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Guided Inquiry-Based Electricity Experiments: Pre-service Elementary Science Teachers' Difficulties

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Abstract

Renewed primary and elementary schools science curriculum has been implemented in Turkey for three years. In this curriculum students are required to learn school science subjects by various inquiry-based learning activities or experiments. However, whether pre-service elementary science teachers (PSTs) are completely ready to implement this curriculum by considering some levels of inquiry is still not known. This study aims to explore PSTs' difficulties in performing guided inquiry-based physic experiments and their perceptions about physics laboratory. A total of 80 PSTs participated in the study and they performed guided inquiry-based electricity experiments. Data were collected through an open-ended questionnaire, the interview and field note. Qualitative content analysis was performed to analyze the data obtained. The results of this study showed that some PSTs faced difficulty in performing the experiments due to their teacher-centered previous learning experiences, insufficient content knowledge about physics, insufficient inquiry skills, poor adaptation to inquiry activities and low-level collaboration. In addition, the majority of PSTs perceived physics laboratory as a place where the physics knowledge was confirmed. As a conclusion, this study showed that most PSTs had some difficulties in performing the guided inquiry-based electricity experiments. How researchers and instructors can decrease the number of the difficulties that PSTs face in the inquiry activities or experiments by taking some precautions is also discussed in this study.

Keywords: difficulties, electricity, guided inquiry-based experiments, perceptions, physics experiments, physics laboratory

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Fen Bilimleri Dersi Öğretmen Adaylarının Elektrik Konusuna Yönelik Rehberli-Araştırma Sorgulama Deneylerinde Karşılaştıkları Zorluklar

Öz

Yenilenen İlköğretim Kurumları Fen Bilimleri Dersi Öğretim Programı üç yıldır Türkiye'de uygulanmaktadır. Bu programda öğrencilerin feni çeşitli sorgulayıcı öğrenme etkinlikleri ya da deneyleri ile öğrenmeleri istenmektedir. Fakat fen bilimleri dersi öğretmen adaylarının, bu öğretim programını sorgulayıcı öğrenmenin bazı düzeylerini düşünerek uygulamaya tam olarak hazır olup olmadıkları bilinmemektedir. Bu çalışmanın amacı fen bilimleri dersi öğretmen adaylarının elektrik konusuna yönelik rehberli-araştırma sorgulama deneylerini yaparken karşılaşmış oldukları zorlukları ve fizik laboratuvarı hakkındaki algılarını tespit etmektir. Çalışmaya 80 fen bilimleri dersi öğretmen adayı katılmıştır ve elektrik konusuna yönelik rehberli-araştırma sorgulama deneylerini yapmışlardır. Açık uçlu anket, mülakat ve gözlem bu çalışmada kullanılan veri toplama araçlarıdır. Elde edilen verileri analiz etmek için nitel içerik analizi uygulanmıştır. Bu çalışmanın sonuçlarına göre bazı öğretmen adayları deneyleri yaparken geçmiş öğretmen merkezli öğrenme deneyimlerinden, yetersiz fizik alan bilgilerinden, yetersiz sorgulama becerilerinden, sorgulayıcı öğrenme etkinliklerine olan adaptasyon problemlerinden ve düşük seviyedeki işbirliklerinden dolayı sıkıntılar yaşamışlardır. Ayrıca öğretmen adaylarının çoğu fizik laboratuvarını bilginin onaylandığı bir yer olarak düşünmüşlerdir. Sonuçta bu çalışma çoğu fen bilimleri dersi öğretmen adayının elektrik konusuna yönelik rehberli-araştırma sorgulama deneylerinde zorlandığını göstermiştir. Bu çalışmada araştırmacıların ve öğretmenlerin, öğretmen adaylarının rehberli-araştırma sorgulama deneylerinde karşılaştıkları zorlukların sayısını bazı önlemler alarak nasıl azaltabileceği de tartışılmıştır.

Anahtar Sözcükler: zorluklar, elektrik, rehberli-araştırma sorgulama deneyleri, algılar, fizik deneyleri, fizik laboratuvarı

Introduction

In Turkey, some changes have been made in primary and elementary schools science curricula for more than ten years. Firstly, the elementary school science and technology curriculum that gives more importance to involve students physically and mentally in the learning of science subjects was put into practice in 2004. This curriculum was mainly based on the philosophy of constructivism and espoused the science literacy as its vision (see Ministry of National Education [MoNE], 2006). Then, this curriculum was renewed in 2013, and the renewed primary and elementary schools science curriculum was put into practice in 2013-2014 fall-semester (see MoNE, 2013). Similar to the old curriculum, this renewed curriculum's vision was also based on science literacy. However, when both curricula are compared carefully it is clear that the most distinct feature of the renewed curriculum from the old one is its more emphasis on inquiry-based learning approaches. It is expected that science teachers should teach the science contents using the different stages of inquiry for different grades. The use of the structured inquiry for Grades 3 and 4, the guided inquiry for Grades 5 and 6, and the open inquiry for Grades 7 and 8 are advised to the teachers (MoNE, 2013).

Levels of Inquiry

There are some levels of inquiry in learning of subjects. One of the widely known classifications for inquiry levels was first made by Schwab in 1962 (as cited in Herron, 1971). According to him, there were three levels of inquiry. In the first one, the problem and procedure are given to students, and then it is wanted from them to discover the relations. In the second one, the problem is given to students again; however, the procedure and answers are not given. In the final one, students are also responsible for constructing the problem and the procedure but answers are not still given.

Recently some researchers (e.g., Banchi & Bell, 2008; Bell, Smetana & Binns, 2005; Wenning, 2005) have tried to make some classifications for the levels of inquiry. Wenning (2005) stated that there were three levels of inquiry lab with respect to degree of intellectual sophistication and locus of control: *guided inquiry lab, bounded inquiry lab* and *free inquiry lab*. The guided inquiry lab starts with clearly defined problems by teachers. After that, students are provided with some questions leading them to carry out the experiments. Finding the relationship between force and acceleration could be an example of this type of inquiry. In the second one the bounded inquiry lab, the objective of the experiments or activities are presented to students, and then students perform them by observing the relationships among the variables and formulating a logical basis for the experiments. Students are required to design their own experiments. The final one the open inquiry lab encourages students to construct their own problems and create their own experiments (Wenning, 2005).

