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# Anxieties, preferences, expectations and opinions of pre-service teachers related to physics laboratory

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**Science anxiety, which is one of the affective dimensions in science learning, is one of the factors affecting success in Science and has been studied for 35 years. The existence of considerable negative attitudes towards Physics courses, which is one of the basic branches of Science, is a fact. This research has been designed to identify the anxiety of Physics pre-service teachers related to the physics laboratory, the difficulties experienced by them in physics laboratory environment, their expectations from the environment, their preferences and opinions about physics laboratory. Thus triangulation approach, where quantitative and qualitative methods are used together, was preferred. Scanning method was employed in order to research the anxiety of pre-service teachers about physics laboratory. In accordance with this purpose, "Physics Laboratory Anxiety Scale" was developed and conducted on 245 pre-service teachers. Moreover, 20 pre-service teachers randomly selected from the sample in which the scanning model was employed were interviewed. The research results show that most of pre-service teachers are concerned about physics laboratory applications in terms of drawing graphs and using materials. Besides, they have constant anxiety concerning physics laboratory. They have difficulty in understanding the purpose of an experiment and converting units. Pre-service teachers prefer to practise physics laboratory applications in groups, as they do not feel confident while studying in the physics laboratory individually. They reported that they would rather theoretical physics courses than physics laboratory applications. It is also found that males were more anxious than females.**

**Key words:** Physics laboratory, anxiety, physics anxiety, affective learning, pre-service teachers.

## INTRODUCTION

Physics is a field of science that has an importance in technology, which makes life easier, by discovering, explaining causes and effects of natural events and using this information. In this respect, physics teaching must be provided in a qualified manner. However, the studies investigating the attitudes of students towards physics courses have shown that physics is a subject that students dislike, fear and find difficult. PISA 2006 (cited in Balım et al., 2009) (Programme for International Student Assessment) study shows that subjects of physics are the subjects of science in which students are the least interested. Also, the researches done in England, Norway and Nigeria within SAS Study (Science and Scientists) researches express that biology subjects are popular between students, and chemistry is frequently mentioned, but physics is not popular(Awar et al., 2011). In their researches conducted in Australia, America and Cyprus, Papanastasiou and Michalinos (2004) determined that biology is liked more than chemistry, and chemistry is liked more than physics. They also determined that there is a positive relationship between liking biology and chemistry, but liking physics has a negative relationship.

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The results of TIMSS 1999 (cited in Martin et al., 2000) (Trends in International Mathematics and Science Study) discovered that 8th grade students show the most positive attitudes towards biology, and then chemistry follows biology and physics comes last (Martin et al., 2000). According to the results of TIMSS 1999, it is seen that positive attitude rates of three fields have increased, biology takes the first place again and the attitudes towards chemistry and physics lessons are at the same level (Awar et al., 2011). Williams et al. (2003) determined that the dominant thoughts among secondary education students about physics imply that physics is difficult and boring. The "difficult" image related to physics has been reported for many times in the literature (Ahlgren and Walberg, 1973; Ford, 1989; Hewitt, 1990; Kessels et al., 2006; Oon and Subramaniam, 2011). Students find physics difficult because they have to cope with many demonstrations in different forms such as experiments, graphs, formulas, calculations, conceptual explanations, and convert them into each other (Redish, 1994; Dolin, 2002).

Students find physics difficult and boring but at the same time, they find it interesting and important (Angell et al., 2004; Nalçacı et al., 2011). Similarly, when the studies conducted on attitudes towards Physics laboratory are examined, it is seen that students generally believe that physics laboratory is important in learning physics, and it is necessary to spare more time for physics laboratory (Dilber et al., 2006; Uluçınar et al., 2004; Hanif et al., 2009; Hofstein and Lunetta, 2004; Lazarowitz and Tamir, 1994; Taşlıdere and Korur, 2012). However, it is observed that laboratory method whose necessity is accepted is not applied as required and there are various obstacles to achieving expected targets. Negative situations, which decrease the performance of physics laboratories, have been identified as inadequate lesson length, inefficient equipment, inadequate in-service training of teachers, the anxiety of students about preparation for university entrance exams, crowded classroom environments, intensive curriculum (Bozdoğan and Yalçın, 2004; Çepni et al., 1995, 2005). The variables associated with students have effects on the performance of laboratory applications as well as the laboratory environment (Uluçınar et al., 2004). Affective dimensions such as anxiety, attitudes, and self-efficacy are other significant factors affecting student performances in laboratory environments (Bowen, 1999). When a student enters into the laboratory environment, s/he may feel anxious by the effect of different stimuli, even though this student never feels anxious in science courses (Azizoğlu and Uzuntiryaki, 2006).

