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The Proficiency and Opinions of the Pre-service Primary Teachers in Performing Hands-on Science Experiments

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It is a challenge to carry out science lessons with experiments both in the conditions that emerged with the COVID-19 pandemic and in schools where there is a shortage of laboratories and materials. This study aims to examine the proficiency and opinions of pre-service primary teachers (PPTs) pertaining to performing hands-on science experiments with simple tools. This case study was carried out with 47 PPTs selected according to the convenient sampling method. Data sources included video recordings of the experiments performed by the PPTs over ten weeks and an open-ended questionnaire. The videos were analyzed with the analytical rubric and presented with descriptive statistics. The open-ended questions were analyzed with content analysis. Results showed that PPTs are sufficient for choosing suitable simple tools for experiments and for applying the experiments gradually, extensively, and correctly, while they need to develop in explaining the concepts and information correctly. In addition, the majority of the PPTs stated that they did not have any difficulties whilst performing the experiments, they could perform science experiments with simple tools, the experiments would reflect positively on the learning outcomes of the students, and they could conduct science lessons with experiments using simple tools and alternative materials, even if there is no laboratory in the school. Future studies should focus on increasing the proficiency of PPTs to give scientific explanations for experiments.

Introduction

The main objective of science courses is to get to knowledge by examining nature, living things, life processes, objects, physical/chemical events, space, and events, and to create products and technologies that will meet the needs of society (Ministry of National Education [MoNE], 2018). For this reason, societies attach great importance to science education to advance and develop in science and technology (Anılan et al., 2020; Cullin et al., 2017; Kwok, 2015; Szott, 2014; Yüzüak et al., 2020). The aim of the science curriculum is to raise scientifically literate individuals who can understand and interpret science-related events and situations (MoNE, 2018). Science courses offer students the opportunity to ask questions, do research, form hypotheses, and interpret the data they have obtained (Agustin et al., 2021;

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Kocakülah & Savaş, 2011; Kwok, 2015). These courses also give importance to experimentation, observation, and discovery (Anılan et al., 2020; Kwok, 2015; Szott, 2014). Thus, science teaching is crucial at the primary school level where children start learning science, although it is important at all levels of education.

Many teaching methods and techniques are used in science teaching. One of the most convenient and effective ways to teach science is to do laboratory experiments (Cullin et al., 2017; İnel-Ekici, 2015; Kwok, 2015; Szott, 2014; Yüzüak et al., 2020). There is consensus among educators that the experiments are a necessary and integral part of meaningful and permanent learning in science lessons (Basey & Francis, 2011; Bolat et al., 2012; Gumala et al., 2020; Hofstein & Lunetta, 2004; Uzal et al., 2010). Experiments help primary school students develop a positive perspective on science, learn subjects that they cannot understand, obtain first-hand information, gain observation-research-inquiry skills, and understand the world they live in (Agustin et al., 2021; Hofstein & Lunetta, 2004; Kwok, 2015; Ünal & Aral, 2014; Yüzüak et al., 2020). Thus, primary teachers (PTs) should be given more space to experiment in science lessons.

The rapid progress of science and technology creates new opportunities in education and teaching, yet it also causes some inequalities in access to these opportunities. This causes learning and teaching methods to change, as well as experimental methods used in lessons to diversify. Virtual labs and hands-on science experiments with simple tools are just two of science teaching opportunities. While the use of virtual labs comes to the fore in classrooms where access to technology is available, experiments are carried out with simple tools and equipment in classrooms where there is no access to labs and materials.

Virtual labs are digital environments where students can access information through experimentation by changing one of the variables that affect the questioned variable and keeping the others under control (Prieto-Blázquez et al., 2009). Performing experiments in virtual labs helps students gain individual questioning skills and a sense of responsibility, and contributes to increasing their success, interest, and motivation (Bozkurt & Sarıkoç, 2008; Großmann & Wilde, 2019; Önder & Sılay, 2016; Trundle & Bell, 2010; Yılmaz & Özkan, 2014). However, in-service/pre-service teachers have limited knowledge of and practice with virtual labs (Çelik & Karamustafaoğlu, 2016; Ekici, 2015). They prefer to experiment in real labs rather than virtual labs (Çelik & Karamustafaoğlu, 2016; Hawkins & Phelps, 2013; Vasiliadou, 2020). Although virtual labs can be effective in science teaching, studies show that there is a need for new studies in this field to increase the effect of the student learning outcomes and the practical proficiency of teachers. In addition, the active participation of students and the teacher’s control of the classroom during the COVID-19 pandemic create new limitations (Bostan-Sarıoğlan et al., 2020; Pınar & Döne-Akgül, 2020; Vasiliadou, 2020). Hands-on science experiments with simple tools are a good alternative to this. It also provides an opportunity for schools that have a lack of laboratories and materials to do experiments.

Although it is not new to perform science experiments with simple tools, it is a frequently used method that is preferred to associate science concepts with daily life (Ahmad et al., 2017; Bostan-Sarıoğlan et al., 2020; Kang et al., 2008; Ornstein, 2006; Önen & Çömek, 2011; Soğukpınar & Gündoğdu, 2020; Uzal et al., 2010). This type of experiment is an educational activity using the tools and equipment found in daily life with direct, active participation—without the need for special materials (Klemm & Plourde, 2003; Haury & Rillero, 1994; Ruby, 2001; Uzal et al., 2010). Performing science experiments with the tools in students’ daily lives aids in concretizing concepts, learning by doing and experiencing, and providing permanent learning (Bostan-Sarıoğlan, et al., 2020; Hussain & Akhtar, 2013; Klemm & Plourde, 2003; Ornstein, 2006). These activities also help students learn the scientific method and problem-solving skills (Leung, 2008), increase their interest, and improve their attitude toward the science course (Ahmad et al., 2017; Çeken, 2010; Öztürk, 2007; Wardani & Winarno, 2017; Yazıcı & Kurt, 2018). In addition, since there is no need for a special place and materials, it is easy to perform science experiments with simple tools.

