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Science and Technology Teachers' Views About the Causes of Laboratory Accidents

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Abstract
Aim of this study was to determine science and technology teachers' views about the causes of the problems encountered in laboratories. In this research, phenomenology, a qualitative research design, was used. 21 science and technology teachers who were working in elementary schools in Eskisehir during the 2010–2011 spring semester were the participants of this study. A semi-structured interview form was prepared to collect data. The interview form included three sections. Content analysis was used to deeply analyze and understand the written answers which were obtained from open ended questions. Approxiamately half of teachers expressed that, lack of caution and lack of necessary safety precautions were the causes of laboratory accidents. Moreover, they also expressed that, insufficient science content knowledge and lack of knowledge were influential in the problems encountered. It is thought that, the findings of this study will contribute to determining the causes of problems encountered in laboratories.

Keywords: Causes of problems encountered in laboratories, content analysis, science and technology teachers' views

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Introduction

It is commonly agreed that there is a close relationship between economical development level and scientific and technological development level. In recent decades, the advances in the fields of science and technology have become increased. With the accumulation of information, the attempts by individuals to access more information have increased. Societies need individuals who can research, question and investigates critically, think critically, solve the problems they come across, produce and who want to increase their share from the value-added things produced by others (Eryaman, 2007). Science education plays significant role to educate such individuals. There are different definitions of science. For instance, İşman et. al. (2002) argue that "science is the practice of scientific thinking in order to think scientifically and to solve daily life problems."Doğru and Kıyıcı (2005) define science is a systemical analysis of nature and natural events and an attempt to predict those natural events which have not yet been observed. In the science and technology educational program, published in 2005, science was described as a discipline which tries to define and account for the physical and biological world and a way of research and thinking which depends on experimental criteria, logical thinking and questioning continously.

Based on these definitions, it can be stated that science whose source is nature helps to explain the natural world. Therefore, science is a vital part of life. In addition to, science deals with both living beings and inanimate objects and science includes facts, concepts and generalizations, principles, rules and natural laws (Doğru and Kıyıcı, 2005). In this way, science contributes to human development through the improvement of scientific knowledge and understanding. Even though science may be understood as very complex at first sight, it is a method which provides reasonable explanations about the events in the world (Bybee et. al. 1989). At the same time, science is a dynamic and creative activity.

The goals of the AAAS (1989) were to improve scientists' studies, cooparate their relations, improve both academical freedom and responsibility, develop science education, encourage a better understanding related to nature of science, scientific research and technology. Nearly all daily life situations students come across are covered in the science courses (Ekim 2007). Therefore, students should be educated effectively in science courses (İşman et. al. 2002; Kaptan, 1998). Since science courses help students to improve their skills related to understand and explain themselves and their environment and to regulate their relationships with this environment. Subjects in science are mainly abstract and complex so one of the basic goals of the laboratory usage is to provide concrete experience to teach these subjects (Morgil, Güngör, Seyhan and Seçken, 2009). Science laboratories are centers designed to make students understand the scientific concepts and acquire the science process skills (Hofstein, Nahum & Shore, 2001).

Contemporary understanding of the science laboaratory regards laboratories as a learning centers in which students make research about they learned theoretical scientific concepts in the course, design experiments to prove their findings and develop significant connections between theory and practice (Tatar, Korkmaz and Ören, 2007). In addition, science laboratories are unique learning environments where students work in small groups to search for scientific events. The basic goal in laboratory practices is to make students understand the scientific concepts, improve their problem-solving skills, acquire scientific habits and understand the nature of science (Hoffstein and Lunetta, 2003). In this way students are given an opportunity to be familiar with the scientific process. Laboratory activities are based on active participation of students in the analysis of facts and in the process of data collection. These activities provide them with the opportunity to understand the basics and methods of science, improve their problem-solving skills, make analyses and generalizations, acquire scientific knowledge and develop positive attitudes towards science (Tamir, 1997; cited in Koray, Köksal, Özdemir and Presley, 2007).