Bell et al. (2005), and Banchi and Bell (2008) reported that there were four levels of inquiry. More recent classification for the levels of inquiry has been presented by them. These levels are: (1) *confirmatory inquiry,* (2) *structured inquiry,* (3) *guided inquiry* and (4) *open inquiry*. This classification was made according to the amount of guidance given to students. The confirmatory inquiry expects students to perform the experiments according to well-defined problem, procedure and solution given by teachers. In the structured inquiry, only the problem and procedure are given to students, and then they try to reach a solution. In the guided inquiry, only the problem is given to students and they are responsible for their own design of the experiments or activities. Though all the three types of inquiry start with a problem determined by the teacher, the open inquiry expects students to formulate their own problems. In addition, in this, students design their own experiments and reach their solutions. Similar to the classification of Bell et al. (2005) and Banchi and Bell (2008), the renewed science curriculum in Turkey also encourages teachers to use the structured, guided and open inquiry in their lessons (MoNE, 2013).

Science Inquiry and Difficulties

In National Science Education Standards (National Research Council [NRC], 1996; 2000) in the U.S.A. students are required to engage in many activities to learn science and try to behave as scientists in the inquiry activities. Some steps such as making observations, carrying out the experiments, and interpreting the data are parts of inquiry (NRC, 2000). In fact, inquiry aims to develop students' questioning and critical thinking skills by involving them active learning (NRC, 2000). Inquiry refers to "a learning process in which students are engaged" (Anderson, 2002, p.2).

Positive contributions of use of inquiry activities or experiments in the lessons to science learning have been discussed by many researchers. For example, some recent studies (e.g., Areepattamannil, 2012; Campbell, Zhang & Neilson, 2011) reported its positive influences on students' science achievement and attitudes towards science. However, teachers can be the main actors that influence the proper implementation of inquiry activities in science lessons (Wee, Shepardson, Fast & Harbor, 2007). Their negative perceptions, beliefs and views about inquiry activities in the classrooms or laboratories can be an obstacle in front of them to carry out the activities (Hofstein & Lunetta, 1982; 2004; Tsai, 2003). Considering this issue, some researchers (e.g., Banerjee, 2010; Steinberg, Wyner, Borman & Salame, 2015; Wee et al., 2007) have been in effort to develop pre-service or in-service teachers' inquiry skills for better implementation of inquiry methods. Banerjee (2010) developed a professional development model for high school science teachers according to the guided inquiry and tested this model during three years. Their results showed that the professional development activities helped teachers design more guided inquiry labs and better understand inquiry. Similarly, Wee et al. (2007) investigated teachers' change in understandings of inquiry after the professional development program. However, they found little or no change in teachers' understanding of inquiry. Teachers could not reflect a high level of inquiry in their teaching. They discussed that insufficient supports that taken from professional development programs and schools could cause this little change in teachers' understanding of inquiry. Contrary to findings of Wee et al. (2007), Steinberg et al. (2015) observed serious changes in students' understanding of inquiry and science after the course for future elementary school teachers. They found that the participants increased their knowledge about nature of science and valued more the importance of use of hands-on science activities.

Moreover, in-service and pre-service teachers who experienced science inquiry activities developed more positive beliefs about learning and inquiry (Choi & Ramsey, 2009; Duran, Ballone-Duran, Haney & Beltyukova, 2009; Hutchins & Friedrichsen, 2012; Pilitsis & Duncan, 2012; Rushton, Lutter & Singer, 2011; Tatar, 2012). Experiencing the activities positively affected teachers' self-efficacy beliefs (Duran et al., 2009), and their values about the science learning based on student-centered (Hutchins & Friedrichsen, 2012; Pilitsis & Duncan, 2012). Pre-service teachers (Tatar, 2012) and in-service elementary teachers (Choi & Ramsey, 2009) also possessed more positive beliefs about the inquiry instruction after they attended science inquiry-based activities. Rushton et al. (2011) indicated that high school chemistry teachers valued inquiry and viewed inquiry as helpful for students to improve their thinking abilities after experiencing inquiry activities. However, although some teachers believed in the inquiry-based science course as valuable, they could not act according to student-centered teaching styles (Brown & Melear, 2006). Furthermore, Bhattacharyya, Volk and Lumpe (2009) found that science inquiry-based field experiences of pre-service elementary teachers lead to increase on their personal agency beliefs. Similarly, Liang and Richardson (2009) reported that the scaffolded student-directed inquiry that pre-service elementary teachers experienced improved their personal science teaching efficacy beliefs.

Although there are some studies concerning the development of learners' inquiry skills, teachers and students can face some difficulties in science inquiry activities. For example, being not able teach the science content accurately in the inquiry lessons (Kim & Tan, 2011; Nowicki, Sullivan-Watts, Shim, Young & Pockalny, 2013), ignoring essential necessities of inquiry in science teaching (Capps & Crawford, 2013), being not able to guide and help students appropriately in the inquiry-based science lessons (Yoon, Joung & Kim, 2012) and having insufficient knowledge about inquiry (Nivalainen, Asikainen & Hirvonen, 2013; Yoon et al., 2012) are some obstacles in front of the teachers to perform science inquiry activities effectively. In addition, students' some difficulties in science inquiry activities can negatively influence the activities to reach their aims. Students' following difficulties in performing the activities; being not able to control the variables, and support the theory according to the evidence collected (Lee, Buxton, Lewis & LeRoy, 2006), and being not able to internalize inquiry as a learning process due to the past traditional learning experiences (Sadaghinai, 2008) can reduce the amount of outcomes that students will acquire in the activities.

To be able to minimize the difficulties mentioned above, graduating pre-service teachers from the universities with sufficient experience on science inquiry activities gains more importance. For example, some researchers (e.g., Duran, McArthur & Van-Hook, 2004; Magee & Flesner, 2012) focused on pre-service teachers' adaptation to science inquiry activities. This adaptation was high and pre-service teachers were more open to innovations. Duran et al. (2004) reported that although pre-service elementary teachers initially felt some frustration with the arrival of inquiry, they were able to espouse the inquiry method. The study conducted by Magee and Flesner (2012) also pointed out that pre-service elementary teachers could overcome the complexities of the inquiry-based teaching.

Rationale and Research Questions

Considering that teachers are the main actors putting the science curriculum reforms into practice (NRC, 2000), graduating pre-service science teachers from the universities by helping them experience science learning methods indicated in the science curricula gains more importance. As discussed before, science inquiry activities have been incorporated with renewed primary and elementary schools science curriculum in Turkey recently. However, whether the Turkish pre-service elementary science teachers (PSTs) are ready for the activities is debatable. Without having sufficient knowledge about the activities and experiencing them enough, they can face some problems when they begin to their professional life. Therefore, identifying PSTs' difficulties in inquiry activities can help particularly the faculty members who conduct science method courses (e.g., Physics Lab, Chemistry Lab and Biology Lab) by considering inquiry. They can be more careful in designing inquiry lab environments and they can help their students overcome the difficulties that they will face in the inquiry activities. In this way, PSTs can graduate from the universities by learning essential characteristics of science inquiry activities and developing their inquiry skills more.