Rationale for the Study

Most of the studies on science experiments with simple tools were conducted with in-service or pre-service science teachers (Anılan et al., 2020; Bostan-Sarıoğlan et al., 2020; Kang et al., 2008; Koç & Böyük, 2012; Sontay & Karamustafaoğlu, 2018; Önen & Çömek, 2011; Weld & French, 2001; Yüzüak et al., 2020). The number of studies conducted with PTs or pre-service primary teachers (PPTs) is quite low (Agustin et al., 2021; Ahmad et al., 2017; Dindar & Yaman, 2003; Çil & Çalışoğlu, 2020; İnel-Ekici, 2015; Karasu-Avcı & Ketenoğlu-Kayabaşı, 2018; Uzal et al., 2010). There are too many studies that revealed that PTs do not use the experimental method and laboratory in their lessons (Agustin et al., 2021; Çil & Çalışoğlu, 2020; Dindar & Yaman, 2003; Koç & Bayraktar, 2013; Uzal et al., 2010), although there are a limited number of studies that showed that PTs use the experimental method more than other methods in science lessons (İnel-Ekici, 2015; Karasu-Avcı & Ketenoğlu-Kayabaşı, 2018). The reasons why PTs do not use labs are that they feel incompetent, they lack time and materials, the classrooms are crowded, and chemicals are seen as dangerous and unsafe (Agustin et al., 2021; Akıncı et al., 2015; Bostan-Sarıoğlan et al., 2020; Çil & Çalışoğlu, 2020; Dindar & Yaman, 2003; Kang et al., 2008; Lang et al., 2005; Özdener, 2005; Tekin, 2008; Kocakülah & Savaş, 2011; Soğukpınar & Gündoğdu, 2020; Stepenuck, 2002; Trna et al., 2010; Uluçınar, 2008). However, teachers do not use labs and do not benefit from materials in daily life although they have labs and materials (Agustin et al., 2021; Bostan-Sarıoğlan et al., 2020; Bostan-Sarıoğlan, 2015; Dindar & Yaman, 2003; Ekici, 2015; Güneş et al., 2013; Harris & Farrell, 2007; Weld & French, 2001). When the PTs and science teachers' use of experiments in their lessons is compared, PTs use the experimental method less and have fewer qualifications (Uzal et al., 2010). In addition, when PTs prefer the plain lecture method in their lessons, students think that the science lesson is difficult and far removed from their daily lives. On the other hand, some of these studies have determined pre-service teachers' opinions about experiments with simple tools and their opinions on the applicability of these experiments through Likert-type scales and open-ended questions (Agustin et al., 2021; Bostan-Sarıoğlan et al., 2020; Çil & Çalışoğlu, 2020; Koç & Bayraktar, 2013; Önen & Çömek, 2011). Some studies have determined the opinions of teachers or pre-service teachers about prepared simple science experiments through semi-structured interviews (Anılan et al., 2020; Sontay & Karamustafaoğlu, 2018; Uzal et al., 2010; Yüzüak et al., 2020). Other studies have developed material on various science subjects (Karamustafaoğlu et al., 2005). However, no study has been found that examines the proficiency of PTs or PPTs by performing experiments with simple tools.

Based on the literature, it remains a problem that PTs do not use labs and experimental methods in science lessons due to the lack of materials and professional competence. This causes the students to perceive the science lesson as far removed from their daily lives and therefore dislike it. In their first professional years, PPTs will work in schools that do not have laboratories or materials. Teachers who can use simple tools found in daily life will be able to teach science lessons with experiments, and these science lessons will enable students to love science and increase their learning outcomes (Agustin et al., 2021; Bostan-Sarıoğlan et al., 2020; Klemm & Plourde, 2003; Ornstein, 2006; Sontay & Karamustafaoğlu, 2018; Yüzüak et al., 2020). Experiments are important for students to concretize science concepts and to associate them with daily life (Bostan-Sarıoğlan, et al., 2020; Klemm & Plourde, 2003). For this reason, it is important for PPTs to have the proficiency to perform science experiments with simple tools and equipment, both in the distance education process encountered in cases like COVID-19, and in the healthy conduct of science education in schools where laboratory and equipment shortages are common. In this context, it is critical to train PPTs who can perform the science lessons with simple tools and experiments under all conditions. However, there is a gap with no long-term studies examining the proficiency of PPTs in performing science experiments with simple tools in this field. Developing or performing a science experiment with simple tools and determining the opinions of PPTs about these experiments with Likert-type or open-ended questions are not sufficient to reveal their proficiency. When PPTs may succeed in performing an experiment, failing in the other. Therefore, the proficiency of PPTs should be determined by observing the processes in which they perform various science experiments in the long term.

The aim of this study is to examine the proficiencies and opinions of PPTs in performing science experiments with simple tools over the course of a semester. The research questions are as follows:

(1) What is the level of proficiency of PPTs to perform hands-on science experiments with simple tools?
(2) How are the opinions of PPTs about the hands-on science experiments they performed with simple tools?

Method

Research Design

Researchers use the qualitative case study model in studies where they aim to provide detailed explanations about one or more situations through various data sources (Creswell, 2014; Kaleli-Yılmaz, 2019). This situation may be an event, activity, or process (Yin, 2009). This study uses the qualitative case study model as it aims to provide detailed explanations examining the proficiency and opinions of PPTs in performing science experiments with simple tools through video recordings of their performed experiments and open-ended questions about these experiments.

Participants

This study was carried out with 65 PPTs in their second year in the Department of Primary Teacher Education at a state university in the central Black Sea Region of Türkiye during the fall semester of the 2020-2021 academic year. Eighteen PPTs were not included in the study group because five PPTs did not volunteer to share the video recordings and 13 PPTs did not continue teaching or did not send whole video recordings during the study period. Thus, the study group consisted of 47 PPTs (3 male, 44 female) who voluntarily agreed to participate. The average age of the PPTs who participated in the study group is 20.36 years. Researchers prefer the convenient sampling method when they work with samples that will serve the purposes of their studies and are easily accessible (Yıldırım & Şimşek, 2011). Since the researcher works in the same institution as the study group and carries out the relevant course, the study group was selected according to the easily accessible sampling method. This proves the trustworthiness of the study and the findings obtained. In addition, at the beginning of the study, 65 PPTs were coded from PPT-1 to PPT-65 to compare the data and ensure the accuracy of the collected data. The findings are presented with these codes. The researcher, as a trainer, shared the subjects they taught in previous years with the PPTs every week and asked them to prepare video recordings of their science experiments conducted using simple tools within the scope of the lesson. At the end of the semester, the researcher informed them of the purpose of the study.

Data Collection Tools

The data of the study were obtained from *video recordings* of the experiments prepared by the PPTs within the scope of the Science Laboratory Applications course and in an *open-ended questionnaire*.

Video Recordings: PPTs took the Science Laboratory Applications course with distance education due to the pandemic. Within the scope of the course, the PPTs performed science experiments with simple tools and video recorded them. These video recordings formed the data of the study. The recordings range between two and four minutes in length, prepared individually by each PPT. A total of 470 video recordings were collected from the PPTs and analyzed.

Open-Ended Questionnaire*:* An open-ended questionnaire created by the researcher/s was used to obtain detailed information about the PPTs' experiences during the experiments they carried out. The questionnaire inquires whether they can perform science experiments with simple tools, whether they have difficulties performing science experiments and what is done to overcome any difficulties, about the benefits of such experiments to the learning-teaching process, and what they have gained. For the content validity of the questionnaire, the suggestions of two experts working in the science education field were taken, and the final version incorporated their corrections.

Procedure

The study was carried out within the scope of the science laboratory applications course. The teacher education program in Turkey is four years long. PPTs take this course in the first semester of the second year of the teacher education program (CoHE, 2018). This course is the only laboratory course in the program. Before this course, PPTs take the Basic Science in Primary School course. During this semester, PPTs start to take teaching courses. Due to the pandemic, distance education was carried out in the 2020-2021 academic year at all levels of education. Therefore, PPTs performed science experiments using materials in their homes and kitchens for this study.

Within the scope of the course, the PPTs were asked to conduct several experiments related to the subject of the week and to make a video recording of them between two to four minutes long. PPTs sent their videos to the researcher via e-mail every week. The subjects of experiments were selected considering the curriculum of MoNE (2018). The subject/concepts of the science experiments and the timeline of the application are given in Table 1.