When anxiety, which is one of the variables affecting learning competence, is at a high level, it affects learning negatively, on the other hand, anxiety at a very low level makes learning difficult (Selçuk, 1996). The conducted researches show that anxiety can enhance or decrease performance depending on the nature of the duty that would be carried out. Therefore, it is important to accept that anxiety may have positive or negative effects on learning and performance (Kurbanoğlu and Takunyacı, 2012). The relationship between anxiety and learning is similar to the relationship between motivation and success. If the issue being learned is simple and easy, high level of anxiety makes learning easier, but if the issue being learned is complicated and difficult, high level of anxiety makes learning difficult (Kaya and Varol, 2004).

Anxiety generally has two types, which are "state anxiety" and "constant anxiety". State anxiety reflects momentary feelings depending on the state, whereas constant anxiety reflects long-lasting feelings that appear formerly. State anxiety is similar to kinetic energy; constant anxiety is similar to potential energy. Like kinetic energy, state anxiety is an event or reaction emerging at a particular time. On the other hand, constant anxiety is the tendency to give a certain reaction like potential energy (Öner and Le Compte, 1985). Researches show that constant anxiety affects success negatively, but state anxiety affects success positively. Both successful and unsuccessful students felt anxious about learning physics but successful students worried about not being able to learn the subject rather than failing the class. Unsuccessful students were not interested in learning the subject but they felt anxious about failing the class (Laukenmann et al., 2003; Azizoğlu and Uzuntiryaki, 2006).

While the level of achieving cognitive behaviours is controlled continually in school environments, affective behaviours cannot be both acquired and measured in a planned way. In fact, affective input traits have the capacity to explain twenty-five percent of variability in learning products. Therefore, achievement can be raised by making the affective input traits positive (Senemoğlu, 2005). It is possible to say that the functionality of education activities can be enhanced by placing more emphasis on the affective dimension, especially for those directed to cognitive targets (Gömleksiz and Kan, 2012). In order to make program development studies rational, it is significant to know students' thoughts about learning physics and motivational factors concerning learning physics (Özek et al., 1998). Once studies related to anxiety, which is one of the important affective traits for education, are examined, it is observed that the studies about maths anxiety and chemistry laboratory anxiety predominate. However, there are not enough studies focusing on physics laboratory anxiety of students. In this study, anxiety of pre-service teachers about physics laboratory and whether these anxieties changed by gender were investigated in order to fill the deficiency in this sense. Furthermore, the difficulties experienced in the physics laboratory, expectations from the environment, interest, desires and thoughts about the physics laboratory were researched by interviewing with pre-service teachers.

## Research questions

1. What is the level of pre-service teachers' anxieties about the Physics Laboratory?
2. Does the anxiety about the Physics Laboratory differentiate by gender?
3. What are the situations that pre-service teachers find difficult in the physics laboratory applications, their expectations from the laboratory environment, their preferences and thoughts about the physics laboratory?

## METHOD

The design of the research is based on triangulation approach. The main purpose of doing the research in accordance with triangulation approach is to present, analyse and gather events by using various methods (Green, 2005; Çepni, 2010). Qualitative and quantitative methods used in the research design, which is based on triangulation approach, have equal importance. The order of applications of the methods follows the quantitative method first and then continues with qualitative method. Scanning method was employed to research anxieties of pre-service teachers about the physics laboratory. For this purpose, "Physics Laboratory Anxiety Scale" was developed and conducted on 245 pre-service teachers. Moreover, 20 pre-service teachers randomly selected from the sample where the scanning model was employed were interviewed.

### Data collection tools

#### *Data collection tools used in the quantitative research*

In order to examine the anxieties of pre-service teachers about the Physics Laboratory, a scale that can be used to determine Physics laboratory anxieties of secondary education students and higher education students was developed. Primarily, an item pool associated with the laboratory anxiety was formed by scanning the relevant field literature and taking the opinions of experts and students during the scale development process. These items were conducted on 245 undergraduates attending the physics laboratory applications at Necmettin Erbakan University. Exploratory factor analyses, confirmatory factor analyses and reliability analyses of the collected data were done. In consequence of the necessary analyses, the item pool prepared for physics laboratory became a scale with 4-sub-dimensions including "Anxiety about finishing an experiment", "Anxiety about doing the experiment appropriately as intended", "Anxiety about using the materials in Physics laboratory", "Constant anxiety towards the physics laboratory" and 16 items. Three of the items include positive judgements and 13 items include negative judgements. Cronbach α value of the scale was computed as .87.

#### *Data collection tools used in the qualitative research*

In order to reveal the reasons of physics laboratory anxieties of pre-service teachers, semi-structured interviews were done with 20 pre-service teachers randomly selected from the same study group. The interviews lasted for 245 min in total.

