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Comparison of the Theoretical and Practical Knowledge of the Pre-Service Science Teachers in Turkey: The Context of Simple Electrical Circuits

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Laboratory applications are one of the most essential strategies in science teaching. Therefore, science teachers are expected to advance their laboratory skills. In Türkiye, there are generally applications for construct theoretical knowledge. Literature indicates the need for individuals who can use knowledge. For this reason, there is a need for laboratory skills through which knowledge is used in science teaching. Hence to meet this need, it is expected that theoretical knowledge will be used unitedly with practical knowledge. This research aims to compare pre-service science teachers' knowledge of simple electrical circuits which is both theorical and practical. The research group consisted of 60 pre-service science teachers studying at a university in Trabzon, Turkey. The study was carried out using the case study method under the category of descriptive research approaches. Data were collected with conducting drawings, observation studies of experimental setups, and clinical interviews. Data were analyzed through content analysis. The data obtained determined that pre-service science teachers had 'theoretical' knowledge within the scope of simple electrical circuits, but they could not put this knowledge into practice 'practically' and could not establish the circuits. In addition, it is one of the findings of the research that pre- service science teachers are theoretically limited in what they learn, and they do not have the opportunity to use the novel forms of knowledge in active learning environments, which indicates they do not have procedural knowledge.

Introduction

Education process is shaped by the demands of individuals in society, the needs of countries, the requirements of age, individual characteristics, and many other ideas (Blossfeld

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and Von Maurice, 2011). Accordingly, it has been discovered that, in contrast to the behaviorist approach's understanding of the learner passively receiving information, the understanding of the learners constructing the information themself, researching and questioning the information, and associating it with previous knowledge will provide more permanent learning. According to Sherman and Kurshan (2005), there is a need for education that may enable learners to engage in one-on-one scientific research processes. With this perspective, Sherman and Kurshan (2005) envisaged a teaching design that would enable learners to engage in a one-to-one scientific research process, Gagnon and Collay (2005) would create positive interest and enthusiasm for science, and Dewey (2004) would develop scientific perspectives and support the development of collaboration and communication skills. When this insight is considered in the context of Turkey, it is evident that it has not come to fruition. Turkey's position in international tests might be seen as one of the primary conclusions.

In the findings of PISA, an international exam, and reports and studies analyzing the Turkish Education System (Gur, Celik and Ozoglu, 2012; Sengul, 2015; Yalcin and Tavsancil, 2014), it is stated that there are some significant problems in terms of reaching the educational design required by the age. The inability to follow the skills required by the age, the inability to focus on innovative laboratory practices (Darmaji, Kurniawan and Irdianti, 2019), the active continuation of traditional lectures, the lack of materials or equipment, the inability of every student to participate in teaching activities due to the large number of students, exam-oriented education, and training rather than talent-building-based education are among these deficiencies. It may be summed up as rote education that is not productive or creative, and education that deviates from universal and national norms (Hofstein and Lunetta, 2004). Although Turkey has achieved significant progress in recent years in strengthening its educational system, local and international experts believe that the Turkish educational culture must change in order to resolve educational issues (Endruweit, 1998). Because socioeconomic and sociocultural elements are expected to play a big role in the disruptions in Turkey's education system (Aydogan, 2009; Copur, Erkal, Dogan and Safak, 2010; Kalaycioglu, 2015). As can be seen, investing in education in today's world leads to increased productivity, economic growth, and, ultimately, development, because it tries to acquire more information and skills (Heyneman, 2009). Besides, given the importance of 21st-century skills and cognitive process skills, it is expected that as a result of Turkey's educational reform movements, practical applications will outnumber theoretical knowledge transfer, and teachers will provide students with as many learning environments and instructional designs as possible within the scope of their lessons. These instructional designs are age-appropriate, incorporating 21st-century abilities and science process skills; they should promote the learning of sub-skills such as inquiring, exploring, finding, and solving issues, analytical thinking, creativity, and critical thinking (Ferreira and Morais, 2020; Husnaini and Chen, 2019).

Science education is one of the field of discipline to work in if you want to learn new skills and create new instructional ideas. Because science education has made it a goal for students to understand, apply, and be aware of the scientific research process (Huppert, Lomask and Lazarowitz, 2002; Lacin-Simsek, 2010), science education has made it a goal for students to know, apply, and be aware of the scientific research process. Science process skills are included in science education (Jones, Taylor and Forrester, 2011). Science process skills, 21st century skills, and science are all linked rings in this perspective. Furthermore, scientists have argued for years that the purpose of science education is to build science process skills (Germann, Aram and Burke, 1996), and that science education aids students in developing science process skills (Guerra and Noll, 2021). Science process skills, according to Myers, Washburn, and Dyers (2004), are the foundation of science instruction as well as teaching inquiring and investigation.