Table 1. The Subjects/Concepts of the Science Experiments and the Timeline of the Application

Week	Subjects/concepts of science experiments	Number of experiments
1.	Meet, presentation of materials used in the laboratory, presentation of security measures by researcher	-
2.	Presentation of the subject of laboratory approaches by researcher	-
3.	Error in measuring and its resources	-
4.	Making "mass, weight, temperature" measuring instruments	3
5.	Types of electrification and light bulb brightness in a simple electrical circuit	3
6.	Refraction, images in plane and spherical mirrors, and refraction of light in lenses	4
7.	Heat-temperature, heat exchange and air pressure	3
8.	Physical and chemical change	4
9.	Methods of separating mixtures	3
10.	Support and movement system (skeleton, muscles, and joints)	3
11.	Respiratory and circulatory system	2
12.	Sense organs, digestive and excretory system	3
13.	Movements of the Earth and Moon, formation of day and night, phases of the Moon	3
14.	General evaluation	-

The researcher made presentations about laboratory materials, security measures, and laboratory approaches in the first two weeks. In the following weeks, the researcher informed PPTs only about the subjects/concepts of the science experiments. Thus, all PPTs conduct experiments on the same subjects/concepts each week, but they were free to select which experiment they wanted to perform on the given subjects/concepts. They were expected to choose experiments suitable for the tools found in their kitchens or at home. In the third week, the PPTs were asked to perform experiments on *the error in measuring and its resources*. This week's video recordings were not included in the analysis as they were used as a pilot experiment. After the researcher made a preliminary assessment, the researcher and PPTs watched the sample videos in the next lesson, and discussed the tools used in the experiment, the creativity of the PPTs, their relationships with the concepts, and their suitability for teaching. Then the subject/concept of the next week was given. Finally, the volunteer PPTs were asked to express their opinions filling out an open-ended questionnaire. The study was completed in 14 weeks. However, only ten weeks were included in the analyses as indicated in Table 1.

Data Analysis

The proficiency of PPTs in performing science experiments with simple tools was analyzed with a rubric consisting of three criteria and four performance levels. The researcher created the criteria and levels by considering the experimental process rubric (URL1) used by Intel. The rubric was chosen to analyze the performances of the PPTs because it is suitable for the purpose of the study. While examining the video recordings for the first time, the researcher adjusted the levels of the rubric, considering the performances of the PPTs. The rubric levels were finalized by taking the suggestions of two experts. The criteria and their levels are given in Table 2. Each PPT's proficiency was determined by considering three criteria: selecting and using simple tools, explaining the concept/information correctly, and applying the experiments gradually, extensively, and correctly. Each criterion has four performance levels, where Level 4 indicates *complete competence* and Level 1 indicates *complete incompetence*.

Table 2. Analytical Rubric of Proficiency Criteria and Levels

Proficiency Criteria	**Proficiency Levels** 4	3	2	1
Selecting and using simple tools	Mostly simple tools were chosen and used appropriately for the purpose.	Often non-simple tools were selected and used appropriately for the purpose.	Simple tools were chosen but not used appropriately for the purpose.	Often non-simple tools were chosen and not used appropriately for the purpose.
Explaining the concept / information correctly	Concepts were scientifically correct and associated with previous information.	Concepts were scientifically correct, but missing or excessive information is given that will affect the integrity.	One misconception or misinformation was given.	Multiple misconceptions or misinformation was given.
Applying the experiments gradually, extensively, and correctly	Experiment was performed step by step completely and accurately.	Some of the steps of the experiment were incomplete or complicated.	The experiment was performed complex and incompletely.	Experiment was not completed.

After the videos were collected from all PPTs, the researcher scored the videos first. To increase the reliability, the researcher examined the videos twice at an interval of three weeks. After that, the videos were further scored by an expert who is a teacher with a master's degree in science education. The researcher informed the expert about the criteria before scoring. All videos of a PPT were scored by two coders together. Then the second coder separately scored the videos of the other PPTs. The consistency between the two scores was calculated as 0.84 with Kendall's W. Different scores were re-evaluated by two raters, and the scores were finalized. The sample scoring of the electrification experiments according to the analytical rubric is given in Table 3. For each criterion, mean scores were calculated from the PPTs' scores for the relevant week. While interpreting the proficiency level of the PPTs, the 1-4 score range is divided into equal intervals (Aktaş, 2020), where 1-2 are interpreted as low, 2-3 as medium, and 3-4 as high.

Table 3. Sample Scoring of Electrification Experiments

Criteria	**Samples**	**Score**
Explaining the concept / information correctly	It performed the experiment of electrification by friction talking about the types of electrification by touch, friction, and impact.	4
	The experiment for electrification by friction was performed without defining the electrification and without mentioning its types.	3
	The experiment stages were performed without explaining knowledge. or some tools were mentioned that did not work before the experiment. It was unnecessary and confusing since that was not used.	2
	Multiple misconceptions or misinformation was given. Example: PPT-13 who used the statement "If we hold the balloon that we rub on the wool fabric against the wall, there will be an electrification between the wall and the balloon" has a misconception. Because the electrical attraction happens between the paint and the balloon.	1

The data obtained from the open-ended questionnaire were analyzed by content analysis. Two coders analyzed the data to increase reliability. First, the researcher and second coder created meaningful sections by analyzing the data of the three PPTs who gave the most answers. Then, the data of other PPTs were divided into meaningful sections separately. Next, the categories were created to form meaningful sections. For example, the opinions of the PPTs on the benefits of experimenting with simple tools in terms of the learning-teaching process were separated into four categories: cognitive structure, affective structure, high-level thinking skill, and learning environment. *Cognitive structure* refers to processes such as information formed in the student's mind, formation of concepts, evaluation of concepts, and academic success. *Affective structure* refers to the desire, attitude, and motivation toward the course and enjoyment of the work done. *High-level thinking skill* refers to such skills as creativity, inquiry, critical thinking, and multidimensionally thinking. *Learning environment* refers to the classroom environment and the physical environment where the activities occurred. The consistency of the coding carried was calculated by determining the amount of coded data as different and the same. The consistency was calculated using this formula: the measurement of consistency = "*the amount of the same encoded data/(amount of the same encoded data + amount of different encoded data)*". Consistency was calculated as 0.87. Finally, the two coders re-examined and re-encoded the differently coded data.

To ensure the credibility and trustworthiness of the study, the researcher carried out the course according to the scope of the previous year's course to minimize the researcher's intervention in the process. In the last week, the PPTs were informed about the purpose of the study and the data of the volunteer participants were used in the study. The procedure and data analysis are explained in detail. For this, sample analyses are included in the Data Analyses section, the quotations are included in the Findings section, and detailed descriptions of the experiments performed by PPTs are presented in the Appendices (Appendix 1-10). In addition, to ensure triangulation of the data, multiple data collection sources such as video recordings for observation and an open-ended questionnaire were used. The data were analyzed by two coders/raters and the consistency coefficient was examined.

Findings

The Proficiency Levels of the PPTs in Performing Science Experiments with Simple Tools

The mean scores of the proficiency levels obtained from the PPTs weekly and in total from the experiments they performed are given in Table 4. According to the mean of total scores, the PPTs have the highest level of proficiency in selecting and using simple tools (X=3.84). PPTs also have a high level of proficiency with *applying the experiments gradually, extensively, and correctly* (X=3.50). They have moderate proficiency with *explaining the concept/information correctly* (X=2.83).