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There are numerous studies dealing with the efficacy of the laboratory activities (Kirschner & Meester, 1988; Hofstein, Nahum & Shore, 2001; Hofstein & Lunetta, 2003; Hofstein & Naaman, 2007).

There are conflicting views about laboratory education that whether it is necessary or not. For instance, Kirschner &Meester (1988) argued that laboratory-based education is cost-effective in terms of both human power and material and that it is not a valuable learning experience for students.

In recent years, activity- and experiment-based approaches in science education have become significant as a result of the intense attempts to use of the student-centered and constructive approaches in science. Therefore, future science educators should have necessary skills to meet these needs (Erökten, 2010). Science teachers are regarded as key players in order for the science course to achieve desired objectives (Yıldız, Aydoğdu, Akpınar and Ergin, 2006).

In order to reduce the problems experienced during the activities carried out in laboratories the knowledge, experience and skills of teachers in laboratory practices are very significant. One of such problems is the accidents occurred during the experiments. The following is two excerpts from the websites showing news about accidents experienced in experiments in the schools in Turkey.

Case 1
MERCURY TUBE BROKEN DURING THE EXPERIMENT; 24 STUDENTS POISONED
In Kayseri 24 elementary science education students were poisoned when gas mercury tube was broken and gas diffused during the experiment. Based on the reports during the laboratory experiment which was conducted by the sixth grade students and mercury tube fell down and was broken in Taşhan village of Yahyalı district. 24 students were poisoned from the gas diffused and were brought to Yahyalı public hospital. They were transferred to an university hospital Kayseri following the first intervention in the cottage hospital. They were discharged from the hospital after they were observed for a while. Yahyalı perfect İdris Bıyık reported that the students do not experience any life-threatening situation and they returned to the village. http://www.aktifhaber.com/24-ogrenci-zehirlendi-203100h.htm Retrieved: 02 / 01 / 2012

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Case 2
BURNING DURING THE EXPERIMENT
The alcohol used by elementary science education students in an experiment caught fire and four students' various body parts were injured. During the experiment which was conducted by fifth grade students and science teacher, alcohol used caught fire in Doğancı village of Bolu. The students who are Murat İpek, Burcu Koçak, Deniz Koç and İsmail Okay were injured. They were brought by the teacher and school administrators to the cottage hospital in the village. They were transferred to an university hospital in Bolu following the first intervention. In the hospital three students were out patiented and one was taken to the burn service. Physician Opr. Dr. Rüya Ayşe Çelik reported that three students were sent to their homes after the treatment. She said that "one student is treating here since his burns are deeper and that his hands and back were burned at the degrees of first and second". 'Alcohol Poured When Fire Was About to Extinguish ' Murat İpek, 10 years old, whose hands and back were burned reported that they were conducting an experiment about how stream rotates the wheels in science and technology course and that they would heat the water in tubes. He continued to tell that their first attempt was unsuccesful and later they managed to began to heat the water. However, the fire was about to extinguish so the teacher poured alcohol and all tubes caught fire. http://www.tumgazeteler.com/?a=1812152], Retrieved: 13/ 04 /2011

As cases one and two show accidents in science laboratories are likely to occur. In order to minimize these accidents necessary precautions should be taken. Identifying the causes of such accidents may contribute to minimize them. This study is significant in that it attempts to reveal the causes the accidents experienced in laboratories and the necessary precautions to be taken. In addition, the findings of the study may inform both teacher training institutions and schools about such undesired experiences in schools.

Aim of the Study

The aim of the study is to identify the views of the science and technology teachers about the problems experienced during the laboratory activities. In parallel to this aim, the study attempts to answer the following research question:

What are the views of the science and technology teachers about the problems experienced during the activities carried out in laboratories?

Method

Design of the Study

The study was designed based on the principles of phenomenology which is one of the qualitative research techniques. The design for phenomenological studies focuses on the facts of which we are aware and about which we do not have detailed understanding (Yıldırım and Şimşek, 2008).