Cepni, Ayas, Johnson, and Turgut (1997) investigated science process skills in science. They defined them as abilities that enable students to take responsibility for and manage their own learning processes, access information on their own rather than being given information, be active in the learning environment by avoiding passivity, gain research process and methods, and increase the permanence of learning. Learning by doing and experiencing is the most successful approach of developing science process skills, conducting research and inquiry, absorption of knowledge, and active participation in teaching. Scientific laboratories are the areas where we may realize and carry out this process in science teaching. Students do experiments, build mechanisms, make observations and conclusions, apply what they've learned in theory to practice, use what they have learned in everyday life, and learn to embody soft information in science education (Setiawan, Malik, Suhandi and Permanasari 2018). Many scientific educators have emphasized the importance of teaching science courses in a laboratory setting (Hofstein and Mamlok-Naaman, 2007) and that science education cannot exist without experiments. So, any science teacher concerned with 21st-century abilities and wishing to improve science process skills should prioritize laboratory activities and effectively manage this process. However, research in the literature (Berkes, 2007; Boddey, 2012; Mamlok-Naamon, 2008; Shi, He, Wang and Huan, 2015) indicated that science instructors lacked knowledge and abilities in laboratory techniques as well as in the subject of science. According to Yildirim, Yalcin, Sensoy, and Akcay (2008), they had issues analyzing abstract concepts, experienced misunderstandings, and had difficulties in experiments. These issues have been identified to be based on scientific instructors' university experiences (Demir, Boyuk and Koc, 2011). Because it is believed that determining the processes of pre-service science teachers transforming theoretical knowledge into practical knowledge in the laboratory environment, where they went wrong in laboratory activities, and the interaction between theoretical knowledge and practical experience will contribute to the literature. As a result, the purpose of this study is to compare pre-service science teachers' theoretical and practical knowledge of simple electrical circuits. Various statements in the literature reveal that students have misconceptions about simple electrical circuits (Asomi, King and Monk, 2000; Chen and Kwen, 2005; Duit and Rhöneck,1997; Heller and Finley,1992; Kucukozer, 2003; Lee and Law, 2001; Orgun, 2002; Pilatou and Stavridou, 2004; Sencar and Eryilmaz, 2002; Tsai, Chen, Chou and Lainb, 2007; Yildirim, Yalcin, Sensoy and Akcay 2008; Zacharia, 2007). Pilatou and Stavridou (2004), in their research conducted with 383 students aged 11-12, to determine the students' thoughts about electrical circuits and their places of use in daily life, found that students had difficulties in associating simple electrical circuits with their places of use in daily life. For this reason, it is observed that it is important to reveal the conceptual knowledge of science teachers and pre-service science teachers' about simple electrical circuits.

Considering the requirements of the age, it is clear that the power of technology rather than the power of information is getting stronger. Transformation of knowledge into technology is only possible with the use of theoretical knowledge. For this reason, developed states attach importance to implementation activities and questions to which knowledge can be applied in daily life. However, it is observed that even though traditional approaches are tried to be abandoned in Turkey, it is not possible to break away from accepted habits. Concordantly, it is observed that students do not have deficiencies within the scope of knowing theoretical knowledge in the physics Olympiads held in Turkey. However, they are found to be unsuccessful when they try to solve the problem situations in daily life with theoretical knowledge such as PISA. Similarly, there are findings in the national literature that frequently express that students do not know where to use the information they have learned. For this reason, it is thought that it is important to determine the relationship between theoretical and practical knowledge based on prospective science teachers. Because it is science teachers who will enable students to feel the problem situations in daily life and to transform theoretical knowledge into practical knowledge. For this reason, since it is thought that pre-service teachers are developed within the framework of new approaches, their applications between theory and practice are very important.

Considering the fields of science, it is known that the places where theoretical knowledge is used practically are laboratory environments. In this context, it is foreseen that pre-services science teacher knowing the theoretical knowledge about the electrical circuit and determining their approaches to constructing electrical circuits will have a very important place in determining the deficiency in Turkey. Therefore, the purpose of this study is to compare pre-service science teachers' theoretical and practical knowledge of simple electrical circuits. For this purpose, answers to the following questions were sought.

(1) How is the theoretical and practical knowledge of pre-service science teachers about simple electrical circuits?
(2) How are the simple electrical circuits drawings of pre-service science teachers?
(3) What is the situation of pre-service science teachers in creating simple electrical circuits?
(4) How is the comparison of pre-service science teachers' situations of setting up and schematizing simple electrical circuits?

Method

Research Design

The purpose of this study is to compare pre-service science teachers' theoretical and practical knowledge of simple electrical circuits. It is necessary to conduct an in-depth research process to compare pre-service science teachers' theoretical and practical knowledge in terms of content, scientific knowledge, and subject matter knowledge. Concordantly, the research technique, which is one of the qualitative research methodologies that allow for an in-depth examination of the research process and summarizes the information gathered about the topic area, should be favored. Therefore, the study was carried out using the case study method under the category of descriptive research approaches. The case study technique is chosen in the research process because it incorporates numerous sources of information on a scenario or occurrence and allows for in-depth analysis and description of the process (Cresswell, 2013). The steps in the research process are summarized as follows :