Table 4. Mean Scores of the PPTs' Levels of Proficiency in Performing Science Experiments with Simple Tools

Experiment Subjects / Concepts	Proficiency Criteria *SST*	*ECC*	*AEG*	Weekly Total
	X	**X**	**X**	**X**
Equal-arm scales, dynamometers, and thermometers	4.00	2.32	2.89	***3.07***
Electrification types and bulb brightness	3.89	2.70	3.61	***3.40***
Refraction and image formation in mirrors	3.89	2.70	3.61	***3.40***
Heat-temperature, heat exchange and air pressure	3.87	2.62	3.60	***3.36***
Physical and chemical changes	3.97	3.02	3.97	***3.65***
Methods of separation mixtures	4.00	3.00	3.91	***3.64***
Support and movement system	3.55	2.58	3.33	***3.16***
Respiratory and circulatory system	3.82	2.98	3.48	***3.43***
Sense organs, digestive and excretory system	3.51	2.85	3.06	***3.14***
Earth and Moon movements	3.91	3.57	3.52	***3.67***
Total	**3.84**	**2.83**	**3.50**	**3.39**

SST= Selecting and using simple tools, ECC= Explaining the concept/information correctly, AEG= Applying the experiments gradually, extensively, and correctly, X= Mean.

The weekly comparison of the PPTs' mean scores in each proficiency criterion and in total from the experiments they performed are given in Figure 1. Upon examination of the PPTs' proficiencies with selecting and using simple tools, it is shown that the PPTs have a high level of proficiency during the first six weeks of experiments on physics and chemistry subjects. During the next three weeks when biology experiments were carried out, although the PPTs' proficiency levels remain high, it is noteworthy that their average scores decreased. During the final week when astronomy experiments were carried out, the PPTs also had a high mean score. Therefore, PPTs have a higher level of proficiency in experiments on physics, chemistry, and astronomy subjects than in biology subjects for selecting and using simple tools.

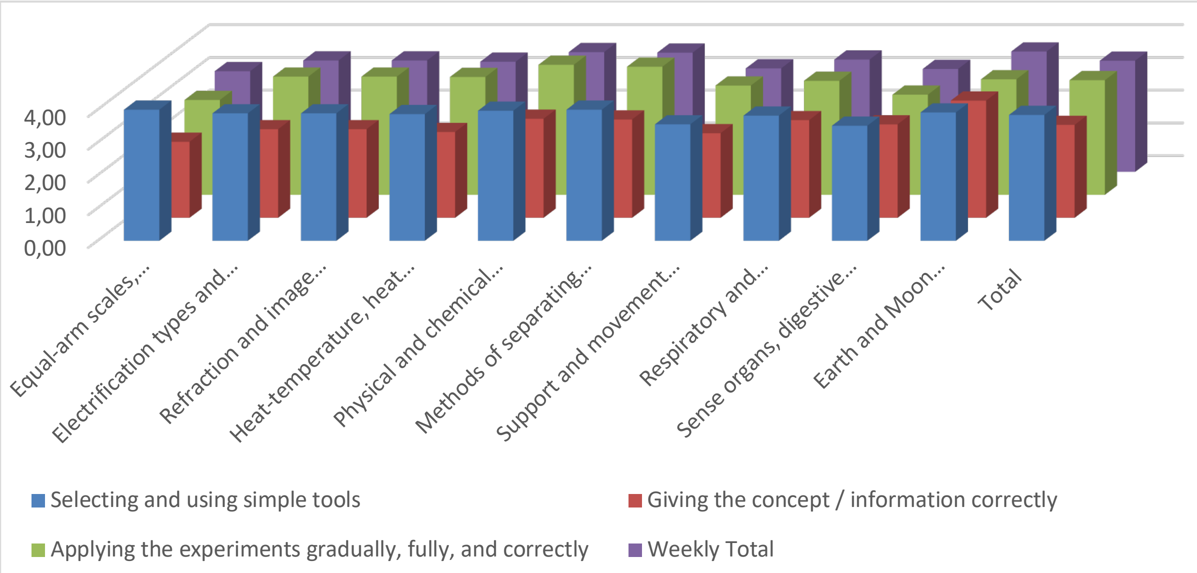

Figure 1. Comparison of the PPTs' Weekly Proficiency Levels

Figure 1 shows that the PPTs generally have moderate mean scores for explaining the concept/information correctly. However, they have higher mean scores on the subjects of physical and chemical changes and methods of separation mixtures, with the highest mean score on the subject of Earth and Moon movements. PPTs demonstrate a moderate level of proficiency for this criterion because they have misconceptions and incorrect information and they cannot associate the subject concepts. For example, PPTs had misconceptions about mass and weight concepts, as well as incorrect information about reflection and refraction concepts and the contraction and relaxation states of muscles. In addition, they have insufficient information on physical and chemical change concepts. During their scientific explanations of the Earth and Moon, some PPTs did not specify the observer's position and confused the lunar eclipse with the new moon or full moon phases.

In applying the experiments gradually, extensively, and correctly, Figure 1 shows that the PPTs have a high mean score. They have only moderate mean scores on the subject of equal-arm scales, dynamometers, and thermometers due to their deficiencies in scaling. In addition, they did not have proficiency explaining a scientific explanation for the events that took place, especially on physical and chemical change experiments. Some PPTs showed low proficiency in regulating control variables in experiments, especially on heat conduction, heat exchange and air pressure. In addition, some PPTs failed to provide unilateral flow of blood in the mechanisms where they show the working principle of the heart in the respiratory and circulatory system.

Opinions of the PPTs on Science Experiments They Performed with Simple Tools

The content analysis results of the open-ended questionnaire used to determine PPTs' opinions on the science experiments they performed with simple tools were presented under four headings. The PPTs were asked, "Did you have difficulty in reaching the experiment tools? If you had it, what did you do to overcome these difficulties? If you didn't have difficulties, please explain why?" Their opinions and frequencies regarding the question are given in Table 5.

Table 5. Frequencies and Opinions of the PPTs about Whether They Had Difficulty in Reaching the Experiment Tools

Categories	**Opinions**	**Frequencies (f)**
No *(∑f=61)*	I performed experiments with the tools I use in my daily life at home.	25
	I bought some tools from markets or stationery stores.	15
	I found and used alternative tools instead of non-existent tools.	14
	I found an alternative experiment and did it when I couldn't find one of the necessary tools.	5
	I performed the experiments borrowing non-existent tools from neighbors.	2
Yes *(∑f=29)*	I used alternative tools available at home.	16
	I used tools I bought from markets or stationery stores.	7
	I used tools I borrowed from neighbors.	3
	I used alternative tools in consultation with individuals close to me.	3

Note. Since some PPTs stated more than one reason, the total frequency is higher than the number of the PPTs who participated in the study.

Most of the PPTs stated that they performed science experiments without difficulty by using the tools in their daily life at home, buying some tools from markets or stationery stores, using alternative tools, or conducting alternative experiments. Some PPTs stated that they had difficulties while performing the experiments but overcame these difficulties by using alternative materials; obtaining them from the nearest market, stationery store, or neighbor; or consulting with acquaintances.

Secondly, PPTs were asked, "Can science experiments be carried out with simple tools without the need for a laboratory in primary school? Please explain the reasons." Their opinions and frequencies regarding the question are given in Table 6.