Past research has shown that teachers could face some difficulties in performing science inquiry activities. Not experiencing the inquiry activities enough in pre-service education in the universities can be major reason of these difficulties. As mentioned in aforementioned literature, pre-service teachers' adaptation to inquiry activities is high and they are willing to perform the activities (Duran et al., 2004; Forbes, 2013; Magee & Flesner, 2012). Although some studies identified some major difficulties of teachers (e.g., Capps & Crawford, 2013; Kim & Tan, 2011; Nivalainen et al., 2013; Nowicki et al., 2013; Yoon et al., 2012) and students (e.g., Lee et al., 2006; Sadaghinai, 2008) in science inquiry activities, more work is needed to take some precautions in pre-service education. Assuming that determining the difficulties that PSTs face in science inquiry activities can contribute to have more qualified future science teachers, this study tries to determine PSTs' difficulties in performing guided-inquiry based electricity experiments.

Furthermore, perceptions of students, teachers or pre-service teachers about the laboratory can hinder their adaptation to inquiry activities. It can be claimed that two dominant perceptions exist in current literature. First one views the laboratory as a place where the theoretical knowledge is confirmed (Hanif, Sneddon, Al-Ahmedi & Reid, 2009; Tsai, 2003) and the other one views it as a place promoting students' skills and encouraging group works (Blue & Jacob, 2009). Considering the laboratory as a place where the theoretical knowledge is confirmed can be an obstacle in front of PSTs to implement guided inquiry electricity experiments properly. Therefore, eliciting also PSTs' perceptions about physics laboratory can help to better understand the difficulties. To be able to identify PSTs' difficulties in guided inquiry-based electricity experiments and their perceptions about physics laboratory the following research questions were prepared;

- What are the difficulties that PSTs face in the guided inquiry-based electricity experiments?
- What are the perceptions of PSTs about physics laboratory?

Method

Sample

A total of 80 PSTs (Male=28, Female=52) from one of the universities in the eastern region of Turkey participated in this study. Convenience sampling procedure (Fraenkel & Wallen, 2005) was used in selecting the participants. They performed some guided inquiry-based electricity experiments in the study. These experiments were performed by considering the requirements of "Physics Lab II" course. In the course, students are required to attain some basic skills and knowledge about constructing electric circuits, and understanding the relationships among elements of electric circuits (i.e., current, voltage, resistance). All the participants of this study also carried out some physics experiments related to mechanics in the compulsory course of "Physics Lab I" previous semester. Therefore, all were a bit familiar to perform physics experiments.

Guided Inquiry-Based Electricity Experiments

Four sections were opened to perform the guided inquiry-based electricity experiments in Physics Lab II course. Each section consisted of 20 PSTs. The participants in each section were divided into five groups and each group performed a different experiment in one week. They were only responsible for their own experiment. They were not allowed to interact with other PSTs in each section. Each group in each section completed five experiments during five weeks.

Before PSTs had begun to perform their experiments, in the first week of the lab session, they were informed about how they would carry out the inquiry activities. In this week, the aims of inquiry activities, students' and teachers' roles in the activities, the process in the activities and some advantages of the activities were mentioned. In addition, the lab materials of each experiment were presented to them by the course teacher (researcher of this study) in this week. Which purposes these lab materials are used was described. Why they would use the multimeter, power supply and resistance wire apparatus (the apparatus including some resistance wires having different resistivity and thickness) was explained before they had begun to perform the experiments. However, the working principles of such devices and the procedure of the experiments were not explained. It was expected that PSTs could learn how these devices work by exploring them and set up their own experimental designs. Only one question for each experiment was asked to PSTs in each group. They tried to answer this question by setting up their experiments. Furthermore, scaffolding was not forgotten while the participants were doing their experiments. When they could not be successful in performing the experiments, some suggestions were given and some questions were asked to them. Some suggestions such as *"connect the wires by changing the place of ammeter and take your measurements again and if you do not reach your aim, consider other variations"*, and *"change the sensibility of multimeter to able to read current values"* were given. Some questions such as *"are you sure that you have connected the voltmeter correctly"*, and *"why do you connect the wires like this"* were also asked.

The aims of the five experiments were to develop PSTs' inquiry skills and help them understand the basic principles of simple electric circuits. Table 1 presents the aim of each experiment and the lab materials used in each experiment.

Table 1

The Aims of Guided Inquiry-Based Electricity Experiments and the Lab Materials Used in the Experiments

Experiments	The aims	The lab materials
1st experiment	To compare the resistance values of three different resistors after finding their values using the multimeter and resistor color code table	Power supply, connecting wires, multimeter, resistor color code table
2nd experiment	To explore that the current values change when the resistance of the rheostat change	Power supply, connecting wires, multimeter, rheostat
3rd experiment	To explore that the current values on the resistances change when they are connected as series and parallel	Power supply, connecting wires, multimeter, three resistances having same magnitude
4th experiment	To explore that the brightness of the bulbs change when they are connected as series and parallel	Power supply, connecting wires, three bulbs having same resistances
5th experiment	To explore that the current value on the resistance wire depends on the length, thickness and resistivity of it	Power supply, connecting wires, multimeter, resistance wire apparatus

In addition, it was expected that students would acquire some inquiry skills such as hypothesizing, controlling the variables, collaborating with the friends, and evaluating their results in these experiments. Some questions were also asked to PSTs to guide them to design their own experiments (see Appendix).

Data Collection

Qualitative research methods interviews and observations were mainly used in data collection (Fraenkel & Wallen, 2005). In addition an open-ended questionnaire was administered to PSTs. They responded the questions in an open-ended questionnaire after the experiments were finished. Then, eleven of them were selected for the interviews. Voluntariness of them was taken into account in this selection. The same questions in an open-ended questionnaire were asked to them in the interviews to attain more information and valid results. Each interview last approximately 5-15 minutes and was audiotaped. In addition to them, each laboratory session was observed and field notes were taken for each week. During the observations, all PSTs' talks were tried to listen by walking around them in the laboratory. Some of the conservations among them were noted after the laboratory session. Particularly the difficulties that they faced in carrying out the experiments were noted. The following questions were asked to PSTs in an open-ended questionnaire and the interview:

- What were the difficulties that you faced in performing the experiments? Please explain the reasons of these difficulties.
- What is the meaning of the physics laboratory according to you?