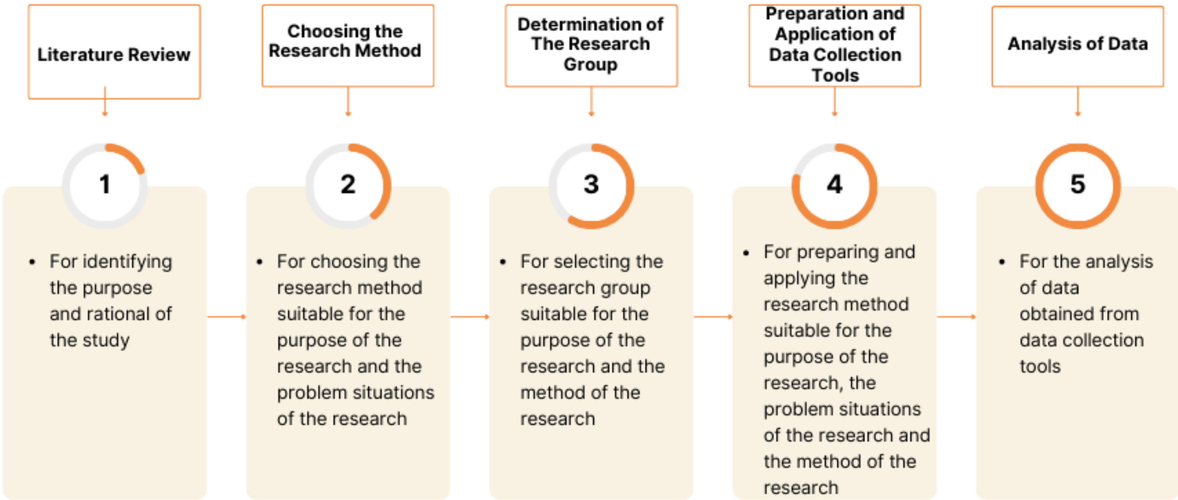


Figure 1. The Steps of Research Process

Participants

The criteria sampling method, which is one of the intentional sampling strategies, was utilized in this investigation. Criterion sampling is the process of selecting a group of individuals who have certain traits that are relevant to the problem (Grix, 2010; Marshall and Rossman, 2014; McNabb, 2015). The primary focus of this study will be 4th grade pupils who have completed the "Physics Laboratory-II" course. In order to test this criterion, research was conducted with 60 participants in the 2021-2022 academic year, consisting of 4th grade pre-service teachers in a university's science teaching program in the province of Trabzon.

Data Collection Process

During the data collection process, pre-service science teachers were expected to first draw drawings on simple electrical circuits. These drawings were carried out in the physics laboratory, where the pre-service teachers regularly conduct their lessons. After the drawings were completed, individual pre-service science teachers were expected to construct simple electrical circuits. related materials (bulb, battery, voltmeter, ammeter, conductive cable and alike) were given to the teacher candidates. The pre-service teachers were not presented with steps with a specific instruction, and they were expected to carry out their own processes. Meanwhile, the steps taken by the pre-service teachers were noted through observations. In addition, simple electrical circuits setups were evaluated with the developed checklist. Finally, clinical interviews were conducted with the pre-service science teachers who completed the drawing and simple electrical circuit installation, and detailed information about the simple electrical circuits they drew and installed was tried to be obtained. In this respect, the process was completed in 3 steps, as observed in Figure 2.

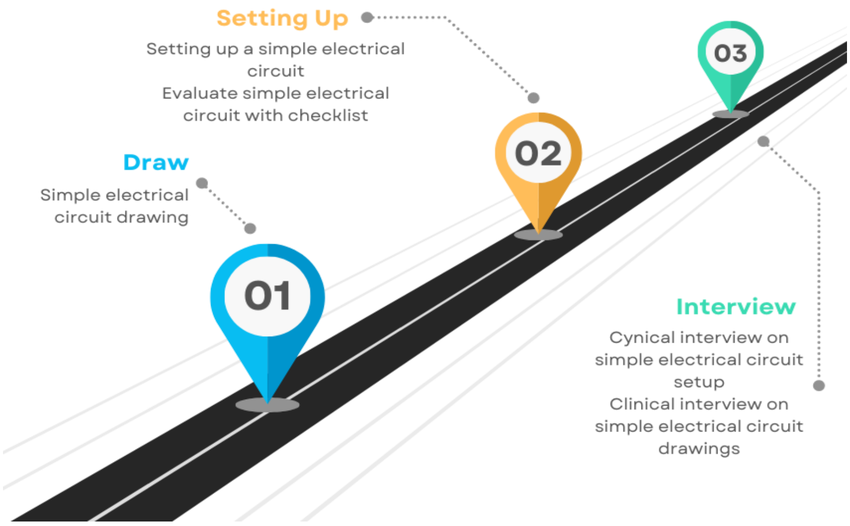


Figure 2. Data Collection Process

Data Collection Tools

Drawings, observation studies of experimental settings, and clinical interviews were used to collect data as part of the study. In this study, observational drawing studies and experimental settings were used in order to examine and disclose the mental processes of individuals in more depth (Tashakori and Teddie, 2003). Drawings and observation studies are vital during the research process for both establishing the needs ahead of time and getting information that may be constrained in clinical interview methods (Creswell, 2013).