Determining the participants randomly for the qualitative researches contributes to the enhancement of reliability in terms of research quality (Bouma and Atkinson, 1995). Therefore, the interviewed pre-service teachers were selected randomly. To provide the descriptive validity of the research, everything that is seen and heard must be reported (Maxwell, 1992). Thus, notes were taken meticulously during interviews and exact quotations from the statements of pre-service teachers were included in findings. In order to enhance the internal reliability of the research, it is necessary to deal with the participants whose opinions are employed as equal as possible and collect correct data from the applications as many as possible (Denzin and Lincon, 2000). Thus, some questions were asked to pre-service teachers in different ways in the interviews. Besides, opinions of the researcher were included in the research at the phase of reporting the results. On the other hand, it is important to determine the position of the researcher in the research process in order to provide external reliability of the research (LeeCompte and Goetz, 1982). The roles and responsibilities that the researcher took in the research can be stated as; designing, conducting and completing the research process; planning the application process, forming the application environment and conducting the application process; doing the required analyses and reporting findings and results, accordingly.

### Study group

The study group consisted of 245 pre-service teachers taking physics laboratory applications during the 2011 to 2012 academic year at Necmettin Erbakan University, Ahmet Keleşoğlu Faculty of Education, in Turkey. 77 of the pre-service teachers are studying at the Department of Physics, 30 of them are studying at the Department of Chemistry and 138 of them are studying at the Department of Science. Sixty-seven of the undergraduates forming the sample are male (27.3%), 178 of them are female (72.7%). Based on the deductive approach, Physics laboratory applications are conducted with pre-service teachers in groups. A two-hour-laboratory application is conducted weekly. In these applications, each group make different experiments by turns.

### Analysing data

To examine the anxieties of pre-service teachers about Physics Laboratory, frequency, percentage and mean values of the items in the scale and mean values of scale dimensions were computed by using Physics Laboratory Anxiety Scale. Whether the anxieties related to the Physics Laboratory differentiate by gender was investigated through the independent sample t test. The interviews were carried out by using a tape recorder. The answers of coded questions and the statements provided by each pre-service teacher were taken down. The answers of each question and the frequencies of these answers were transferred into the frequency table. Furthermore, exact quotations taken from the statements of some pre-service teachers were included.

## FINDINGS

### Findings of the quantitative research

First, the answers given to the scale items were evaluated in order to see to what extent pre-service teachers feel anxieties about Physics laboratory. Thus, frequency, percentage and mean values belonging to each item in the Physics laboratory anxiety scale and mean values belonging to each dimension of the scale were calculated. To evaluate these calculated values, the limits of the scale were determined. The interval width of the scale was computed to determine the limits of scale. The interval width of the scale is calculated by using a =

**Table 1.** Frequency, percentage and mean values belonging to the items in the Physics Laboratory Anxiety Scale and mean values of dimensions.

| S/N | | I totally disagree | | I disagree | | I am not sure | | I agree | | I totally agree | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | f | % | f | % | f | % | f | % | f | % | X |
| 1 | I am afraid of not being able to draw a conclusion from the data that I collect. | 47 | 19.2 | 94 | 38.4 | 26 | 10.6 | 43 | 17.6 | 35 | 14.3 | 2.69 |
| 2 | I am afraid that the data that I collect disagree with the physical hypothesis. | 29 | 11.8 | 96 | 39.2 | 43 | 17.6 | 47 | 19.2 | 29 | 11.8 | 2.79 |
| 3 | Not being able to reach the correct conclusion causes me stress. | 33 | 13.5 | 68 | 27.8 | 44 | 18.0 | 65 | 26.5 | 35 | 14.3 | 3.00 |
| 4 | I shrink from answering the questions related to the conclusion of the experiment. | 28 | 11.4 | 74 | 30.2 | 50 | 20.4 | 54 | 22.0 | 39 | 15.9 | 3.00 |
| 5 | I feel anxious about preparing a graphic with the data that I collect. | 17 | 6.9 | 49 | 20.0 | 40 | 16.3 | 81 | 33.1 | 56 | 22.9 | 3.45 |
| 6 | Being late with the experiment because of spoilt materials in the laboratory stresses me. | 41 | 16.7 | 101 | 41.2 | 35 | 14.3 | 43 | 17.6 | 24 | 9.8 | 2.62 |
| **1st DIMENSION:** Anxiety about finishing the experiment | | | | | | | | | | | | 2.92 |
| 7 | I am worried about determining the material required for the experiment. | 32 | 13.1 | 86 | 35.1 | 46 | 18.8 | 49 | 20.0 | 31 | 12.7 | 2.84 |
| 8 | I feel anxious about not being able to do the experiment appropriately. | 24 | 9.8 | 82 | 33.5 | 46 | 18.8 | 57 | 23.3 | 34 | 13.9 | 2.97 |
| 9 | I feel nervous about not being able to understand the purpose of the experiment clearly. | 25 | 10.2 | 100 | 40.8 | 37 | 15.1 | 53 | 21.6 | 29 | 11.8 | 2.84 |
| 10 | I feel worried as I am not sure whether I can do the experiment correctly or not. | 19 | 7.8 | 74 | 30.2 | 68 | 27.8 | 56 | 22.9 | 28 | 11.4 | 3.00 |
| **2nd DIMENSION:** Anxiety about doing the experiment as intended | | | | | | | | | | | | 2.91 |
| 11 | I can easily install the experimental set-up. | 99 | 40.4 | 97 | 39.6 | 22 | 9.0 | 20 | 8.2 | 6 | 2.4 | 1.92 |
| 12 | I am relaxed when I use the laboratory equipment | 63 | 25.7 | 95 | 38.8 | 61 | 24.9 | 13 | 5.3 | 9 | 3.7 | 2.21 |
| 13 | I can easily comment on graphics | 62 | 25.3 | 106 | 43.3 | 50 | 20.4 | 16 | 6.5 | 9 | 3.7 | 2.19 |
| **3rd DIMENSION:** Anxiety related to the use of materials in the laboratory | | | | | | | | | | | | 2.10 |
| 14 | I would not take physics laboratory lessons if I were not forced to. | 16 | 6.5 | 48 | 19.6 | 43 | 17.6 | 98 | 40 | 40 | 16.3 | 3.40 |
| 15 | I shrink from the questions asked by the teacher. | 27 | 11.0 | 23 | 9.4 | 36 | 14.7 | 91 | 37.1 | 66 | 26.9 | 3.60 |
| 16 | I feel anxious while doing the experiments. | 16 | 6.5 | 38 | 15.5 | 57 | 23.3 | 73 | 29.8 | 57 | 23.3 | 3.48 |
| **4th DIMENSION:** Constant anxiety towards the physics laboratory | | | | | | | | | | | | 3.49 |