Table 6. Frequencies and Opinions of the PPTs on Whether Science Experiments Can Be Performed with Simple Tools Without the Need for a Laboratory in Primary School

Categories	**Opinions**	**Frequencies (f)**
Can be performed *(∑f=68)*	I can perform it because the tools used in the experiments are the things I encounter in my daily life.	26
	I proved that it can be performed by doing the experiments at home during this period.	17
	Teachers can perform it by forcing themselves a little to find alternative materials.	15
	I can do it because science subjects are part of daily life.	5
	They can be performed in the classroom or in the schoolyard because primary school science concepts are simple.	5
Should perform *(∑f=17)*	I should perform it because it will contribute to the student's learning outcomes such as success, permanence, concretization, and attention.	11
	I should perform it because there is no laboratory in every school.	6
May differ from experiment to experiment. *(∑f=5)*	Some experiments cannot be performed because they are dangerous.	5

PPTs stated that experiments could be performed using tools that they encounter in their daily lives or finding alternative materials, and they proved it by doing the experiments at home during this period. For example, PPT-6 stated, "Yes, it can be done absolutely. In fact, we use the experiments we have already done in our daily life without realizing it." PPT-21 responded, "Yes it can be done. Because we can create a mechanism by combining and using the simple materials we use in our daily life." Some PPTs stated that it was a requirement for them to perform the experiments because it contributes to students' learning outcomes such as success and retention, and every school does not have a laboratory. Few PPTs stated that dangerous experiments could not be performed.

Thirdly, PPTs were asked, "What are the benefits of experimenting with simple materials in terms of the learning-teaching process? Please explain the reasons." Their opinions and frequencies regarding the question are given in Table 7.

Table 7. Frequencies and Opinions of the PPTs on the Benefits of Experimenting with Simple Tools in Terms of the Learning-Teaching Process

Categories	**Opinions**	**Frequencies (f)**
Cognitive structure *(∑f=70)*	Meaningful and permanent learning occurs.	28
	Science subjects are associated with daily life.	20
	Learning gets easier.	12
	Science concepts are embodied.	10
Affective structure *(∑f=34)*	It attracts the attention of the students, arouses their curiosity.	19
	Students learn having fun.	10
	Students love the science lesson.	4
	Students become combative.	1
High-level thinking skill *(∑f=28)*	Students' imagination and creativity develop.	14
	Students learn to investigate and inquire.	7
	Students can think multidimensionally.	4
	Students' critical thinking skills develop.	3
Learning environment *(∑f=13)*	It ensures active participation of students.	7
	It occurs learning by doing.	4
	It increases the variety of experiments.	2

Most of the PPTs stated that performing science experiments with simple tools would contribute to the cognitive structure as it will positively affect meaningful and permanent learning, associating science subjects with daily life, and facilitating learning. Some of the PPTs stated that it would contribute to the cognitive structure because it attracts the attention of the students, arouses curiosity, provides fun learning, and makes students love the lesson. For example, PPT-53 stated, "They understand the concepts better with the mechanisms they create, and what they learn becomes more memorable because they make an effort." According to PPT-44, "The experiments carried out cause the concepts to be concretized, and the permanence in the mind increases. It makes science simpler and more understandable." Some PPTs stated that performing science experiments with simple tools would contribute to the high-level thinking structures because it develops students' imagination and creativity, directs students to research and inquiry, and encourage active participation.

Lastly, PPTs were asked, "What do you gain by experimenting with simple materials to realize your profession? Please explain the reasons." Their opinions and frequencies regarding the question are given in Table 8.

Table 8. Frequencies and Opinions of the PPTs about the Gains of Experimenting with Simple Tools to Realize the Teaching Profession

Categories	Opinions	Frequencies (f)
Gains related to perform science experiment *(∑f=70)*	I can perform science lessons with experiments even if there is no laboratory in the school where I will work.	27
	I can perform science experiments with simple tools.	24
	I can do experiment using alternative tool.	13
	I gained the ability to design, plan and implement the experiment.	6
Gains related to the effect on students' learning outcomes *(∑f=38)*	It can provide students easy, meaningful, and permanent learning.	17
	I could attract students' attention by experimenting with simple tools.	14
	Students will learn the science subjects having more fun with these experiments.	4
	It would increase students' creativity, research, and inquiry skills.	3
Gains related to professional self-efficacy *(∑f=46)*	It helped me to think more creatively by developing my imagination.	18
	My academic knowledge increased while researching for experiments.	12
	I gained the idea that I could create an effective education-teaching environment with limited opportunities.	7
	My self-confidence increased in being able to experiment without a laboratory.	5
	I could be successful in associating science lesson with daily life.	4

Most of the PPTs stated that they can perform science lessons with experiments by using simple and alternative materials, even if there is no laboratory in the school where they will work. Some PPTs stated that experimenting with simple tools allows them to increase students' learning outcomes and attract students' attention and interest. Some stated that they gained professional self-efficacy, such as being able to think creatively and imagine, increase science content knowledge, create an effective learning-teaching environment even with limited opportunities, and experiment without a laboratory. Some of the PPTs' statements are as follows:

- "I have always learned science lessons on books throughout my education life, and while doing these experiments, I realized that it is much more useful and remarkable to learn concretely with experiments and materials. With these experiments, I both had an idea about what I could do, and I think that by developing my creativity, I will have the opportunity to explain the subjects with more original experiments and materials in the future." (PPT-21)
- "In the future, I may not be able to work in a school with good conditions or I may not have all the materials. In this case, instead of avoiding doing experiment, I learned how to think simple and perform the experiment with simple materials, and how I can benefit my students in the highest way. I realized that the lack of material was not an excuse to not do experiment." (PPT-53)
- "I learned how to turn this into an advantage if I am assigned to a village school without a laboratory. I will be able to engage my students and involve them more in experiments." (PPT-13)

Discussion and Conclusions

The results of this study revealed that PPTs are moderately proficient in explaining the concepts and information correctly, while they are highly proficient in selecting and using simple tools and in applying the experiments gradually, extensively, and correctly. The opinions of the PPTs stated in the open-ended questionnaire supports these qualifications. Most PPTs stated that they had no difficulty in acquiring the tools for the experiment because they used tools from their daily lives at home, the nearest market, or stationery, or they used alternative tools and experiments. For this reason, they stated that science experiments can be performed with simple tools. PPTs believe these experiments will contribute to students' cognitive, affective, and high-level thinking skills, as well as the learning environment. PPTs also stated that they gained experience performing science lessons with experiments even if there is no laboratory in the school where they will work.

There are two possible reasons why the PPTs' level of proficiency in choosing simple tools for science experiments and performing experiments correctly is high. First, many experiments suitable for all levels of education are available on the Internet (Boy et al., 2020; Morcillo et al., 2016). Today, individuals prefer the Internet as the first source for their research (Boy et al., 2020). The Internet is a convenient source for the PPTs to select the experiment and determine the tools and equipment to be used. Thus, the PPTs had no difficulties both in choosing the experimental tools and in applying the experiment step by step, showing a high level of proficiency. The second reason is that the experiments were chosen in accordance with the primary education level. Since primary school science subjects are more intertwined with daily life (Agranovich & Assaraf, 2013; MoNE, 2018), the PPTs were easily able to choose and apply tools from daily life.