In addition, clinical interviews were used to gather information. Clinical interviews are used in schools to define students' tactics, knowledge structures, and abilities, as well as to better understand their developmental processes and study their mental models (Goldin, 1998). In the observation studies, pre-service science instructors were asked to build circuits according to instructions in the Physics Laboratory Applications-II course for 15 minutes apiece, and observations were taken. The observations' findings were documented in a checklist created by the researchers. On the other hand, 60 pre-service science instructors were subjected to clinical interview investigations.

Data Analysis

The material gathered from clinical interviews was evaluated using the content analysis approach, which established the existence of codes, built themes by combining these codes, and made conclusions (Creswell, 2013). In the construction of codes and themes, the NVivo 9 package software, which is a qualitative data analysis application, was selected. The researchers' checklist was used to capture and evaluate observational studies on setting up and schematizing the experimental setup. Table 1 lists the items in the checklist.

Table 1. Checklist

1. Setting up the circuit	Item 1	Established a workable circuit and the lamp gave light
	Item 2	Connected the lamp to the circuit correctly
	Item 3	Used the switch in the circuit
	Item 4	Connected the switch to the circuit
	Item 5	Connected the amperemeter in series with the circuit
	Item 6	Connected the voltmeter in parallel to the circuit
	Item 7	Correctly chose the current direction of the amperemeter in the circuit
	Item 8	Chose the correct current direction of the voltmeter in the circuit
2. Schematization	Item 9	Knowing the serial connection of the amperemeter to the circuit
	Item 10	Knowing the parallel connection of the voltmeter to the circuit
	Item 12	Drawing the series circuit in accordance with the instruction
	Item 13	Drawing the parallel circuit in accordance with the instruction

The components on the checklist used to examine the circuit building and schematization scenarios of pre-service science instructors are listed in Table 1. The checklist's propositions were graded as either "done" or "failed to do." Within the context of validity and reliability, the researcher spent more time with the participants, the gathered data was presented for participant confirmation, and the conclusions were presented in depth.

Results

The data analyzed as a result of observation studies and clinical interviews are presented to the reader in the findings section of this study, which aims to reveal the proficiency of 4th grade pre-service science teachers taking the "Science Teaching Laboratory Practice I and II" course in establishing and schematizing simple electrical circuits and the problems they encounter. Table 2 shows the participants' progress in constructing a single bulb simple electrical circuit.

Table 2. The situations of establishing a single lamp circuit of pre-service science teachers

Items	**Done**	**Failed**	**Total**
He/she set up a workable circuit and the lamp gave light	34	32	66
Connected the lamp to the circuit correctly	61	5	66
He/she used a key in the circuit	62	4	66
Switched on switch	58	8	66
He/she connected the amperemeter in series with the circuit	57	9	66
He/she connected the voltmeter to the circuit in parallel	27	39	66
He/she chose the current direction of the amperemeter correctly in the circuit	21	45	66
Chose the correct current direction of the voltmeter in the circuit	29	37	66

As shown in Table 2, pre-service science teachers single-lamp circuit setting status is provided by assessing them according to the elements on the checklist. "He attached a switch to the circuit" was the highest accurate statement among 62 participants, while "He properly picked the current direction of the ammeter in the circuit" was the lowest right statement among 21 people. The examples below were put up according to the instructions and assessed using the checklist.

Table 3. T8 coded single lamp simple electrical circuit and its evaluation

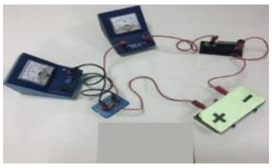
Circuit	Items	Done	Failed
	He/she set up a workable circuit and the lamp gave light	X	
	Connected the lamp to the circuit correctly	X	
	Used switch in circuit	X	
	Connected the switch to the circuit	X	
	Connected the amperemeter in series	X	
	Connected the voltmeter in parallel to the circuit	X	
	Chose the current direction of the amperemeter correctly in the circuit		X
	Chose the current direction of the voltmeter correctly in the circuit		X

Table 1. T30 simple electrical circuit with a single lamp and its evaluation

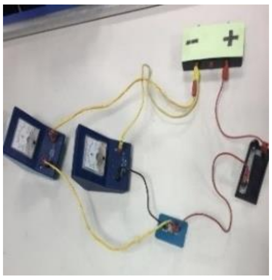
Circuit	Items	Done	Failed
	He/she set up a workable circuit and the lamp gave light	X	
	Connected the lamp to the circuit correctly	X	
	Used switch in circuit	X	
	Connected the switch to the circuit	X	
	Connected the amperemeter in series	X	
	Connected the voltmeter in parallel to the circuit		X
	Chose the current direction of the amperemeter correctly in the circuit		X
	Chose the current direction of the voltmeter correctly in the circuit		X

Table 3 and Table 4 include a checklist for the construction and evaluation of a simple single-lamp simple electrical circuit as examples.

Table 2. The situations of establishing a two-lamp circuit of pre-service science teachers

Items	Done	Failed	Total
He/she set up a workable circuit and the lamp gave light	20	46	66
Connected the lamp to the circuit correctly	3	63	66
He/she used a key in the circuit	58	8	66
Switched on switch	52	14	66
He/she connected the amperemeter in series with the circuit	29	37	66
He/she connected the voltmeter to the circuit in parallel	2	64	66
He/she chose the current direction of the amperemeter correctly in the circuit	12	54	66
Chose the correct current direction of the voltmeter in the circuit	16	50	66

Table 5 shows completed, and failed realizations based on the items on the pre-service science teachers' status of putting up a two-lamp circuit checklist. The highest accurate answer was "he utilized a key in the circuit," which was completed by 58 participants, while the lowest was "attached the voltmeter to the circuit in parallel," which was completed by 2 people. Below are examples that were established in accordance with the instructions and evaluated according to the checklist.