Data Analysis

Qualitative data analysis as suggested by Miles and Huberman (1994) was used. According to them, *data reduction*, *data display*, and *conclusion drawing and verification* are parts of this analysis. In addition, all the data collected in this study was analyzed by content analysis (Fraenkel & Wallen, 2005). First of all, the first research question that concerned with PSTs' difficulties in guided inquiry based physics experiments was answered. To be able to answer this question all the data obtained from open-ended questionnaire, interview and field note were used. Firstly, the data obtained from the open-ended questionnaires of PSTs were analyzed. According to the responses of PSTs to the open ended-questions, some categories and codes were constructed for data reduction as suggested by Miles and Huberman (1994). However, limited number of the categories and codes were identified in PSTs' responses to these questions. Therefore, the data obtained from interviews and field notes were also used to identify some extra codes and categories. Miles and Huberman (1994) also proposed some tactics such as 'clustering', and 'triangulation' for drawing conclusions and verification. In this regard, the codes were first clustered under the categories. For the triangulation, the findings obtained from the open-ended questionnaires, interviews and field notes were compared with each other. To be able to triangulate the data interviews conducted with PSTs were first transcribed into documents. Then, some field notes that taken during the data collection were taken into consideration. Some important points that planned to use in presenting the data were identified in these data sources. Some statements/dialogs in the open-ended questionnaires, transcribed interviews and field notes were used in presenting the results. Therefore, trustworthiness of the results was also achieved as suggested by Lincoln and Guba (1985).

Five categories and some codes such as 'task-sharing', 'knowledge transfer', and 'observing the teachers' were identified to be able to answer the first research question of this study (see Table 2). In addition, the category names representing the codes in this study were also used by some other researchers in the literature. The category names: low-level collaboration (Hubbard & Abell, 2005; Lee et al., 2006), previous learning experiences (Sadaghinai, 2008), insufficient knowledge (Kim & Tan, 2011; Yoon et al., 2012), insufficient inquiry skills (Kim & Tan, 2011; Lee et al., 2006; Yoon et al., 2012) and poor adaptation (Campbell et al., 2011; Duran et al., 2004; Forbes, 2013) were discussed in the literature before. Table 2 presents the conceptualization of each category representing the difficulties that PSTs have faced in the guided inquiry-based physics experiments.

Table 2

Conceptualization of Each Category Representing the Difficulties that PSTs Have Faced in the Guided Inquiry-Based Physics Experiments

Category	Conceptualization
Difficulties due to low-level collaboration	Facing difficulties in task-sharing, knowledge transfer, valuing others' ideas, listening to the friends
Difficulties due to previous learning experiences	Facing difficulties due to performing cookbook-style experiments, observing the experiments that teachers performed, doing the experiments by imitating the teachers
Difficulties due to insufficient knowledge	Facing difficulties in having sufficient physics content knowledge, physics lab materials, inquiry activities
Difficulties due to insufficient inquiry skills	Facing difficulties in hypothesizing, testing the ideas, experimenting, discussing the findings
Difficulties due to poor adaptation	Facing difficulties in getting rid of previous learning habits, concentrating on the activities, being interested in the activities

Furthermore, to be able answer the second research question that was about PSTs' perceptions about physics laboratory similar data analysis strategy as in the first question was used. However, the main data source to be able to identify the perceptions was an open-ended questionnaire. Interviews were only used to confirm the results obtained from the open-ended questionnaires for more valid results. As suggested by Miles and Huberman (1994) to achieve also more valid results the number of students who had different perceptions was counted. PSTs' perceptions about physics laboratory were categorized as *quantitative* and *qualitative* that similar to Tsai's (2004) classifications. In Tsai's (2004) work quantitative view of learning includes acquiring information in memory by memorizing the fact, solving some problems and calculating while qualitative view of learning concerns with understanding the phenomena, applying the knowledge that acquire to new situations and having different perspectives in analyzing the knowledge. In this study, by inspiring the Tsai's (2004) work students' perceptions about physics laboratory were categorized as quantitative and qualitative. While the quantitative perceptions concern with PSTs' knowledge confirmation in the laboratory, the qualitative conceptions relate to knowledge construction in the laboratory. In Table 3, conceptualization of PSTs' perceptions about physics laboratory is presented.

Table 3

Conceptualization of PSTs' Perceptions about Physics Laboratory

Category	Conceptualization
Quantitative perceptions	Viewing physics laboratory as a place where the theoretical physics knowledge is confirmed, the physics experiments are performed
Qualitative perceptions	Viewing physics laboratory as a place in which some physical phenomena are discovered, daily life and physics knowledge are interrelated, group studies and discussions are conducted

Reliability of the findings was also tested by requesting a second person to confirm the categories and codes found in the study by considering the suggestions of Silverman and Marvasti (2008). A second person having a PhD degree analyzed some of the results obtained from the data sources. After the discussion of the results, it was agreed on the names and numbers of the codes and categories. Agreed codes' and categories' names were presented in this study. Firstly, the author of this study analyzed all the data. Then he requested a second person to analyze 10 open-ended questionnaires, one interview transcript and one field note. Three were no inconsistencies between the author and the second person in terms of the number of the categories and codes that were suggested. Sometimes name of the categories or codes identified by them are different from each other but they all refer to same meaning. The best names that they believed to reflect the difficulties that PSTs have faced in the guided inquiry-based physics experiments and the perceptions about physics laboratory were used.

Results

In presenting the results, some example quotes were taken from the open-ended questionnaires, interviews and field notes. These quotes were represented with some labels; i.e., I18 refers to interview response of 18th PST, OQ70 refers to open-ended questionnaire response of 70th PST and FN2 refers to field note of second week.

Difficulties that PSTs Face in Performing Guided Inquiry-Based Electricity Experiments

PSTs' difficulties in the experiments were categorized into five major categories. The first one was about collaboration among PSTs while performing the activities, the second one was concerned with previous learning experiences of PSTs, the third one was related to PSTs' sufficient knowledge about physics and physics lab materials, the fourth one was concerned with PSTs' sufficient inquiry skills and the final one was about adaptation of PSTs to the activities.

Difficulties due to low-level collaboration

The majority of PSTs faced difficulty in sharing the tasks. One or two PST(s) mostly tried to perform the experiments in each group. They behaved liked a leader of the group. Others did not appraise the leaders' ideas and they accepted them without questioning. They usually waited the leaders to finish the experiment. Their roles in the experiments were passive. Although they accomplished some tasks (e.g., reading the values on the ammeter or voltmeter, and connecting the wires) given to them by the leaders of the group, there was no knowledge transfer among students in terms of relating their experiments to theoretical backgrounds. Below example quote from the field note illustrates this weak collaboration among PSTs;

> *"In the experiment III, only two students have performed the experiment. Others only listened to these students' ideas and supported these ideas. In this situation, I ("I" refers to researcher of this study) asked the students ("the students" refers to PSTs who only observed the experiments that performed by their friends) that what they thought about connection of wires to resistances. The answer was amazing. They said that they ("they" refers to PSTs who performed the experiment) did not listen to us and they behaved according to their thoughts. Therefore, I advised students to value the ideas. However, the two students who were carrying out the experiment said that they ("they" refers to PSTs who only observed the experiments that performed by their friends) always made mistakes when they set up their experiments according to their own ideas." (FN2)*