(interval width/number of groups) formula (Tekin, 2002). According to the calculation, the coefficient of interval was found as a=((5-1)/5)=0.8. Accordingly, 1.00 to 1.80 interval was defined as “I totally disagree”, 1.81 to 2.60 interval was defined as “I disagree”, 2.61 to 3.40 interval was determined as “I am not sure”, 3.41 to 4.20 interval was identified as “I agree” and 4.21 to 5.00 interval was determined as “I totally agree”. The means of scale items were evaluated pursuant to these intervals.

Frequency, percentage and mean values belonging to the each item in Physics laboratory anxiety scale and mean values of each dimension of the scale are given in Table 1.

According to Table 1, 10 items of the scale are in “I am not sure” interval, 3 items are in “I disagree” interval and 3 items are in “I agree” interval. “Anxiety about finishing the experiment” is within “I am not sure” interval (X=2.92). When the items related to this dimension are considered separately, it is surprising to see that “I feel anxious about preparing a graph with the data that I collect” item is in “I agree” interval (X=3.45). Fifty-six percent of pre-service teachers are worried about drawing graphs. Nearly 41% of pre-service teachers are anxious about not being able to obtain the correct conclusion, even though its mean is in “I am not sure” interval.

The dimension of “Anxiety about doing the experiment appropriately as intended” is in “I am not sure” interval (X=2.91). Among the items in this dimension, the “I feel anxious about not being able to do the experiment appropriately as intended” item is the highest with 37%.

The “Anxiety about using the materials in the Physics laboratory” dimension is in “I disagree” interval (X=2.10). However, the items in this dimension are expressed positively. Actually, pre-service teachers have anxieties

**Table 2.** The results of independent sample t test examining physics laboratory anxiety in terms of gender.

| Dimension | Gender | N | Mean | Standard deviation | df | t | p |
|---|---|---|---|---|---|---|---|
| 1 | Male | 67 | 3.33 | 1.03 | 96.54 | -3.97 | .000 |
| | Female | 178 | 2.77 | .79 | | | |
| 2 | Male | 67 | 3.17 | .95 | 243 | -2.88 | .004 |
| | Female | 178 | 2.81 | .85 | | | |
| 3 | Male | 67 | 1.92 | .85 | 243 | 2.39 | .017 |
| | Female | 178 | 2.18 | .70 | | | |
| 4 | Male | 67 | 3.46 | 1.16 | 97.01 | .34 | .732 |
| | Female | 178 | 3.51 | .89 | | | |

about using materials in the physics laboratory. Eighty percent of pre-service teaches stated that they disagree with the item of “I can easily install the experimental setup”, 65% of them stated that they do not agree with the item of “I am relaxed when I use the laboratory equipment” and 69% of them expressed that they disagree with the item of “I can easily comment on graphs”. Therefore, fifty-six percent of pre-service teachers are anxious about forming graphs, sixty-nine percent of them are worried about making comments on graphs.

Finally, it is seen that the dimension of “Constant anxiety towards the physics laboratory” is in “I agree” interval (X=3.49). According to this, the pre-service teachers feel constant anxiety about the Physics laboratory. As it is stated before, constant anxiety reflects long-lasting feelings that appear formerly. This means that pre-service teachers have prejudice against the physics laboratory. This situation can be associated with having prejudice against the physics lesson or this may result from not joining physics laboratory applications before undergraduate education.

In order to see whether the anxieties related to the physics laboratory vary by gender, the data collected through the Physics Laboratory Anxiety Scale were evaluated through the Independent sample t test. The results of the evaluation can be seen in Table 2.