Table 3. T27 Two-Lamp Simple Electrical Circuit

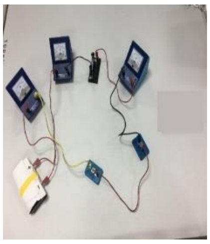
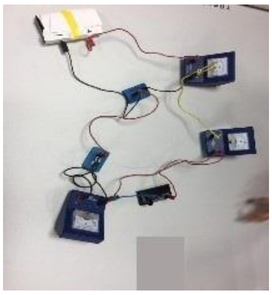
Circuit	Items	Done	Failed
	He/she set up a workable circuit and the lamp gave light		X
	Connected the lamp to the circuit correctly		X
	Used switch in circuit	X	
	Connected the switch to the circuit	X	
	Connected the amperemeter in series	X	
	Connected the voltmeter in parallel to the circuit		X
	Chose the current direction of the ampere meter correctly in the circuit		X
	Chose the current direction of the voltmeter correctly in the circuit		X

Table 4. T39 two-lamp simple electrical circuits

Circuit	Items	Done	Failed
	He/she set up a workable circuit and the lamp gave light		X
	Connected the lamp to the circuit correctly		X
	Used switch in circuit	X	
	Connected the switch to the circuit		X
	Connected the amperemeter in series		X
	Connected the voltmeter in parallel to the circuit		X
	Chose the current direction of the amperemeter correctly in the circuit		X
	Chose the current direction of the voltmeter correctly in the circuit		X

In Table 6 and Table 7, the image of the setting up of the two-lamp simple electrical circuit and its evaluation from the checklist is presented.

Table 5. Situations of pre-service science teachers in schematizing a single lamp circuit

Items	Done	Failed	Total
Knowing the serial connection of the amperemeter to the circuit	58	8	66
Knowing the parallel connection of the voltmeter to the circuit	52	14	66
To be able to draw the series circuit in accordance with the instruction	60	6	66
Ability to draw parallel circuit in accordance with the instruction	49	17	66

Table 8 displays the percentages of completed and failed assessments based on the elements on the pre-service science teachers' checklist to schematize a single-lamp circuit. While it was established that at most 60 participants completed the task of "drawing the serial circuit properly according to the instructions," at least 49 participants completed the task of "drawing the parallel circuit in accordance with the instructions." Below are examples that were schematized in accordance with the instructions and evaluated according to the checklist.

Table 6. T4 schematic of a simple electrical circuit with a single lamp

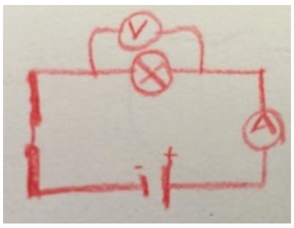
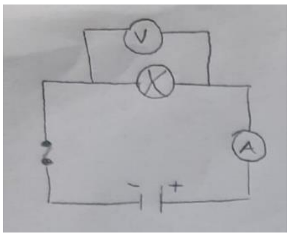
Circuit	Items	Done	Failed
	Knowing the serial connection of the amperemeter to the circuit	X	
	Knowing the parallel connection of the voltmeter to the circuit	X	
	To be able to draw the series circuit in accordance with the instruction	X	
	Ability to draw parallel circuit in accordance with the instruction	X	

Table 7. T22 schematic of a simple electrical circuit with a single lamp

Circuit	**Items**	**Done**	**Failed**
	Knowing the serial connection of the amperemeter to the circuit	X	
	Knowing the parallel connection of the voltmeter to the circuit	X	
	To be able to draw the series circuit in accordance with the instruction	X	
	Ability to draw parallel circuit in accordance with the instruction	X	

Sample drawing and checklist evaluation for schematizing a simple single lamp simple electrical circuit are presented in Tables 9 and 10.

Table 8. The Situations of Pre-Service Science Teachers in Schematizing a Two-Lamp Circuit

Items	**Done**	**Failed**	**Total**
Knowing the serial connection of the amperemeter to the circuit	52	14	66
Knowing the parallel connection of the voltmeter to the circuit	46	20	66
To be able to draw the series circuit in accordance with the instruction	55	11	66
Ability to draw parallel circuit in accordance with the instruction	47	19	66

In Table 11, it is stated as done and failed according to the items in the checklist for pre-service science teachers to schematize a two-lamp circuit. In this section, while the item of “drawing the serial circuit correctly according to the instructions” was carried out correctly by at most 55 participants, the item of “knowing the parallel connection of the voltmeter to the circuit” was carried out by at least 46 participants.

Below is an example that was schematized in accordance with the instructions and evaluated according to the checklist.