The latter reason is consistent with the findings from the analysis of the questionnaire, in which PPTs revealed that it is not difficult to select and apply experiments that can be done with simple tools, especially at the primary school level. This is inconsistent with previous study findings. Some studies revealed that teachers do not give enough space to experiments in science lessons (Bostan-Sarıoğlan et al., 2020; Bostan-Sarıoğlan, 2015; Çil & Çalışoğlu, 2020; Dindar & Yaman, 2003; Ekici, 2015; Güneş et al., 2013; Koç & Bayraktar, 2013; Uzal et al., 2010). Due to the lack of materials and laboratories in schools, some teachers see chemicals as dangerous and unsafe (Akıncı et al., 2015; Çil & Çalışoğlu, 2020; Dindar & Yaman, 2003; Lang et al., 2005; Özdener, 2005; Soğukpınar & Gündoğdu, 2020; Stepenuck, 2002; Tekin, 2008; Uluçınar et al., 2008).

On the other hand, the findings of the present study are consistent with previous study findings related to PPTs' training and self-perception. Earlier studies revealed that PTs/PPTs do not see themselves as sufficient, lacking self-confidence or field knowledge (Bostan-Sarıoğlan et al., 2020; Chin & Chia, 2006; Howit, 2007; Kocakülah & Savaş, 2011; Zion et al., 2007). Furthermore, many PPTs do not receive adequate pre-service and in-service training (Howit, 2007; Palmer, 2006). The findings of this study support these conclusions, with the PPTs demonstrating a lower level of proficiency in explaining concepts and information correctly than the other two criteria. Previous studies show the PTs' lack of content knowledge as the cause of various difficulties during the implementation of the experiments (Coştu et al., 2005; Kim & Tan, 2011; Kocakülah & Savaş, 2010), which is consistent with the findings of this study. PPTs are selected according to the Turkish-Mathematics score type for the Primary Teacher Education. Since they prepare according to this score type and most are not interested in science courses, they often lack science content knowledge.

The opinions of the PPTs revealed that most of them would perform experiments without difficulty by using simple tools in daily life at home, alternative tools, and alternative experiments. They proved they could perform such experiments during the study period, and, according to the questionnaire, they gained self-confidence. Previous studies revealed that PPTs gain self-confidence through practicing experimental applications and receiving pre-service training (Anılan et al., 2020; Kocakülah & Savaş, 2010; Palmer, 2006; Roehring &

Luft, 2006). This is further supported by the week-to-week increase in the PPTs' proficiency scores during this study (Figure 1). Using the experimental method in science lessons is critical in increasing the attitude and success of both PPTs and students (Gumala et al., 2020; İnel-Ekici, 2015; Önen & Çömek, 2011; Öztürk, 2007; Uluçınar et al., 2008). It changes the perspectives of the PPTs and students toward the lesson in a positive way. The PPTs stated that experiments will contribute to students' cognitive, affective, high-level thinking skills, and learning environment, all of which reveal the importance of performing experiments with simple tools at the primary school level. According to the PPTs, they have gained experience in conducting science lessons with experiments, even if there is no laboratory in the schools they will work. The PPTs expressed positive opinions about performing science experiments with simple tools. A possible reason for this is that they had received science education only theoretically, not experimentally—until now (Agustin et al., 2021; Çil & Çalışoğlu, 2020). Performing science experiments with simple tools increased PPTs' creative thinking and self-confidence (Anılan et al., 2020; Palmer, 2006; Roehring & Luft, 2006). They realized their own abilities by performing different experiments on various subjects using simple tools and they learned which tools they could use in their environment.

The proficiency and opinions of the PPTs revealed that science experiments can be performed with simple tools and contribute to students' learning outcomes. For this reason, science experiments with simple tools can be performed in distance education, where active participation of students and classroom management are limited while gaining knowledge (Aktaş & Özmen, 2022). Some students also have limited access to virtual labs, the Internet, or a computer (Bostan-Sarıoğlan et al., 2020). During the COVID-19 pandemic, distance education prevents experiments from being carried out in a science lab, which negatively affects the success of students. (Bostan-Sarıoğlan et al., 2020; Pınar & Döne-Akgül, 2020). Thus, simple science experiments will be useful for teachers who prefer real labs to virtual labs (Çelik & Karamustafaoğlu, 2016). The teacher is one of the most important factors affecting the learning process (Agustin et al., 2021). Teachers should be trained to have the proficiency to perform science experiments with simple tools from their daily lives.

This study has some limitations. This study was carried out in a distance education process, during which PPTs communicate frequently through various platforms. This may cause the PPTs to influence each other. For instance, a group could write a proposal for an experiment, which could then be used by a PPT who has difficulty in selecting experimental tools. Although this situation can happen in face-to-face education, it happens more regularly in the distance education process. Thus, the proficiency scores of the PPTs may have been positively affected. Another limitation is that after PPTs received the science subjects, they were free to choose the experiment. If they chose the experiment they know best, this may have had a positive impact on their scores.

PPTs are highly proficient in performing science experiments with simple tools. The practice provides them with professional competencies such as self-confidence, academic knowledge, and creativity. They form positive opinions of performing science experiments with simple tools, even in schools that do not have laboratories, and associating science concepts with daily life.

- Future studies should focus on increasing the proficiency of PPTs in scientifically explaining the concepts, results, and processes of experiments while performing science experiments with simple tools.

- Training courses about performing science experiments with simple tools from daily life should be offered to increase PTs' and PSTs' awareness of the practice. Teachers should conduct science experiments with simple tools during distance education, in case of another pandemic or in a village school without a laboratory.
- Primary teacher education should put more emphasis on science experiments with simple tools because it contributes to PPTs' proficiency and positive opinions.

Declaration of interest

Author/s declare that:

a) Conflict of Interest: They have no conflict of interest.

b) Research involving human participants: Prior to the study, ethical approval was obtained from the Institution. The participants were told about the aims of the research, and giving consent to the use of their data that was obtained. Participation in the elective course and the study was on a voluntary basis.

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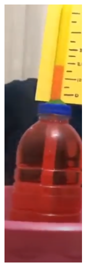
Appendices

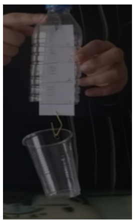
Appendix 1 Sample images of the experiments the PPTs performed for the making of equal-arm scales, dynamometers, and thermometers


PPT-43

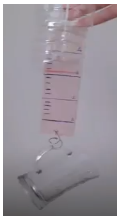

PPT-41


PPT-57


PPT-31


PPT-12


PPT-31


PPT-48


PPT-38

The number of measuring instruments made by the PPTs for making equal-arm scales, dynamometers, and thermometers is high and varied. However, they had various misconceptions and did not present the concept associating it with other concepts of the subject. Some of the PPTs used the expressions of measuring the weight instead of measuring the mass, that is, the amount of matter, on an equal-arm balance. They used the concept of weight instead of mass, and expressions of greater weight rather than the amount of substance or greater mass. Sample statements: PPT-17 "*in equal-arm scales, the one with the greater weight will be determined*" and "*its mass is heavier*", PPT-30 "*A pan with three balls is heavier*" and PPT-28 "*right pan was heavier*" PPT-40 "*I put weight on the pans*" PPT-50 "*we made our equal arm balance now we can measure our weight*". This reveals that the PPTs cannot fully distinguish the concepts of mass and weight and they have misconceptions. In the making of dynamometers and thermometers, they have moderate proficiency in the item of *applying the experiments gradually, extensively, and correctly* due to their deficiencies in scaling. They either did not do the scaling or did it incorrectly, there was a distance between the level of the liquid and the first line of the scale, or random lines were drawn that did not match the actual scale.