Similar ideas were also indicated in the interview with one PST. He said that only one or two PST(s) carried out the experiments. Others only observed what was done in the experiment. Therefore, they faced difficulty in understanding what had been done in the experiments. The following example quote from the interview with one PST illustrates the difficulty;

> *"In the experiment that is about the brightness of bulbs, we were angry with Arda ("Arda" refers to pseudonym of one PST in the group). He behaved like a boss of us and always praised himself. He did not listen to our ideas. Although he was successful in performing the experiment, he also should help us understand the experiments." (I18)*

The major difficulty in performing the experiments among some PSTs was about their insistence on the correctness of their own ideas. Therefore, some PSTs did not allow other students to test their ideas on the experiment. Although their ideas were mostly correct, others' motivation and concentration on the experiment have decreased due to these behaviours. Therefore, they sometimes had difficulty in following what was done in the experiment. Moreover, the majority of PSTs did not know how to share their ideas. For example, they immediately began to perform the experiment according to the ideas that came to their mind. They did not explain the ideas to others. They were carrying out the experiment silently without explaining their acts to reach the aims of the experiment.

Difficulties due to past learning experiences

Past learning experiences of PSTs in the elementary and high schools influenced their performances in carrying out the experiments. The majority of PSTs experienced more cookbook-style experiments that include previously-defined procedures. They also only observed the experiments that were performed by the teachers or they performed the experiments after observing the experiments by imitating the teachers. Therefore, they expected more assistance from the teacher of the lesson. An example quote from the interview with one PST that illustrates the past learning experience of him in the physics laboratory is as follows;

> *"We have carried out the experiments by observing our teachers' actions in the laboratory up to now. He/she performed the experiments and did not give us much responsibility. We only observed them. However, your position in performing the experiments was rather different. At the beginning, I did not like the method that you used. I believed that it was difficult to perform the experiments without your much help. However, we could reach the aims of the experiments after testing different ways to perform them. I realized that I had learned more things." (I45)*

Similarly, some PSTs also complained about the amount of assistance given to them by the instructor. Their expectation was that the teacher (researcher of this study) solved the problems about the experiment by performing them. They sometimes said to the teacher that *"we could not perform the experiments please could you demonstrate how to perform them"* during the experiments. Instead of requesting some hints, they insisted that the teacher should demonstrate the experimental procedure to them. Their wish from the teacher was that he could act like their previous lab teachers. Below example dialog between the teacher and PSTs while they were performing the experiment shows the difficulty that based on their past lab experiences;

> ***PSTs:*** *Teacher! We have not measured the resistances of resistance by using this tool ("tool" refers to multimeter).*
> ***The teacher:*** *Have you adjusted your multimeter to measure the resistance? Perhaps, it can be adjusted for measuring current or voltage.*
> ***PSTs:*** *Yes. But, it cannot measure.*
> ***The teacher:*** *It is probable that you are measuring them in low sensibility. Please adjust sensibility.*
> ***PSTs:*** *Puff! We cannot do it.*
> ***PST (1):*** *Everything was better before. The teachers (teachers refer to previous teachers of PSTs) did everything in the lab and we did not make an effort so much. (FN1)*

During the experiments, some PSTs expected that the teacher could show them how the experiments were done. However, this expectation was not met by the teacher. Fortunately, the majority of PSTs were aware that they learned more due to inquiry experiments. Therefore, they respected this learning process. They tried to reach correct electric circuits patiently.

Difficulties due to insufficient knowledge

Some of PSTs primarily did not have sufficient background of physics knowledge. Their physics content knowledge was poor. They did not have sufficient knowledge about some basic concepts such as voltage, current and resistance. This was an obstacle in front of them to carry out the experiments effectively. For example, not having sufficient knowledge about potential difference on the resistances and distribution of currents on the resistances influenced students' success in the experiments. The following quote from the dialog between PSTs and the teacher illustrates the influence of insufficient knowledge about physics on PSTs' understanding of the electric circuits;

> ***The teacher:*** *What do you think about the distribution of currents on the circuit? Have you ever heard what the total current means?*
> ***PST (1):*** *I do not have any idea.*
> ***PST (2):*** *Yes, I have heard the total current. It is a current that power supply produces. But, I do not know how the currents are distributed on the resistances. (FN4)*

Some PSTs also did not have a deep understanding about how some devices such as multimeter and power supply work. Although they had a superficial knowledge about them, they had difficulty in using them. For example, some of PSTs made some mistakes in connecting the wires to power supply. Instead of connecting the wires to only DC output of power supply, they sometimes connected one wire to DC output, and another one to AC output. In addition, their unsuccessfulness in adjusting the right scale to measure current, voltage or resistance lead them to take wrong measurements or fail to achieve the experiments. These devices' fuses also sometimes blew due to wrong connections. Therefore, they sometimes could not accomplish the aims of some experiments. Although PSTs perceived these events as difficulties in front of performing the experiments, they constructed right circuits by trying different alternatives at the end. Some example quotes that illustrate PSTs' perceived difficulties to perform the experiments are as follows;

> *"I always had difficulty in deciding which scale I will use in measuring the values of current, voltage or resistance. I confused them." (OQ4)*

> *"I could not understand how to use multimeter. I always adjusted the scale wrong. For example, I adjusted the voltage instead of the current while measuring the current. Therefore, multimeter showed the value of zero." (I4)*

Another difficulty that PSTs faced in the experiments was that some did not understand the philosophy underlying guided inquiry-based electricity experiments though how PSTs behave in the experiments was mentioned during one week in this study. It was expected that all PSTs should be mentally and physically active in the experiments. However, some seemed timid to perform the experiments. Some questions such as *"what happens when we change the voltage of the power supply", "what happens if we choose wrong scale on the multimeter"* and "*are the bulbs burned out if we do not connect the wires appropriately"* were frequently asked by PSTs during the experiments. They were always anxious about whether the tools were broken down. They did not know that they could only learn something by testing the alternatives as suggested in inquiry. Therefore, the teacher allowed them to test their all ideas on the experiments by considering security precautions.