As it is seen in Table 2, there are sinnificant differences between male and female pre-service teachers in terms of anxiety related to the Physics laboratory. When it is regarded in general terms, it is seen that males are more anxious than females in the physics laboratory ($p = .002$, $p < .05$). When the dimensions are taken into consideration, it is observed that males feel more anxiety than females in terms of completing the experiment, doing the experiment appropriately and using the materials in the Physics laboratory. No significant difference was found between males and females in the context of “Constant anxiety towards the physics laboratory”. This outcome means that there is no difference between males and females in terms of having prejudice against the physics laboratory but males are more anxious than females in the laboratory environment.

## Findings of the qualitative research

In order to reveal the situations that may cause pre-service teachers feel anxious about the physics laboratory, semi-structured interviews were conducted with 20 pre-service teachers randomly selected from the same study group. The following questions were asked to the pre-service teachers;

1. What are the situations that you have the biggest difficulty while performing in the Physics Laboratory?
2. What are your expectations from the Physics Laboratory environment?
3. What is the manner of application that you prefer in the Physics Laboratory?
4. Does the Physics laboratory help you understand the subjects of Physics?
5. What do you think about increasing the number of Physics Laboratory applications?
6. Would you select if Physics Laboratory lessons were not compulsory but elective?
7. On behalf of learning Physics, do you prefer Physics laboratory applications or theoretical physics courses?

The pre-service teachers were asked to explain the reasons of answers that they had given for the questions. The interviews were performed by using a tape recorder. The answers of coded questions and the statements provided by each pre-service teacher were taken down. The answers given for each question and the frequencies of these answers were transferred into the frequency table. Five frequency tables were formed by this way.

In Table 3, physics laboratory applications stated as difficult by 20 pre-service teachers and frequencies of

**Table 3.** Physics laboratory applications in which pre-service teachers have difficulty.

| Situations where difficulty is experienced in the Physics Laboratory | Pre-service teachers<br>$P_11$→Department of Physics 1st year undergraduate 1st Pre-service teacher<br>$S_22$ → Department of Science 2nd year undergraduate 2nd Pre-service teacher | | | | | | | | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $P_11$ | $P_12$ | $P_13$ | $P_21$ | $P_22$ | $P_23$ | $P_31$ | $P_32$ | $P_41$ | $P_42$ | $S_11$ | $S_12$ | $S_13$ | $S_14$ | $S_15$ | $S_21$ | $S_22$ | $S_23$ | $S_24$ | $S_25$ | |
| Understanding the purpose of the experiment | | √ | √ | √ | √ | √ | | | √ | √ | √ | | | √ | | | √ | √ | √ | | 12 |
| Using experimental materials | √ | | √ | √ | | | | | √ | | | | | | | | | | | | 4 |
| Use of measuring tools | | √ | | √ | | | | | √ | √ | | | | | | | | | | | 4 |
| Completing in time | | √ | √ | | | | √ | | | | √ | √ | | √ | √ | | | | | √ | 8 |
| Communication with group members | √ | | | | | | | | | | | | | | √ | | | | √ | | 3 |
| Drawing a graph | √ | | | | | √ | | √ | | | √ | √ | | √ | √ | √ | | | √ | √ | 10 |
| Converting units while computing | √ | √ | √ | √ | √ | | √ | √ | | √ | | √ | | | | √ | √ | | | | 11 |
| Making comments on results | | | | | | | | | | | √ | | | | √ | √ | | √ | | √ | 5 |

these applications are given. The pre-service teachers frequently reported that they had difficulties in "Understanding the purpose of an experiment", "Converting units while computing" and "Drawing graphs".

Thirteen of 20 pre-service teachers stated that they had difficulty in understanding the purpose of an experiment. This situation shows that pre-service teachers perform some applications in the physics laboratory without knowing why they do perform them. It means that these applications do not achieve their goals. In this regard, some pre-service teachers think that:

"Watching how to do an experiment on tablets first, and then performing the same experiment individually would be more effective for the student". ($P_2$1)

"First of all, a demonstration experiment must be done, and then group work must follow it" ($P_4$2)

"I do not understand the experiments whose theories are on topics that I do not know" ($S_2$2)

"All groups must perform the same experiment" ($S_1$5)

"I understand the experiment but I cannot associate it with its theory" ($S_1$2)

"If there are more extensive experiment books on how to do experiments, understanding experiments gets easier for me." ($P_4$2)

As in the results regarding physics laboratory anxiety scale, pre-service teachers stated that they had difficulty in drawing graphs. Some of the opinions on this matter are as in the following;

"Training of drawing graphs must be provided before starting experiments" ($S_2$4)

"I have difficulty in naming graphs" ($S_1$2)

"How is a graph drawn? I have no idea."($S_1$1)

"I think drawing a graph is a sensitive and difficult task" ($P_1$1)Eleven of 20 pre-service teachers and most of the physics pre-service teachers reported that they have difficulty in converting units while computing. Converting units is a mathematical operation. This situation may indicate that pre-service teachers do not have the necessary mathematical competence needed for physics subject.