Table 9. T34 schematizing a two-lamp simple electrical circuit

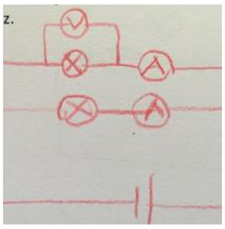
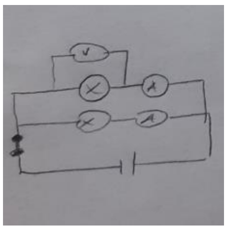
Circuit	**Items**	**Done**	**Failed**
	Knowing the serial connection of the amperemeter to the circuit	X	
	Knowing the parallel connection of the voltmeter to the circuit	X	
	To be able to draw the series circuit in accordance with the instruction	X	
	Ability to draw parallel circuit in accordance with the instruction	X	

Table 10. T34 Schematizing a Two-Lamp Simple Electrical Circuit

Circuit	**Items**	**Done**	**Failed**
	Knowing the serial connection of the amperemeter to the circuit	X	
	Knowing the parallel connection of the voltmeter to the circuit	X	
	To be able to draw the series circuit in accordance with the instruction	X	
	Ability to draw parallel circuit in accordance with the instruction	X	

In Tables 12 and 13, an example drawing for schematizing a simple two-lamp simple electrical circuit and its evaluation from the checklist are presented.

Table 11. Problems Encountered in Establishing and Schematizing Simple Electrical Circuits

Issues	Description	f	%
Not having the opportunity	Pre-service science teachers attribute their problems in constructing and schematizing circuits to the fact that they do very little work in the laboratory.	43	81,66
Lack of content knowledge	Pre-service science teachers state that they have incomplete content knowledge in electricity as the reason for their failure in establishing and schematizing electrical circuits.	13	21,66
The problem stemming from group work	Pre-service science teachers say that while working, the groups consist of too many people, and they remain passive.	4	6,66

As can be seen in Table 14, the main reasons for the problems faced by pre-service science teachers in setting up and schematizing simple electrical circuits are discussed under 3 codes. These are presented as not being able to find opportunities, lack of field knowledge, and problems arising from group work. Sample sentences of pre-service science teachers are presented below.

Not having the opportunity:

-T15: *"I have difficulties in connecting voltmeter and amperemeter because we did not do many activities that will gain this skill".*

-T19: *"I think that what I have learned is not repeated enough. Crowded classrooms prevent healthy learning".*

-T39: *"The lessons in the physics laboratory were fun, but they were forgotten because there was not enough repetition and practice".*

-T31: *"I have difficulties because I did not set up enough circuits".*

Lack of content knowledge:

-T2: *"My problem in establishing and schematizing electrical circuits may be due to my lack of knowledge about the subject".*

-T6: *"I have difficulty in making a drawing that measures the current flowing through the bulbs separately".*

-T34: *"I don't know exactly what to connect and where at the stage of applying the theoretical knowledge".*

-T38: *"I had difficulties in building and schematizing circuits because I had deficiencies in theoretical knowledge and practice".*

The problem stemming from group work:

-T43: *"The groups were very crowded, and the time was running out before the turn came".*

-T45: *"We could not acquire hand habits since my friends who knew in group activities were directly involved.*

Conclusion, Discussion and Recommendations

This section discusses the research's discussion and related conclusion, which aimed to compare the practical knowledge of 4th grade pre-service science teachers in establishing simple electrical circuits and their theoretical knowledge in schematizing, as well as to reveal the situations in which they had difficulty in this process.

According to the findings, only a small proportion of pupils were able to effectively establish a single-lamp and two-lamp simple electrical circuit (Table 2 and Table 5). Furthermore, as the number of lamps, switches, voltmeters, ampere meters, and power supply in the circuit increased, the participants' difficulty increased. These findings reflect the limited number of productive hours that pre-service science instructors spend in the laboratory and with equipment. Laboratory activities expose pre-service science instructors to a variety of situations (Lindwall, 2008). As a result, the contact process in the laboratory should last if feasible. As a result, pre-service science instructors who were not exposed to the long-term interaction process struggled to connect the light bulbs and were unable to complete the installation. Celik, Pektas and Demirbas (2012) discovered that pre-service instructors had difficulty creating simple electrical circuits in the laboratory environment. Because the obstacles that pre-service science teachers have cannot be overcome, they do not integrate science laboratory activities at the necessary level in their future lectures (Sahin, 2001). According to Yung (2001), this problem scenario in pre-service science teachers may be resolved by removing the lack of experience. It is well established that identifying and resolving the root of pre-service science teachers' difficulties in building circuits would provide positive feedback in terms of accomplishment, methodological, and cognitive quality to both them and the educational environment (Hofstein and Lunetta, 2004; Hofstein and Mamlok-Naaman, 2007; Lunetta, Hofstein and Clough, 2007). It is expected that the growth of teaching activities within the framework of practice and skill development in Turkey, as well as the engagement of pre-service science teachers in additional applications, will be an effective step in resolving educational challenges. The pre-service science instructors did not have any difficulty operating the switch or connecting it to the circuit, according to the findings of the study. It should be noted, however, that in circuits produced with many tools, this rate lowers. It appears that major issues with the installation of circuits containing two light bulbs, two ampere meters, a voltmeter, a switch, and a battery are present. Furthermore, severe flaws in the voltmeter's connection were discovered. The findings of pre-service science instructors schematizing circuits with parallel instructions were examined to see if these inadequacies are caused by a lack of topic expertise.