Difficulties due to insufficient inquiry skills

Some PSTs did not have sufficient inquiry skills such as hypothesizing, controlling the variables, testing their ideas and experimenting. They could not propose some alternative ways to handle the problems that they faced in the experiments. They did not think and discuss the reasons of mistakes that they had made in carrying out the experiments. They immediately wanted the teacher to help them. Although the teacher gave some suggestions and clues to overcome the problem, their desire from the teacher was to set up the experimental design. Instead of testing the ideas by using these suggestions and clues, they chose the easy way that was finishing the experiments without reaching the aims of it. Below example quote from the field note illustrates the difficulty about testing the ideas by setting up the experiment;

The teacher: *What do you wait?*
PSTs: *We could not do it ("it" refers to connecting bulbs as parallel).*
The teacher: *What is the problem?*
PSTs: *The bulbs did not light.*
The teacher: *Did you try to connect the wires to bulbs after putting the bulbs as parallel on the table?*
PSTs: *No!*
The teacher: *Try it.*
PST (1): *Do not waste time in doing it, friends! We cannot do it. (FN2)*

In addition, when the teacher asked PSTs some questions such as *"why did you connect this wire like this"*, and *"what did you think when you set up your experiments"*, satisfactory answers were not given by some of them. This can indicate that they performed their experiments without much thinking. They only observed the values that they found in these experiments without discussing such values. Being not able to answer these questions can also indicate that PSTs could not hypothesize. In addition, though the circuits that PSTs set up were right, they sometimes could not observe the values on the multimeter and light the bulbs. Instead of controlling whether the bulbs worked or the wires were broken, they immediately began to set up a new experimental design. They could not discuss the possible problems and trust their experimental designs.

Difficulties due to poor adaptation

Past learning habits of some PSTs influenced their adaptation to the experiments. They used to set up the experiments by using clearly defined procedures. Because this strategy was not espoused in this study, they were sometimes discouraged while performing the experiments. They lost their interest in carrying out the experiments. Therefore, they began to be hasty to finish the experiments by considering the experiments as a burden on their shoulders. Instead of viewing these experiments as a learning process, they began to view them as unneeded. Thus, they could not completely concentrate on the experiments. For example, one PST believed that if someone had been always unsuccessful in reaching a solution, their desire to study on the problem decreased. After that, he/she could not adapt. Below quote from the interview with one PST illustrates the adaptation problem of her in performing the experiments;

> *"At the first, my concentration on the experiments was high. But, this changed as time goes by. I began to be bored in the experiments. We always faced different problems to overcome in each experiment. This ("this" refers to overcoming the problems) took much time. I did not want to struggle with these problems. For example, think one person who is always unsuccessful, how he/she can motivate him/herself?" (I27)*

Adapting some PSTs to inquiry experiments took some time. In the first weeks, they faced some difficulties in hypothesizing, testing the hypothesis, and discussing the ideas or results. However, the majority of PSTs internalized the inquiry experiments after performing one or two experiment(s). After that, during the experiments the questions coming from PSTs decreased and they began to more discuss their ideas and findings.

Perceptions of PSTs about Physics Laboratory

Considering that PSTs' perceptions can be an obstacle in front of them to perform the experiments, their perceptions about physics laboratory was also investigated. As discussed before, PSTs' perceptions about physics laboratory were categorized as quantitative and qualitative. 64 PSTs had quantitative and 12 PSTs had qualitative perceptions about physics laboratory. 4 PSTs did not indicate their ideas about physics laboratory in an open-ended questionnaire.

Quantitative perceptions about physics laboratory

PSTs mainly perceived the physics laboratory as a place where the theoretical physics knowledge was confirmed and as a place that consisted of some lab materials to perform the physics experiments. In fact, it can be claimed that these perceptions contradict with the requirements of inquiry. Therefore, these perceptions can be evaluated as obstacles to perform the experiments. The following example quotes illustrate the quantitative perceptions of one PST about physics laboratory;

> *"According to me, physics laboratory is a place consisting of some lab materials related to physics." (QQ70)*

> *"I think physics laboratory as a place consisting of some lab materials to perform the physics experiments. In there, students can consolidate their knowledge that was learned in physics classrooms." (I70)*

Experiencing more cookbook-style of physics experiments during past educational life can lead PSTs to have these perceptions. However, it is surprising that there are high numbers of PSTs having such conceptions after experiencing the inquiry experiments. This result can imply that PSTs can need to experience more experiments to have more qualitative perceptions about physics laboratory.

Qualitative perceptions about physics laboratory

Small number of PSTs perceived the physics laboratory where the physical phenomena were discovered, daily life and physics knowledge were interrelated and group studies were conducted. According to them, students can better learn when they perceive the laboratory as a learning environment that encourages them to construct their knowledge. The following example quotes illustrate the qualitative perceptions of one PST about physics laboratory;

> *"It ("it" refers to physics laboratory) means that we will discover something related to physics." (OQ61)*

> *"In the laboratory, students can discover everything. They can invent new things. It is a place in which new things are discovered. Now, scientists discover many things in the laboratories. All the drugs are produced in the laboratories and we use them." (I61)*

These perceptions can help PSTs acquire some skills indicated in inquiry. For example, PSTs who perceive the laboratory as a place in which they discover something might develop their creative and critical thinking skills more easily. In the discovery process, they might develop their imaginations. Furthermore, studying as a group and sharing the ideas in the laboratory might help PSTs develop more robust ideas. In this way, they could set up their experiments on the more logical basis. Thus, qualitative perceptions might be considered as more related to the inquiry activities. These might also be accepted as assistance factors to carry out the activities due to this close relationship.

Conclusions and Discussion

The results of this study showed that PSTs faced some difficulties in performing the experiments. Some of them could not appropriately connect the wires and use the multimeter. They thought these processes as very complex and difficult. Laboratory observations also showed that the majority of PSTs could not predict the results of the experiments. Therefore, they sometimes could not formulate logical hypotheses. Instead of trying to discover the relationships between current values and magnitude of the resistance in experiment II, in general their aim was only to find the values of the current using the multimeter without thinking deeply. They were not aware of the relationships between magnitude of resistance and current value. This result can also imply that PSTs were not able to use their higher order thinking skills such as analyzing and evaluating. This result was consistent with the findings of the study of Lee et al. (2006). They found that students faced difficulty in activating their higher order thinking skills. According to them, students were not successful in controlling the variables and hypothesizing that require higher order thinking skills. Thus, during inquiry activities teachers should be more careful in choosing the questions that guide students to develop their thinking skills. Even if students have reached correct solutions in the experiments, scaffolding as discussed by Liang and Richardson (2009) for better conceptual understanding should not be ignored in the activities.

The observations also pointed out that the main difficulty in front of PSTs to perform the experiments might be their timidity. As they indicated, their educational background had a serious influence on their performances in doing experiments. Because they could not perform any experiments based on inquiry in their high school years, they claimed that they had difficulty in adapting the experiments. Similar to this finding, some researchers (e.g., Campbell et al., 2011; Wee et al., 2007) also indicated that some adaptation problems of students in science inquiry activities was one of the major reasons of their unsuccessfulness in the activities. In this regard, increasing adaptation of students in the activities should be one of the main concerns of teachers. They should choose the activities that students should be more interested in and that were more related to students' daily life experiences.

