientific inquiry and how to apply scientific method through asking questions, making predictions, observations, data collection and analysis. Jane stated, "Teachers should teach science to produce rather than consume the science." Participants defined scientific inquiry around designing and carrying out investigations in collaboration through observations, hands-on experiments, modelling, and simulations. They discussed that science teachers should give importance to exploration and explanation that students could express their ideas and apply their understandings into different scientific problems and real-world issues through trips for nature and media materials.

The participants discussed that learning process involves cognitive, social, epistemic, and affective demands from both teachers and learners. Lena defined learning and stated,

> *Learning is a continuous process … to progress through an ongoing process of learning. As human beings, we begin our journey of learning at birth and continue to learn until our death. This learning process may result from our experiences, perceptions and information that gained during lessons etc.*

Lena indicated that teachers were the supporters of the learning process through planning and providing directions while it requires individual effort. Jane emphasized the role of the neural system, in which individuals make sense of the environment, create signals with the senses, and give responses to the environment through control and stimulation. Jane added,

> *The brain is responsible for learning. The brain has different functions including long-term and short-term memory. When a person learns new information, it is stored in the short-term memory. If a person repeats this information a few times, it is conducted and stored in the long-term memory. The brain stores the information with the help of*

neural system. We sense the environment and create signal with our senses then give response to the environment. These signals are carried via chemical and electrical transmission.

This explanation supported the necessity of learners' active involvement in their learning process. Jane suggested that students should join a collaborative activity to communicate with each other and engage in scientific practices such as asking questions, giving feedback, making predictions and observations, experimenting, collecting, and analyzing data inside and outside a science classroom. In the learning process, students are expected to link new knowledge to prior knowledge through making explanations with sufficient content knowledge and relating their understandings with daily life experiences. Jane made an elaboration and thought that science teachers should create authentic learning environments where students could learn through exploration. Dorothy suggested that schools should focus on scientific experience rather than grades or exams; schools should aim to integrate active learning- highly collaborative hands-on experiment with extensive use of technology.

The participants' explanations also referred to the use of sufficient formative and summative assessments methods to understand whether learning is occurring. All participants suggested the use of different types of questions such as multiple-choice tests, open-ended questions, fill-in-the-blanks questions, matching questions. Only one student teacher, Lena, suggested the preparation of lesson plans through instructional models such as 5E learning cycle, argumentation-based instruction, and project-based instruction to support student learning.

Evaluating Teaching Practice within a Community

Participants were dependent on their immediate environment and larger society as pre-service science teachers. First, all participants thought that during their internship process, their job as a student-teacher was defined by their mentor teachers, who was an in-service science teacher assigned as a mentor by national education center. Student teachers had a student role with a lot of responsibilities to make observations, take notes, attend meetings with the mentor teacher, check student assignments, and fill the teacher notebook. During the teaching process, student teachers' topic was selected by the mentor teacher based on the national curriculum. The student teachers were obliged to use national science curriculum and textbook when they prepared the lesson plans to determine what to teach and what not to teach.

Audrey described her role as belonging to students, who she should communicate to maintain science learning environment. She discussed that she should address students' diverse psychological and social needs to help them apply scientific knowledge in their daily life experiences. Additionally, Audrey and Lena indicated that being a science teacher made them dependent on society. These student teachers thought their job was to raise awareness about socio-scientific issues and to help students be life-long learners and responsible citizens. The student teachers argued that they should be aware of what is happening around them, be knowledgeable in every field to increase scientific literacy and be a role model for society. Lena and Jane described themselves as belonging to classmates of other pre-service science teachers for courses offered in the teacher education program. They believed that they were required to work as a group in these courses and communicate with each other effectively to become innovative and student-oriented teachers.

Discussion

The examination of pre-service science teachers' reflections brought their experiences, practices, interactions, and beliefs into focus. Even though pre-service teachers attended the science method courses addressing teaching through inquiry, they were not able to enact inquiry-oriented practices. The results indicated the participants' problematizing experiences since they were not able to integrate student-centered strategies in the classroom, and state-test mandate, teacher beliefs and physical conditions forced them to use traditional approaches. Their practices were at a routine level; they could not integrate student-centered strategies (Clarke, 2007; Tiainen et al., 2018). They taught lessons to cover the content through presentations or demonstrations because their choice of instructional practices depended on the contextual factors.