"I often forget to convert units. I do not pay attention." ($P_4$2)

"As we often convert units incorrectly, the results are wrong" ($P_2$1)

In Table 4, the expectations of 20 pre-service teachers from the environment where physics laboratory applications are performed and the frequencies of these expectations are given. The

**Table 4.** Expectations of pre-service teachers from the physics laboratory environment.

| Expectations from the physics laboratory environment | Pre-service teachers<br>$P_11$→Department of Physics 1st year undergraduate 1st Pre-service teacher<br>$S_22$ → Department of Science 2nd year undergraduate 2nd Pre-service teacher | | | | | | | | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $P_11$ | $P_12$ | $P_13$ | $P_21$ | $P_22$ | $P_23$ | $P_31$ | $P_32$ | $P_41$ | $P_42$ | $S_11$ | $S_12$ | $S_13$ | $S_14$ | $S_15$ | $S_21$ | $S_22$ | $S_23$ | $S_24$ | $S_25$ | |
| Experimental materials must be abundant and durable | √ | | √ | √ | | √ | √ | | √ | √ | √ | | √ | | √ | | | √ | √ | √ | 13 |
| Experimental materials must be more modern | | | | √ | √ | | | | | √ | | | | | | √ | √ | | | | 5 |
| Instructors must provide more help | | | √ | | √ | | | √ | √ | | √ | √ | | √ | | √ | √ | √ | | | 10 |
| Number of undergraduates in groups must be less | | | | | | | | √ | | | | | √ | | | | | | | | 2 |
| Experiment manuals must be more explanatory | | | | | | | √ | | | | | | | | | √ | | | √ | | 3 |

**Table 5.** Opinions of pre-service teachers about the physics laboratory method.

| Opinions about the physics laboratory method | Pre-service teachers<br>$P_11$→Department of Physics 1st year undergraduate 1st Pre-service teacher<br>$S_22$ → Department of Science 2nd year undergraduate 2nd Pre-service teacher | | | | | | | | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $P_11$ | $P_12$ | $P_13$ | $P_21$ | $P_22$ | $P_23$ | $P_31$ | $P_32$ | $P_41$ | $P_42$ | $S_11$ | $S_12$ | $S_13$ | $S_14$ | $S_15$ | $S_21$ | $S_22$ | $S_23$ | $S_24$ | $S_25$ | |
| Demonstration experiment must be done | | | | | | | | | √ | √ | | | √ | | | | | | | | 3 |
| Group work must be done | | √ | √ | | √ | | √ | | | √ | √ | √ | √ | √ | | √ | √ | √ | | √ | 13 |
| Students must work individually | √ | | | √ | | √ | | √ | | | | | | | √ | | | | √ | | 6 |
| Teaching must be provided through discovery | | | √ | √ | √ | | √ | | | | | | √ | | | | | √ | √ | | 7 |

most common expectations stated by pre-service teachers include; “experimental materials must be abundant and durable” and “instructors must provide more help”. The opinions of some pre-service teachers on these matters are as follows:

“I get really bored while doing physics laboratory experiments. Instructors must help more.”($S_1$1)
“Department of science education must have a physics laboratory including only physics subjects of science curriculum.” ($S_2$3)
“Old materials must be replaced with new ones” ($S_2$3)
“Number of instructors dealing with us must be more. We encounter problems and we cannot solve them by ourselves.” ($P_3$2)
“Only reading the laboratory manual is not enough. We do not understand how to use the materials. More help is needed.” ($P_1$3)

The manners of application that 20 pre-service teachers prefer in physics laboratory applications and their frequencies are given in Table 5. The pre-service teachers want to perform physics laboratory applications in groups. Besides, most of the pre-service teachers of science demanded groups work, whereas the pre-service teachers of physics preferred self-study.
“We cooperate in group works. Those who understand the subject explain those who do not understand.”($P_1$2)
“We can exchange information in group work.
“We cannot gain experience in the demonstration experiment. Exchange of information is not possible in self-study.” ($P_2$2)
“We do not make any efforts in the demonstration experiment. If we perform alone, we cannot exchange information. Group work is the best.”($S_2$5)
“I am already afraid. I do not have enough knowledge. I cannot work alone. I am not sure of myself. I cannot understand just through the demonstration experiment. I prefer group work. ”