Furthermore, some PSTs did not have sufficient knowledge about the lab materials and sufficient content knowledge about physics to be able to perform the experiments effectively. Although they improved their some knowledge about physics concepts related to electricity and lab materials due to the experiments, their deficient knowledge about them negatively influenced their performance at the beginning of the experiments. Some researchers (e.g., Kim & Tan, 2011; Nowicki et al., 2013) also found that teachers faced some difficulties in performing science inquiry activities due to students' lack of content knowledge. Similarly, the participants of this study faced some difficulties in performing the experiments due to their poor content knowledge about physics. Although science inquiry activities encourage students to explore some relations among scientific concepts (NRC, 2000), having a deep understanding of some concepts might be necessary for better conceptual understanding in the experiments. For example, in this study, some PSTs faced difficulty in explaining some basic concepts such as current and voltage. In addition, they did not have a deep understanding about the function of resistance in the circuit. Therefore, before beginning to science inquiry activities, teachers should help students learn some basic concepts deeply.

Some PSTs also did not have enough competencies to use some devices such as multimeter and power supply. They could not overcome the problems about these devices. Fuses of these devices sometimes blew due to wrong connection of connecting wires. Although PSTs were informed about this problem before they had begun to perform the experiments, they sometimes faced difficulty in replacing new fuse. The teacher helped them replace it. Another difficulty that PSTs faced was that they could not understand the philosophy underlying the experiments. Some of PSTs expected the teacher to demonstrate them complete circuit. This can imply that PSTs did not have complete knowledge about science inquiry experiments. Yoon et al. (2012) also emphasized this problem and indicated that insufficient knowledge about implementation of inquiry activities could lead these activities to not reach their aims. Though PSTs were informed about how to perform experiments considering science inquiry approach in this study, they faced these problems. Therefore, increasing the duration of time in teaching students how the science inquiry activities are performed should be necessary to increase their adaptation to the activities. More importance should be given to teaching of science inquiry activities' benefits.

PSTs' perceptions about physics laboratory were also investigated in this study. Many of PSTs hold the perceptions about the physics laboratory more based on making students passive in learning mentally. They mostly viewed physics laboratory as a place where the theoretical physics knowledge was confirmed. This perception was also reported by some researchers (e.g., Blue & Jacob, 2009; Hanif et al., 2009; Tsai, 2003). However, this study was different from them because the perceptions of PSTs were identified after the guided inquiry-based electricity experiments. Although the perceptions of PSTs which they hold before and after they performed the experiments could not be compared in this study, existence of a great number of the perceptions more based on teacher-centered had a serious importance. It was expected that PSTs could have more student-centered perceptions related to the physic laboratory after experiencing the experiments. Additionally, some of PSTs viewed the physics laboratory as a place where the physics knowledge was discovered and discussed. This result was also consisted with the finding of some researchers (e.g., Blue & Jacob, 2009; Tsai, 2003).

According to results of this study, it might be asserted that PSTs cannot be completely ready to implement renewed science education curriculum of primary and elementary schools. They faced lots of difficulties in performing the guided inquiry-based electricity experiments and their previous learning experiences and poor knowledge about physics had a serious impact on their successfulness in the experiments. Due to these reasons, they might face serious problems in performing inquiry-based activities when they begin to their professional life. Therefore, preparing them to future professional life gains more importance due to the emphasis on the inquiry-based activities in the current renewed curriculum. Exploring some solution ways to overcome these difficulties can be main concern of educators in Turkey. Putting the courses explaining the importance and theoretical background of the inquiry-based learning, and performing the lab activities using inquiry can help science instructors in the universities overcome these problems. However, giving this responsibility to expert educators about the inquiry-based learning cannot be disregarded. As Yoon et al. (2012), and Capps and Crawford (2013) indicated, students who perform the inquiry activities with the help of instructors that have a poor knowledge about inquiry cannot be successful in carrying out the experiments.

It was obvious that some professional development programs related to inquiry-based activities had a positive influence on the development of more student-centered beliefs (Hutchins & Friedrichsen, 2012; Pilitsis & Duncan, 2012). Therefore, increasing the number of studies aiming to develop PSTs' science inquiry skills should be necessary. Conducting particularly the lab courses about physics, chemistry, and biology considering inquiry activities should help them view science learning as more student-centered. If they experienced the activities, they can internalize them, and then they might teach science contents by using inquiry activities when they will begin to their professional life.

References

Anderson, R. D. (2002). Reforming science teaching: what research says about inquiry. *Journal of Science Teacher Education, 13*(1), 1-12.

Areepattamannil, S. (2012). Effects of inquiry-based science instruction on science achievement and interest in science: evidence from Qatar. *The Journal of Educational Research*, *105*(2), 134-146.

Banchi, H., & Bell, R. (2008). The many levels of inquiry. *Science and Children, 46*(2), 26-29.

Banerjee, A. (2010). Teaching science using guided ınquiry as the central theme: a professional development model for high school science teachers. *Science Educator, 19*(2), 1-9.

Bell, R. L., Smetana, L., & Binns, I. (2005). Simplifying inquiry instruction. *The Science Teacher, 72*(7), 30-33.

Bhattacharyya, S., Volk, T., & Lumpe, A. (2009). The influence of an extensive inquiry-based field experience on pre-service elementary student teachers' science teaching beliefs. *Journal of Science Teacher Education, 20*(3), 199-218.

Blue, J., & Jacob, J. (2009). Student perceptions of an introductory physics course. *Proceedings of the 2009 Physics Education Research Conference.* (pp. 101-04). AIP Press

Brown, S. L., & Melear, C. T. (2006). Investigation of secondary science teachers' beliefs and practices after authentic inquiry-based experiences. *Journal of Research in Science Teaching, 43*(9), 938-962.

Campbell, T., Zhang, D., & Neilson, D. (2011). Model based inquiry in the high school physics classroom: an exploratory study of implementation and outcomes. *Journal of Science Education and Technology, 20*(3), 258-269.

Capps, D. K., & Crawford, D. A. (2013). Inquiry-based instruction and teaching about nature of science: are they happening? *Journal of Science Teacher Education, 24*(3), 497-526.

Choi, S., & Ramsey, J. (2009).Constructing elementary teachers' beliefs, attitudes, and practical knowledge through an inquiry-based elementary science course. *School Science and Mathematics, 109*(6), 313-324.

Duran, L. B., McArthur, J., & Van-Hook, S. (2004). Undergraduate students' perceptions of an inquiry-based physics course. *Journal of Science Teacher Education 15*(2), 155-171.

Duran, E., Ballone-Duran, L., Haney J., & Beltyukova, S. (2009). The impact of a professional development program integrating informal science education on early childhood teachers' self-efficacy and beliefs about inquiry-based science teaching. *Journal of Elementary Science Education, 21*(4), 53-70.