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Participants

In qualitative research there are purposive sampling techniques. Purposive sampling techniques provide researcher with an opportunity to analyse significant situations in-depth (Patton, 2002). More specifically the participants of the study were determined through the use of the maximum diversity and easily accessible sampling techniques which are part of the purposive sampling techniques. In the maximum diversity sampling technique the aim is to construct a small-size sampling and to maximize the diversity of the participants which are closely related to the problem at hand (Yıldırım and Şimşek, 2008). Participants of the study were 21 science and technology teachers. They were working in the elementary science education schools in Eskişehir province during the spring semester of the school year of 2010-2011. They were chosen based on their experience and the characteristics of the schools they were working in. These science and technology teachers were working in twelve different elementary education schools. Their demographical characteristics are given in Table 1 as follows:

Table 1.

Demographical characteristics of the participants

Characteristic		N	%
Experience	0-10 years	10	47.6
	11-25 years	4	19.1
	26 years or more	7	33.3
Graduation	Faculty of Education	12	57.1
	Institute of Education	8	38.1
	Faculty of Arts and Sciences	1	4.76
Gender	Female	12	57.1
	Male	9	42.9
TOTAL		21	100

Table 1 presents the demographical characteristics of 21 science and technology teachers participated in the study. In regard to the teaching experience it was found that 47,6% of the participants had a teaching experience of 0-10 years. Those with the experience of 11-25 years were found to be 19,1%of the participants. It was also found that 33,3% of them had a teaching experience of 26 years or more. Concerning the origin of graduation it was found that more than half of the teachers were the gradutes of the faculty of education (57,1%). Those who were the gradutes of the educational institutes were found to be 38,1% of the participants. It was also determined that only 4,76% of them were the graduates of the faculty of arts and sciences. In relation to the gender it was found that female teachers were more than male teachers (57,1% and 42,9%, respectively).

Data Collection Tools

In order to identify the views of the science and technology teachers about the problems experienced in laboratories, semi-structured interview form was used. The interview form is consisted of three sections of which the first one included items about the demographical characteristics of the participants. The second section covered items about the accidents in the laboratories. The last one was

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composed an open-ended item concerning the causes of the possible accidents in the laboratories. The answers of this item were written by the students.

Data Analysis

The answers of the science and technology teachers participated in the study to the open-ended item were analysed through content analysis which is one of the qualitative data analysis techniques. Firstly, the interview forms of the participants were numbered. Then, similar concepts and themes used in these forms were identified (Yıldırım ve Şimşek, 2008). Themes identified were divided into sub-themes in parallel to the aim of the study. In order to establish the reliability of the coding these codes were analysed by a field specialist. There was an agreement between the original codes and those produced by the specialist.

Findings

This section presents the findings on the views of the science and technology teachers about the problems experienced in the laboratories as well as the discussion these findings. The views of the participants about the problems experienced in the laboratories are found to be categorized around six themes as follows: teacher-related problems, student-related problems, practice-related problems, security-related problems, material-related problemsandlaboratory-related problems. The findings about each theme with its subthemes are given in the following tables.

Table 2.
Teacher-related problems

Themes	Sub themes	f	%
Teacher	Educational background	6	28,6
	Knowledge of subject matter	8	38,1
	Practical skills	7	33,3
	Professional knowledge	5	23,8
	Financial support	1	4,8

Table 2 presents that regarding the teacher-related problems in laboratories. 38,1% of the participants stated that such problems occur due to poor knowledge of teachers about their subject matter. Some participants also reported that these problems are the result of poor practical skills of teachers (33,3%). There were some participants who stated that such problems are experienced due to poor educational background in regard to the use of laboratories (28,6%). The others reported that poor professional knowledge of teachers leads to these problems (23,8'%). One of the participants stated that no extra time and financial support were also related to such problems (4,8%).