These findings reveal that pre-service science instructors recognized "theoretically" that the ampere meter and voltmeter should be linked in series and parallel, but they were unable to apply this knowledge into practice and create the circuits shown above. Laboratories play a vital role in translating theoretical knowledge into practice and applying knowledge since they are active areas where information is employed (Hancer, Aydogan and Cankaya, 2021; Keskin-Gecer, 2018; Lord and Orkwiszewski, 2006). As a result, the scarcity of pre-service science teachers' laboratory activities exposes the reason for the difficulty in applying this knowledge, even though they dominate the theoretical explanations of established circuits. For this reason, it would not be wrong to assume that the main source of the problems experienced by pre-service science teachers in simple electrical circuits is their lack of practical experience. In Turkey's pre-service teacher training concept, there are two main parts (Baran, Yasar and Maskan, 2015). The first of these aspects is theoretical knowledge, which any teacher who wishes to perform his profession should possess, and the second is practice activities, which guarantee that the taught theoretical knowledge is put into practice in schools (Koc and Yildiz, 2012). Although there is no problem with the findings obtained in the first step of presenting theoretical knowledge, it is predicted that there will be difficulties in acquiring technical skills in the second step of becoming familiar with the behavioral teaching system, conducting activities that require practical application such as laboratories, even though application courses are available. In teacher education, it is recognized that, in comparison to other nations, the transfer of theoretical knowledge into practice may be carried out in a limited scope in Turkey (Maandag, Deinum, Hofman and Buitnik, 2007).

It is claimed that science subjects cannot be fully taught without laboratory applications, that theoretical subjects cannot be embodied without laboratory applications, and that difficulties in establishing the necessary connections with life cannot be overcome without laboratory applications (Khalaf-Arat, Al Sheikh and Aziz, 2018). This demonstrates that in classrooms where pre-service science teachers do not actively engage and the content is confined to a set of theoretical knowledge, meaningful learning does not occur. As a result, aspiring science instructors will be expected to spend more time in the laboratory environment and with laboratory equipment. Similarly, certain research in the literature (Kanari and Millar, 2004; Kind, Kind, Hofstein and Wilson. 2011; Lubben, Sadeck, Scholtz and Braund, 2010) have come to similar conclusions and have made good contributions to laboratory teaching procedures. Increasing the number of instructional activities that are carried out in laboratory settings would help to eliminate the problems in creating the circuit found in the findings.

Pre-service science instructors had difficulty choosing the current direction of an ampere meter and a voltmeter in simple electrical circuits, according to the study's findings. The challenges encountered in detecting the current direction of ampere meter and voltmeter rise in simple electrical circuit assemblies organized with surplus equipment, which is a visible outcome. The schematization circumstances were investigated to see if the cause for the problems encountered in the circuit creation was connected to the instances of not knowing the tools. It may be argued that pre-service science instructors have a theoretical understanding of the ampere meter and voltmeter equipment. They do not realize their present path accurately, however, because they lack the ability to utilize these tools and equipment, as well as the necessary experience to put information into effect. It is an undeniable fact that, despite the practical teachings, some technical skills for using laboratory instruments could not be gained. Theoretical knowledge alone is insufficient in laboratory applications, according to Tatli and Ayas (2002); actual application activities, laboratory skills, and laboratory equipment competence are also required. In laboratory tasks, it is apparent that some cognitive abilities are required in addition to technical skills. Pre-service science instructors, for example, utilize their spatial thinking abilities to identify the current directions of an ampere meter and a voltmeter. Because spatial thinking involves mentally shifting, flipping, rotating, and building and manipulating mental representations of transformations, spatial thinking is a valuable talent (Clements, 2004; Cross, Woods and Schweingruber, 2009; Olkun, 2003; Ramirez, Gunderson, Levine and Beilock, 2012).

One of the sub-components of spatial competence is spatial visualization, which involves spinning pictures of things and their pieces in three-dimensional space and visualizing new circumstances that will arise (Cross, Woods and Schweingruber, 2009; Olkun, 2003). It is projected that science teachers will have difficulty envisioning the current direction of ampere meters and voltmeters and cognitively visualizing the circuit, and that spatial thinking abilities will be effective as a result. According to the research, prospective instructors have an intermediate level of spatial thinking abilities (Cole, Cohen, Wilhelm and Lindell, 2008; Hamm, 2016; Heyer, Slater and Slater, 2013), and in this scenario, the necessity to enhance spatial thinking skills is critical (Alkan and Erdem, 2011; Kaberman and Dori, 2009). It would not be incorrect to underline the theoretical knowledge flow's continuity and its shortcomings in encouraging skill development in instructional activities in Turkey. Pre-service teachers are really assigned to schools to do internships in order to apply academic knowledge in a practical setting. However, trainee pre-service science teachers are not given much opportunity to practice due to the intensity of the teachers and the curriculum. There are gaps in the education of science instructors who know how to use experimental equipment, set up experimental setups, and manage their restrictions, especially because they do not conduct experiments in internships and do not do so in the classroom. The basis of these deficiencies is that pre-service teachers take an exam such as KPSS (State Employee Selection Examination in Turkey) that measures content knowledge and pedagogical content knowledge and concentrate on theoretical development. For this reason, it is predicted that pre-service teachers do not provide orientation to laboratory interests and activities.