Fraenkel, J. R., & Wallen, N. E. (2005). *How to design and evaluate research in education* (3rd ed.). New York: McGraw-Hill.

Forbes, C. T. (2013). Curriculum-dependent and curriculum-independent factors in preservice elementary teachers' adaptation of science curriculum materials for inquiry-based science. *Journal of Science Teacher Education, 24*(1), 179-197.

Hanif, M., Sneddon, P. H., Al-Ahmedi, F. M., & Reid, N. (2009). The perceptions, views and opinions of university students about physics learning during undergraduate laboratory work. *European Journal of Physics, 30*(1), 85-96.

Herron, M. D. (1971). The nature of scientific enquiry. *School Review*, *79*(2), 171-212.

Hofstein, A., & Lunetta, V. N. (1982). The role of the laboratory in science teaching: neglected aspects of research. *Review of Educational Research, 52*(2), 201-217.

Hofstein, A., & Lunetta, V. N. (2004). The laboratory in science education: foundations for the twenty-first century. *Science Education, 88*(1), 28-54.

Hubbard, P., & Abell, S. (2005). Setting sail or missing the boat: comparing the beliefs of preservice elementary teachers with and without an inquiry-based physics course. *Journal of Science Teacher Education, 16,* 5-25.

Hutchins, K., L., & Friedrichsen, P. J. (2012). Science faculty belief systems in a professional development program: inquiry in college laboratories. *Journal of Science Teacher Education*, *23*(8), 867-887.

Kim, M., & Tan, A. -L. (2011). Rethinking difficulties of teaching inquiry-based practical work: stories from elementary pre-service teachers, *International Journal of Science Education, 33*(4), 465-486

Lee, O., Buxton, C., Lewis, S., & LeRoy, K. (2006). Science inquiry and student diversity: enhanced abilities and continuing difficulties after an instructional intervention. *Journal of Research in Science Teaching, 43*(7), 607-636.

Liang, L. L., & Richardson, G. M. (2009). Enhancing prospective teachers' science teaching efficacy beliefs through scaffolded, student-directed inquiry. *Journal of Elementary Science Education, 21*(1), 51-66.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic Inquiry*. Beverly Hills, CA: Sage Publications

Magee, P. A., & Flessner, R. (2012). Collaborating to improve inquiry-based teaching in elementary science and mathematics methods courses. *Science Education International, 23*(4), 353-365.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis. (2nd ed.)* California: Sage Publications.

Ministry of National Education [MoNE] (2006). Elementary School Science and Technology Curriculum.

Ministry of National Education [MoNE] (2013). Primary and Elementary Schools Science Curriculum.

National Research Council [NRC]. (1996). National science education standards. Washington, DC: National Academic Press.

National Research Council [NRC]. (2000). Inquiry and the national science education standards: A guide for teaching and learning. Washington, DC: National Academy Press.

Nivalainen, V., Asikainen, M. A., & Hirvonen, P. E. (2013). Open guided inquiry laboratory in physics teacher education. *Journal of Science Teacher Education, 24*(3), 449-474.

Nowicki, B. L., Sullivan-Watts, B., Shim, M. K., Young, B., Pockalny, R. (2013). Factors influencing science content accuracy in elementary inquiry science lessons. *Research in Science Education, 43*(3), 1135-1154.

Pilitsis, V., & Duncan, R. G. (2012). Changes in belief orientations of preservice teachers and their relation to inquiry activities. *Journal of Science Teacher Education, 23*(8), 909-936.

Rushton, G. T., Lotter, C., & Singer, J. (2011). Chemistry teachers' emerging expertise in inquiry teaching: the effect of a professional development model on beliefs and practice. *Journal of Science Teacher Education, 22*(1), 23-52

Sadaghinai, H. R. (2008). Physics by inquiry: addressing student learning and attitude. *Proceedings of the 2008 Physics Education Research Conference.* (pp. 191-94). AIP Press

Silverman, D., & Marvasti, A. (2008). *Doing qualitative research: A comprehensive guide.* Los Angeles, CA: Sage Publications.

Steinberg, R., Wyner, Y., Borman, G., & Salame, I. I. (2015). Targeted courses in inquiry science for future elementary school teachers. *Journal of College Science Teaching, 44*(6), 51-56.

Tatar, N. (2012). Inquiry-based science laboratories: an analysis of preservice teachers' beliefs about learning science through inquiry and their performances. *Journal of Baltic Science Education, 11*(3), 248-266.

Tsai, C., - C. (2003). Taiwanese science students' and teachers' perceptions of the laboratory learning environments: exploring epistemological gaps. *International Journal of Science Education, 25*(7), 847-860.

Tsai, C., -C. (2004). Conceptions of learning science among high school students in Taiwan: a phenomenographic analysis. *International Journal of Science Education, 26*(14), 1733-1750.

Yoon, H. - G., Joung, Y. J., & Kim, M. (2012). The challenges of science inquiry teaching for pre-service teachers in elementary classrooms: difficulties on and under the scene. *Research in Science Education, 42*(3), 589-608.

Wee, B., Shepardson, D., Fast, J., & Harbor, J. (2007). Teaching and learning about inquiry: insights and challenges in professional development. *Journal of Science Teacher Education, 18*(1), 63-89.

Wenning, C. J. (2005). Levels of inquiry: hierarchies of pedagogical practices and inquiry processes. *J. Phys. Tchr. Educ. Online 2*(3), 3-12.

APPENDIX

Please design experiment I by considering the following question;

- Find the values of the resistors' resistances by using the multimeter first, and then resistor color code table. Compare the values that were found according to the multimeter and resistor color code table.

Please design experiment II by considering the following question (please perform this experiment under the constant voltage);

- Explain that how does the current value change when you increase the resistance of the rheostat first, and then decrease it.

Please design experiment III by considering the following question (please perform this experiment under the constant voltage);

- Explore whether the difference between the current values of the three resistances having the same magnitude in the circuits that you have constructed as series and parallel respectively exists. If the difference exists, explain it.

Please design experiment IV by considering the following question (please perform this experiment under the constant voltage);

- Observe whether the difference between the brightness of the three bulbs having the same resistance in the circuits that you have constructed as series and parallel respectively exists? If the difference exists, explain it.

Please design experiment V by considering the following question (please perform this experiment under the constant voltage);

- Explore the current value change when you double the length of the resistance wire on the resistance wire apparatus. Explore the current value change when you change the thickness of the resistance wire on the resistance wire apparatus. Explore the current value change when you change the resistivity of the resistance wire on the resistance wire apparatus. Explain the relationship among length, thickness, and resistivity of the resistance considering your findings.