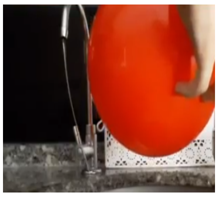
Appendix 2 Sample images of the experiments the PPTs performed for the electrification


PPT-13

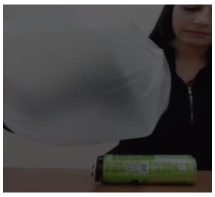

PPT-41


PPT-16


PPT-13


PPT-3


PPT-22


PPT-45


PPT-58

While the PPTs performed different experiments using various tools for electrification, they performed similar experiments with small bulbs and batteries that they supplied from outside for the factors affecting the brightness of the bulb. This is due to the nature of the simple electric circuit subject. The limited number of alternative materials that can be used instead of light bulbs, batteries and connection cables has affected the experiment variety. The PPTs performed various experiments on electrification. Some PPTs performed experiments well known to teachers, such as pulling the paper, salt or chili pepper after rubbing the balloon on the hair, and pulling the paper after rubbing the plastic cup to the wool sweater. Some PPTs used inflated bags instead of balloons, and aluminum foil pieces instead of paper, chili peppers and salt. Some moved the paper ship they put on the water with balloons/inflated bags, the toothpick placed on the coin, the pen placed on the plastic bottle. Some had glued a hair-rubbing balloon to wall paint, diverted thin water from the faucet, and made an electroscope by placing pieces of aluminum foil and conductive wires in a jar.

Appendix 3 Sample images of the experiments the PPTs performed for the refraction and image formation in mirrors


PPT-58

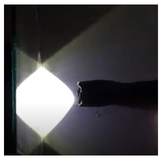

PPT-15

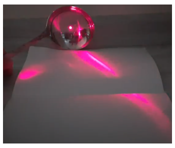

PPT-48


PPT-33

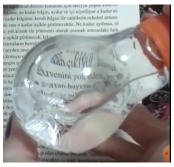

PPT-3


PPT-21


PPT-46


PPT-3


PPT-3


PPT-14

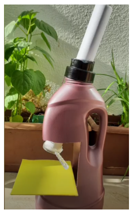

PPT-46


PPT-12


PPT-11


PPT-11


PPT-59


PPT-41

The PPTs performed quite different experiments using various materials related to refraction and image formation in mirrors. This is due to the subject area is wide and it is widespread in our environment and in our daily life. Some of the experiments performed by the PPTs are as follows: The jar filled with water acted as a concave lens (PPT-58), the tea glass was not seen because the light was refracted when water was filled into the mug with the tea glass inside (PPT-15), a spherical aquarium filled with water or a bulb filled with water served as a magnifying glass (PPT-33), when the laser is pointed at the flowing water, the laser light is refracted and follows the direction of the water (PPT-3), there were differences in the appearance of cologne, water and the fork in the empty glass, due to refracted (PPT-48), the view field of the mirror was shown (PPT-46), the thin-waisted glass acted as a concave lens, scattering the light (PPT-11), and simple microscope, telescope and periscope were made. Some PPTs used the concepts of reflection instead of refraction in lenses, refraction instead of reflection in mirrors such as PPT-25 "*We saw the reflection of the light in the convex lens*", and PPT-19 "*I will show the refraction of light in concave and convex mirrors … we see the refraction of light in the convex mirror*".

Appendix 4 Sample images from various experiments performed by the PPTs on heat conduction, heat exchange and air pressure


PPT-35

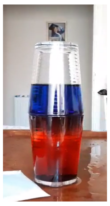

PPT-20

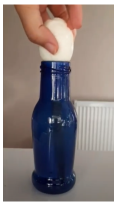

PPT-17


PPT-1


PPT-19


PPT-46


PPT-44


PPT-3


PPT-30

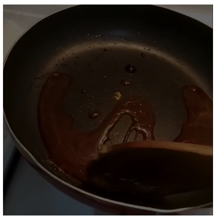

PPT-49

The PPTs performed quite different experiments related to heat, temperature, and air pressure due to these concepts are widespread in our daily life. Putting solid oil into wooden, plastic and metal spoons, keeping the spoons in hot water and observing which oil will fall first is the most common experiment on heat conduction (PPT-19). Some PPTs put half a lemon in one bag, half a lemon and a glass full of water in the other bag, kept them in the freezer for a certain time, then squeezed the lemons and observed which of them froze. (PPT-1). Most of the PPTs placed the cold-water bottle on top of the colored hot-water bottle and observed the distribution of the colored liquid into the colorless liquid in the bottles for heat exchange (PPT-46). The distribution was much slower when the liquids were at the same temperature (PPT-44). They performed experiments showing the egg falling into the bottle (PPT-3), the flow of liquid (PPT-35, 49), and the plastic bottle and cola can, which change shape when heated and sealed (PPT-17) for air pressure. PPTs showed low proficiency in regulating control variables in heat conduction experiments. The fact that the spoons they used were different in size was a serious mistake for the success of the experiments. In addition, they did not have proficiency explaining a scientific explanation for the events that took place. The reason for the different hardness of lemons coming out of the refrigerator and the effects of air pressure had not been adequately and scientifically explained.

Appendix 5 Sample images of the experiments performed by the PPTs on physical and chemical change


PPT-58


PPT-7


PPT-20


PPT-52


PPT-31

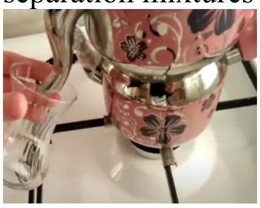

PPT-31


PPT-50


PPT-35

The PPTs performed the experiments on physical change, such as tearing the paper, slicing the bread, crumbling the sugar (PPT-20), slicing the apple (PPT-31), grating the carrot and potato (PPT-31), obtaining ayran from yoghurt (PPT-50), steaming the glass, and melting the wax. The experiment of mixing vinegar and baking soda (PPT-58) was the most common experiment on chemical change. Adding lemon to tea (PPT-52), burning a candle, spilling bleach on a piece of cloth (PPT-35), burning of paper, molding of bread (PPT-7), soaking eggs in vinegar and fermentation of dough were other experiments. Regarding the *explaining the concept / information correctly,* the PPTs gave insufficient information on their own such as PPT-37 "*There is a change in both its internal and external structure*" PPT-41 "*We cannot return it to its original state*" PPT-9: "*Matter has not lost its essence, it is a physical change… it has lost its essence, it is a chemical change*", and also gave wrong information such as PPT-40 "*The example I gave to chemical state change*!". This revealed that PPTs had deficiencies in providing a scientific explanation for physical and chemical change experiments.