**Table 6.** Expectations of pre-service teachers from the physics laboratory environment.

| Expectations from the physics laboratory environment | Pre-service teachers<br>$P_11$→Department of Physics 1st year undergraduate 1st Pre-service teacher<br>$S_22$ → Department of Science 2nd year undergraduate 2nd Pre-service teacher | | | | | | | | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $P_11$ | $P_12$ | $P_13$ | $P_21$ | $P_22$ | $P_23$ | $P_31$ | $P_32$ | $P_41$ | $P_42$ | $S_11$ | $S_12$ | $S_13$ | $S_14$ | $S_15$ | $S_21$ | $S_22$ | $S_23$ | $S_24$ | $S_25$ | |
| Experimental materials must be abundant and durable | √ | | √ | √ | | √ | √ | | √ | √ | √ | | √ | | √ | | | √ | √ | √ | 13 |
| Experimental materials must be more modern | | | | √ | √ | | | | | √ | | | | | | √ | √ | | | | 5 |
| Instructors must provide more help | | | √ | | √ | | | √ | √ | | √ | √ | | √ | | √ | √ | √ | | | 10 |
| Number of undergraduates in groups must be less | | | | | | | | √ | | | | | √ | | | | | | | | 2 |
| Experiment manuals must be more explanatory | | | | | | | √ | | | | | | | | | √ | | | √ | | 3 |

**Table 7.** Opinions of pre-service teachers about the physics laboratory method.

| Opinions about the physics laboratory method | Pre-service teachers<br>$P_11$→Department of Physics 1st year undergraduate 1st Pre-service teacher<br>$S_22$ → Department of Science 2nd year undergraduate 2nd Pre-service teacher | | | | | | | | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $P_11$ | $P_12$ | $P_13$ | $P_21$ | $P_22$ | $P_23$ | $P_31$ | $P_32$ | $P_41$ | $P_42$ | $S_11$ | $S_12$ | $S_13$ | $S_14$ | $S_15$ | $S_21$ | $S_22$ | $S_23$ | $S_24$ | $S_25$ | |
| Demonstration experiment must be done | | | | | | | | | √ | √ | | | √ | | | | | | | | 3 |
| Group work must be done | | √ | √ | | √ | | √ | | | √ | √ | √ | √ | √ | | √ | √ | √ | | √ | 13 |
| Students must work individually | √ | | | √ | | √ | | √ | | | | | | | √ | | | | √ | | 6 |
| Teaching must be provided through discovery | | | √ | √ | √ | | √ | | | | | | √ | | | | | √ | √ | | 7 |

($S_22$)

"I prefer working alone because I have to do it. I do not trust anyone else. I learn better. I overcome, even though I am afraid and my self-confidence increases."($P_32$)

"I would like to work alone because there can be individuals who do not work in a group. There is interference. I work better when I am alone. " ($P_11$).

In Table 6, the answers to the question whether the physics laboratory applications are effective on under-standing subjects of physics, and their frequencies are given. It was observed that the pre-service teachers agreed that physics laboratory applications are effective on understanding subjects of physics. Some of the pre-service teachers suggested that physics laboratory applications would be effective if they were studied with theoretical physics lessons, they would not be that effective alone. Furthermore, it was seen that physics pre-service teachers agree that physics laboratory appli-cations help learning subjects of physics better, but science pre-service teachers are in doubt about this matter.

"For example, I never forget free fall test. I remember it in every relevant situation. Learning by seeing is easier and more permanent." ($P_12$)

"When I encounter a subject in the laboratory which I studied in the lesson before, I never forget." ($P_23$)

"Theoretical physics is mostly maths and non-physical. It is learnt by heart in general. However, it is not forgotten easily because laboratory is visual." ($P_21$)

"I think it is very effective. We attend the lesson individually. If the result is positive, our self-confidence increases. We test ourselves. We get excited because we wonder whether the result is true or not. Taking part in the task helps us understand the subject much better. It is more effective than the theoretical lesson." ($P_42$)

In Table 7, the answers responded by pre-service teachers to the questions including "Do you think that the number of physics laboratory courses must be increased?", "If physics laboratory

courses were not obligatory but they were elective, would you select them?" and "Do you prefer physics laboratory courses or theoretical physics courses in order to learn physics?", and the frequencies of these answers are given. Pre-service teachers stated that number of physics laboratory lessons must be increased; they would select physics laboratory courses if they were elective and they would prefer physics laboratory courses rather than theoretical physics courses.

"The concepts that I see in the laboratory stick in my mind and become concrete. I prefer laboratory courses to theoretical courses." ($P_3$1)

"I think I objectify concepts. Therefore, I prefer physics laboratory courses to theoretical physics courses." ($P_3$2)

"Physics laboratory courses are fewer, in comparison with number of theoretical physics courses. It would be better even if all courses were laboratory courses." ($P_4$2)

"There is no need to increase. However, theoretical courses can be replaced with laboratory courses." ($P_1$1).

## RESULTS AND DISCUSSION

According to the results of physics laboratory anxiety scale, pre-service teachers feel anxiety in physics laboratory applications in terms of drawing graphs and using materials. Besides, they feel constant anxiety related to the physics laboratory. Dilber et al. (2006) discovered a similar result on constant anxiety.