Increasing application lessons, increasing individual activities, and taking on the task of each participant in group activities (Hofstein and Mamlok-Naaman 2007; Khalaf-Arat et al. 2018; Wenglinsky, 2002) will provide an advantage in learning the technical features of a simple tool, ampere meter and voltmeter, and contributing to the development of spatial skills. Simultaneously, one of the proposals is to organize periodic events to improve the quality of laboratory abilities. Pre-service science instructors are obliged to participate actively in the laboratory environment by "doing-living" with their own experiences in this approach. Regardless, laboratory investigations are undervalued in educational settings. The scientific laboratory, on the other hand, provides a space where knowledge can be used in practical ways, problems and hypotheses can be felt, and abstract concepts may be cognitively embodied to gain meaning (Celik, Koken and Kanat, 2021). Simultaneously, scientific laboratories have been found to bring significant benefits in terms of boosting topic knowledge, familiarity with laboratory equipment, and the development of practical skills (Millar, 2004). There are studies in the literature that indicate parallelism and highlight laboratory contexts in the application of theoretical knowledge (Akgun, 2000; Hofstein and Mamlok-Naaman, 2007; Ottander and Grelson, 2006; Ozturk and Koca, 2021). As a result, science laboratories have become necessary for pre-service science teachers to successfully elaborate the knowledge they utilize when schematizing circuits. Individual exploration and the chance to investigate and build their own understandings are emphasized Pyatt and Sims (2007) in this direction. Because the fact that science laboratory activities in Turkey are largely explanatory and teacher-centered laboratory activities, as well as the fact that they are carried out according to steps prepared under the supervision of the instructor, are factors that prevent learners from participating in the practice themselves. The removal of these barriers will also open the way for the training of competent, technical, and cognitive personnel in Turkey who will be able to react to the skills necessary in the twenty-first century.

The findings of clinical interviews done to ascertain the perspectives of pre-service science teachers on the problems they faced during the process revealed three major issues. These are issues that arise because of a lack of opportunity, field expertise, and group work. Pre-service science teachers' feelings about not being able to locate chances is a significant discovery in terms of showing Turkey's existing socioeconomic and sociocultural framework. According to field notes and clinical interviews, they theoretically knew how to connect an ampere meter in series and a voltmeter in parallel, but while constructing a simple electrical circuit, most pre-service teachers were unable to connect the voltmeter in parallel. This data indicates that aspiring science instructors do not spend much time in the laboratory and have limited expertise. When looking through the literature, it has been discovered that other research arrives to similar conclusions (Cepni, Ayas, Johnson and Turgut, 1997; Moodley and Gaigher, 2019). This clearly demonstrates that pre-service science teachers' theoretical knowledge is weak, and they are unable to use this information in active learning contexts. This problem reflects the fact that Turkey's existing educational system is theoretically extremely burdened. As a result, pre-service science teachers and science teachers must compensate for this shortcoming by offering enough chances. Prospective science instructors who participate in laboratory activities have been shown to improve academic accomplishment (Cardak, Onder, and Dikmenli, 2007; Cavallo, 1996; Marshall and Dorward, 2000; Wang and Andre, 1991).

Recommendations Based on Research Results

- Technical skills are one of the reasons for the difficulties experienced by pre-service science teachers in the simple electrical circuit installation process. For the development of technical skills, it may be appropriate to start laboratory applications from pre-school or to add appropriate courses to the education-teaching processes. Thus, it will be possible to develop students' technical skills and psycho-motor skills.
- It is predicted that one of the reasons for the difficulties experienced by pre-service teachers during the simple electrical circuit installation process is that they do not spend enough time with laboratory equipment. Providing equipment in parallel with the number of students in laboratories is very important in terms of the individual's own experiences in the learning process. In addition, in group work, each individual can be provided with duties and responsibilities and work in cooperation. For this reason, it is recommended that group work be meticulously planned to support peer teaching in solidarity and that individuals learn from their own experiences.
- Since the pre-service science teachers have theoretical knowledge of the process but have deficiencies in practical applications, increasing the hours of practice activities and including practical applications from daily life as much as possible in the theoretical lessons can create a quality that can overcome this negative situation. In this way, it is thought that it will be effective for prospective pre-service science teachers to use laboratories when they start working.

Recommendations for Future Research

- The contribution of these activities to practical applications can be determined by designing various teaching activities in which pre-service science teachers can actively participate in the process by doing and living on abstract topics such as electricity and in which misconceptions are detected.

- Within the scope of determining the study group of this study, which is carried out with pre-service science teachers, as primary school 7th-grade students, simple electrical circuits in the science curriculum can be applied within the framework of subject acquisitions, and research can be carried out to examine the theoretical and practical knowledge of students.

- Experimental studies can be carried out that reveal the effect of pre-service science teachers on their participation in laboratory practices and spending time in the laboratory, and on the development of their technical skills.

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