Appendix 6 Sample images of the experiments performed by the PPTs on methods of separation mixtures


PPT-50


PPT-19


PPT-46


PPT-49


PPT-58


PPT-11

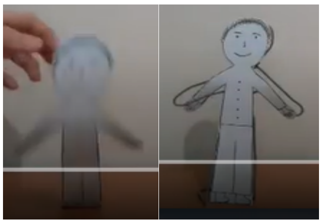

PPT-57

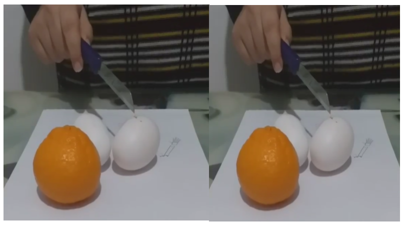

PPT-32

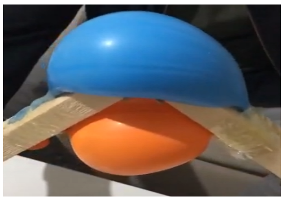
Regarding the methods of separation mixtures, the PPTs used simple tools such as the lentil, toothpicks, flour, rice, salt, pins, pebbles, leaf soil, pieces of paper for sieving, straining, floating, magnetic separation methods. PPTs, for the fractional distillation, placed the large teapot upside down on the small teapot where they put the mixture and covered the openings with aluminum foil, then boiling water flowed from the strainer of the big teapot into the glass (PPT-50, 11). For a separating funnel, they made a hole in the cap of a plastic bottle and placed a pipette, closed the bottle's cap after filled the bottle with the oil-water mixture, turned it upside down, waited for the water to flow through the pipette, and separated the water and oil (PPT-58). Some PPTs did not elaborate on what kind of mixtures could be separated by their methods or there was a lack of knowledge such as PPT-35 "*We will separate the needle, wire and stone mixture with magnetism using the magnet separation method… The wires are not made of metal!*". The fact that the magnet does not attract does not mean that the wire is not metal. The magnet attracts materials such as iron cobalt nickel and does not attract all metals. PPT-9 used the expression "*Staples remained at the bottom because they were heavier*" for the separation method with floatation. The Staples sank to the bottom of the water because it has a high density.

Appendix 7 Sample images of the experiments performed by the PPTs on support and movement system


PPT-17


PPT-41


PPT-12


PPT-31


PPT-46

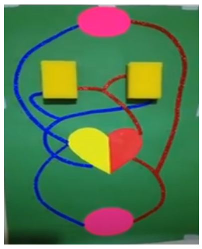

PPT-49

For the importance of the skeletal system, the PPTs performed experiment with the human model they made from play dough (or real dough) in which they put wire or bush pieces could stand upright, while the human model they made only from play dough could not stand upright (PPT-17). They showed that while a piece of paper cannot stand upright, it can stand upright when a straw is taped, or a support is placed on its back (PPT-41). For the importance of the joints, most of them made a hand model from cardboard paper and moved the model via straws and wires they cut (PPT-49) or demonstrating that fingers cannot move by attaching ice cream sticks to fingers (PPT-46). They performed experiments on muscle contraction and relaxation by making arm models with balloon wood pieces (PPT-31). Some of them performed experiments on how the rib cage protects the internal organs (PPT-12). Some PPTs confused the contraction and relaxation states of the muscles such as PPT-49 "*the muscle in the back contracts and relaxes in the front*", and PPT-1 "*the upper muscle contracted and the lower one relaxed*".

Appendix 8 Sample images of the experiments performed by the PPTs on respiratory and circulatory system


PPT-58


PPT-46


PPT-53


PPT-30

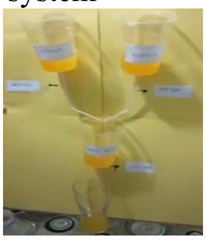

PPT-38


PPT-1

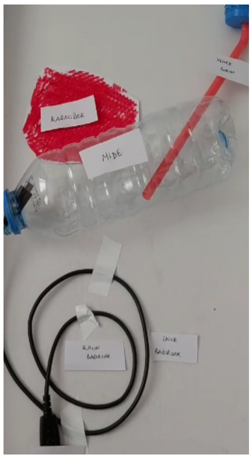
PPTs performed experiments with little variation in the respiratory and circulatory system. They performed experiments on the respiratory system with balloons in plastic bottles or bags that they inflated with straws (PPT-58, 1). They used experiments based on the working principle of the heart or models they created with various materials related to the circulatory system (PPT-30, 38, 53). Some PPTs failed to provide unilateral flow of blood in the mechanisms where they show the working principle of the heart.

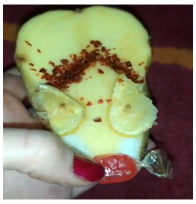
Appendix 9 Sample images of the experiments performed by the PPTs on sense organs, digestive and excretory system


PPT-58


PPT-19


PPT-33

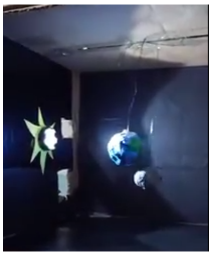

PPT-42

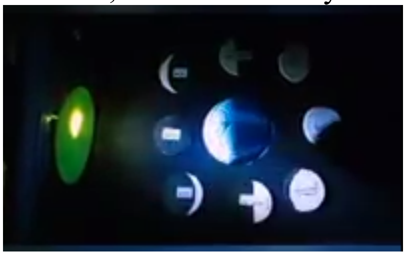

PPT-58

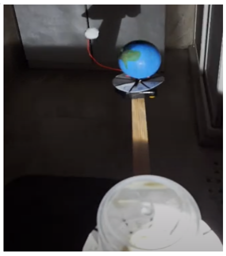

PPT-22

PPTs performed experiments with little variation in the sense organs, digestive and excretory system. The most common experiment performed by the PPTs on the digestive system is that to turn the nutrient-vinegar-carbonate mixture into a slurry in a bag or balloon (representation of the stomach), filtering through thin and thick socks/napkin respectively, and obtaining pulp (PPT-58). The most performed experiment on excretion is to make kidneys (representative) with plastic cups filled with water (or bottles) and transfer them into a new pet glass with the help of straws and transfer them to the empty glass from there (PPT-19). Determining the properties of various foodstuffs by touching, tasting, and seeing is the most common experiment on sense organs (PPT-33). In addition, some PPTs prepared various models for the systems.

Appendix 10 Sample images and descriptive of the experiments performed by the PPTs on movements of the Earth and Moon, formation of day and night, phases of the Moon


PPT-17


PPT-25

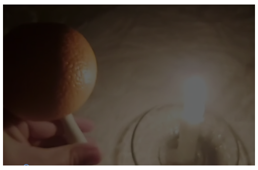

PPT-3

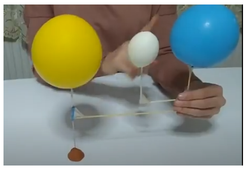

PPT-33


PPT-46


PPT-20


PPT-31


PPT-20


PPT-5

The PPTs performed various experiments using different simple tools on the movements of the Earth and Moon and the phases of the Moon. They used flashlights or candles for the representation of the sun, oranges, small balls, or tools that they rolled the paper into a ball for the representation of the earth and the moon. Some PPTs for the phases of the moon drilled holes on the four sides of a shoe box, while observing the moon from one hole, light was shed through the other holes, and the phases of the moon were observed. However, the PPTs did not specify the observer's position in their scientific explanations: "*Is the observer in the world? Outside the system?*" or did not specify the sun-earth-moon order. This caused confusion when explaining concepts. Some PPTs confused the lunar eclipse with the new moon and sometimes the full moon phases.