As it was reported in the results belonging to Physics Laboratory anxiety scale and in the interviews, pre-service teachers have difficulty and feel anxious especially about "drawing graphs" among the physics laboratory applications. The skill of drawing and understanding graphs is one of the basic science process skills (Burns et al., 1985; Tobin and Capie, 1982). Graphs are used to express the relationships between physics concepts. Understanding and interpreting the relationship between physics concepts properly are related to understanding and commenting on graphs (Demirci and Uyanık, 2009). It is significant to convert the collected data into graphs in order to identify the relationship between measured variables, especially for drawing a conclusion with the experimental study. Having the ability to benefit from graphs is necessary to obtain correct information about many things concerning our lives (Taşar et al., 2002). Additionally, expressing data through forms such as graphs makes their interpretation easier (Çepni et al., 1997). It is seen that most of undergraduates draw their first graph in university years. However, providing students with the use of this influential tool of scientific communication should not be postponed until university years (Temiz and Tan, 2009).

On the other hand, the results of Physics laboratory anxiety scale show that pre-service teachers have anxieties about "doing the experiment appropriately as intended", the results of interviews express that pre-service teachers have difficulty in "understanding the purpose of the experiment". These conclusions imply that pre-service teachers have difficulty in understanding purposes of experiments. As stated by some pre-service teachers, this situation may result from not combining the theory of the experiment and its practice. At this point, the matter whether introducing the theory of a physics concept first, then performing its application or whether performing its application first, then explaining its theory would be more effective becomes crucial.

The interview results show that pre-service teachers have difficulty in "converting units of measure while calculating", which is one of the physics laboratory applications. "converting units of measure" is a mathematical skill that is used in physics courses very often, whether it is theoretical course or application course. Besides, pre-service teachers must have a comprehensive knowledge of units and unit systems in physics.

The results of physics laboratory anxiety scale indicate that pre-service teachers feel anxious about the use of materials in the physics laboratory. According to the results of the interview, pre-service teachers expect more help from the instructors in the physics laboratory environment. It is possible to say that these two situations are caused by the need of pre-service teachers for preliminary information about how to use the materials in the physics laboratory because these materials require technical knowledge in general.

The pre-service teachers that are deprived of this knowledge both feel anxious about the use of materials and may break the materials. The interviews show that most of the pre-service teachers' expectation is that materials must be durable. In this respect, it is important to repair the materials, which are out of order, immediately. Therefore, technicians are needed in the physics laboratories. These results are in accord with the results of Akdeniz and Karamustafaoğlu (2003).

The research results showed that male pre-service teachers were more anxious than female pre-service teachers were about physics laboratory applications. This situation is in accordance with the results of PISA that indicate that females precede males in terms of science competence in our country (Balım et al., 2009). In fact, the studies conducted until 1990s suggest that gender is effective on attitudes towards science and male students possess attitudes that are more positive (Simpson and Oliver, 1985; Czerniak and Chiarelott, 1984; Schibeci, 1984; Schibeci and Riley, 1986; Mason and Kahle, 1989; Johnson, 1987; Weinburg, 1995). Since 1990s, the conducted studies show that gender does not have a considerable effect on attitudes towards science (Osborne, 2003). When this matter is taken into consideration in terms of physics lesson, it is seen that there are many studies showing that males have more positive attitudes towards physics courses than females have (Demirci, 2004; Hoffmann et al., 1998; Yaman et al., 2004; Mitrevski and Treagust, 2011; Farenga and Joyce,

1997, 1999). However, when gender differences are examined in the context of attitudes towards laboratory courses, it is interesting to see that mostly females exhibit more positive attitudes than males do (Taşlıdere and Korur, 2012). It is emphasized in the literature that the way to enhance interest, performance and self-confidence of females in science is to increase the hands-on training (Mason and Kahle, 1989; Kahle and Rennie, 1993; Lee and Burkam, 1996; Simpson and Oliver, 1985; Burkam et al., 1997). Casserly (1980) stated that females need learning based on co-operation and practice, practical applications, opportunities for creative solutions and active, open-ended learning styles rather than competition.

The interviews express that pre-service teachers prefer studying physics laboratory lessons in groups. Most of the pre-service teachers state that they are not sure of themselves to study alone in physics laboratory. This situation is an indicator of the anxiety about the physics laboratory. On the other hand, the pre-service teachers accept the effectiveness of physics laboratory applications on understanding subjects of physics and they would rather physics laboratory courses than theoretical physics courses. Similarly, Dilber et al. (2006) discovered that pre-service teachers think that physics laboratory applications are more effective on learning physics.

Although they feel anxiety, they stated that they would choose physics laboratory lessons if they were elective. Maybe the reason of this situation is that pre-service service teachers find physics laboratory courses more pleasurable than theoretical physics courses. Nevertheless, they are uncertain about taking more physics laboratory courses.

Science anxiety, one of the affective dimensions of learning science, is one of the factors affecting success in Science and has been studied for more than 35 years. The presence of considerable negative attitudes towards Physics, which is one of the basic branches of Science, is a known fact. When attitudes towards Chemistry, which is another branch of science, are examined, it is seen that undergraduates feel anxious about Chemistry laboratory. However, there are not enough studies examining anxieties concerning the Physics laboratory. There is a need for studies examining the level of anxieties of students about Physics laboratory.

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