As O. McGarr et al. (2019) and Toom et al. (2019) suggested, lack of teaching experience and logistical factors might lead student-teachers to focus on science content knowledge without addressing students' alternative conceptions as well as personal needs. As Brownell and Tanner (2012) suggested, student-teachers might have lack of training, time, and incentives to change their traditional practices towards more student-centered practices. Even though they believed that they should provide scientific experiences through exploration, their practices mostly focused on triadic dialogue: Initiate, Response, Evaluate (IRE) (Osborne et al., 2004). Clarà et al. (2019) suggested an action to address these problems that pre-service science teachers should develop knowledge of students' needs including academic background, psychological, and social needs through evidence-based instructional practice; they should also support students' social and affective needs. Pre-service teachers should become aware of the challenging aspects of teaching in a real classroom setting. Teacher education programs should help student-teachers develop both theoretical and practical knowledge through learning how to be responsive to diverse student questions and interactions in a specific classroom context. This suggests that student teachers should develop professional identity including responsibility and autonomy to ensure high-quality instruction through preparing interventions and actions based on diverse students' academic needs.

The Framework for K-12 Science Education (National Research Council [NRC], 2012) supports the development of science teachers to enact science and engineering practices to understand the characteristics of nature of science. The participants' intentions to teach for enhancing science literacy require a closer look to what science teachers are doing in science classrooms. Their reflections revealed participants' beliefs that students learned through being actively involved in their own learning processes, so science should be taught through inquiry by using experimentation and observation. However, student-teachers realized the classroom context as inaccessible to maintain student attention since students had to receive the information from the teacher or smartboard and take notes on given worksheets. Science experiments were also done to follow and replicate the procedures and to prove the formulas. Instead of focusing on only science content in an individual context, pre-service science teachers should learn how to teach in different learning contexts by using different instructional models. Even though participating teachers were familiar with the 5E instructional model to teach, they have never had a chance to plan and teach thoroughly through scientific inquiry during the internship process.

The findings of this study showed the challenges and problems that student teachers faced to integrate their beliefs into practice and emphasize their professional role through their interactions with students, colleagues, and society. Pre-service science teachers should be given opportunities to teach through student-centered innovative strategies and reflect-in and reflect-on their practices to understand the problems with the implementation of new methods to support teacher learning. Student teachers should be supported to experience teaching in different classroom settings and in different content contexts to learn how to be responsive to diverse situations. Pre-service science teachers' internship practices should support them to recognize the value of their beliefs and their role in society to address scientific and socio-scientific issues and enhance development of scientific literacy for all. As an example, Zavala et al. (2007) argued that active learning classrooms showed its positive influence in learners' problem-solving, collaboration, and communication abilities as well as attitudes towards science. Science classrooms should support students to work on explorative hands-on science activities collaboratively to actively involve within the process through engaging in diverse literacy skills such as doing, writing, talking, and reading while the teacher was acting as a guide.

Conclusion

A reform-minded teacher should understand how to address students' learning needs and enact non-traditional or alternative instructional strategies. Even though the pre-service science teachers felt responsible and caring to help students, their actions could not mediate their teaching and students' learning through scientific inquiry. In this study, pre-service science teachers had problematizing situations such as teaching through lecturing, student misconceptions, integration of experiment, and physical conditions of the classroom. These teachers found it difficult to attend the teaching and learning process and made suggestions to overcome these difficulties. Pre-service teachers also explained how they planned and taught lesson planning for four lesson hours and discussed their orientations including beliefs and attitudes towards science teaching.

The study suggested that teacher education programs must help student teachers understand the dramatic influence of contextual factors on their teaching practice to develop practical knowledge for teacher learning. School and classroom contexts should accommodate the needs of student teachers in becoming a science teacher to reduce their level of anxiety for teaching through inquiry. Teacher education should provide extensive professional development and in-depth learning experiences to enhance student teachers' pedagogical as well as affective reasoning in the use of alternative or student-centered pedagogies. Pre-service teachers should see themselves as part of a community, and mentor teachers at internship schools, principals, science educators, and other teachers should support and facilitate their development through active learning.

Recommendations

The results of this study indicated that pre-service science teachers problematized different aspects of their practices. They complained about being forced to teach through lecturing without integrating alternative strategies to address students' alternative conceptions. Future research should aim to explore pre-service science teachers' use of inquiry-based instructional strategies to elicit students' ideas and engage them in experimentation. Teacher education programs should support pre-service teachers' development to teach through inquiry-based instruction in real-classrooms. Student-teachers should learn how to apply their knowledge into practice in real schools through long-term teaching experiences. These findings also suggest that mentor teachers need professional development to guide pre-service teachers' teaching through inquiry.

Limitations

Limitations were covered in the methodology section in terms of number of participants and sampling methods.

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