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In addition these numerical data the answers of the participants to the open-ended item are also given the following is an exemplary statement for the participants who regarded the poor educational background of teachers as a reason for the problems occured in laboratories: "*I think that the reason for the accidents occured in laboratories is the lack of necessary knowledge of student teachers about chemicals or other laboratory."*

Some of the participants reported that the accidents in the laboratories occur due to insufficient knowledge of teachers about their subject matter. One of these teachers expressed his view as follows:

> *In the teacher training programs we were given only theoretical knowledge in regard to chemistry education. In addition, I think accidents occur when teachers try to carry out the experiments without any significant preparation.*

Some participants remarked that these problems are the result of poor practical skills of teachers in relation to the activities in laboratories. The following is an example for such views: *"The accidents occur when teachers do not prepare the materials to be used in experiments in advance."*

There were also participants who reported that poor professional knowledge of teachers leads to these problems. This view was expressed as follows *"The problems in laboratories are experienced since teachers cannot control the many students' movement there."*

One of the teachers participated in the study reported that no financial support was also related to such problems. She reported that*"There is no extra time and financial support for teachers to design the experiments."*

Based on these findings it may argued; that most of the problems experienced in laboratories occur due to poor knowledge of techers in subject matter, poor practical skills and professional knowledge of teachers and lack of financial assistance. Such problems appear to be experienced because of their pre-service and in-service training.

Table 3 shows there two main themes in regard to the student-related problems observed in laboratories, namely uncontrolled student curiosity and students' poor background information. More specifically, 33,3% of the participants regarded the curiosity of students leads to these problems, whereas9,5% of them considered students' poor background information as a principal cause for such problems. The following quotations exemplify such views as follows: *"...Students are extremely interested in chemicals and want to work with chemicals in laboratories without giving permission from teachers."*, and *"The problems in laboratories occur since students unconsciously intervene the experiments."*

Table 3.*Student-related problems*

Theme	Sub themes	f	%
Students	Curiosity	2	9,5
	Lack of background information	8	33,3

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One of the factors affecting the success of the laboratory-based activities is related to the knowledge-base of the people about topic to be studied in laboratory. If they have poor theoretical knowledge about the topic the possibility to have a succesful laboratory experience is quite low(Aydoğdu, 1999). The student-related problems experienced in laboratories include the topics of curiosity and lack of information. Given that students first come across laboratory practices at the primary and elementary science education level they may have an extreme interest in these activities.

Tablo 4.
Practice related problems

Themes	Sub themes	f	%
Practice	Group	1	4,8
	Care		10
47,6			
	Rules		6
28,6			
	Time		1
4,8			

Table 4 shows that the practice-related problems in laboratories are categorized under four sub-themes, namely group-related, care-related, rules-related and time-related problems. It was found that 47,6% of the participants considered the lack of necessary care lead to such problems. There were also participants who regarded the rules as the cause for these problems (28,6%). The factors of time and group were also given as the reasons for the problems (4,8% each).

The following statements are the examples of these views: *"Given that there are time constraints teachers try to complete more than one experiment in one class hour.", "Problems occur because of lack of necessary care and rigor during the experiments.", "Because students do not follow the rules during the experiments."* and *"Experiments are not conducted in small groups. "*Practice-based problems experienced in laboratories are stated by the participants as a result of students' work individually or in a group, lack of care during the experiments, not following the rules about experiments or laboratories and time constraints. Yıldız, Aydoğdu, Akpınar and Ergin (2006) in their study, elementary science teachers' attitudes towards laboratory activities, concluded that teachers have "undecided level" attitudes for the items about the cost of experiments, time constraints, lack of order during the experiments and chaos experienced during the experiments. Aydoğdu (1999) concluded in his study, the identification of difficulties encountered in chemistry lab, that students interviewed also reported the negative effects of time constraints and poor theoretical knowledge on the practices carried out in laboratories. These findings are consistent with the findings of the present study concerning practice-related problems in laboratories.

Table 5 indicates that security-related problems include two major subhemes; namely precaution and guide about laboratory work. More specifically, of the participants 47,6% reported that the lack of precautions lead to the problems whereas 4,8% reported that the lack of guides is the reason for such problems. The following exemplifies these views:*"All necessary precautions should be taken while carrying out the experiments",* and *"conducting experiments without reading hazardous chemical substances' usage guide.*

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Table 5.
Problems related to security

Themes	Sub themes	f	%
Security	Precaution	10	47,6
	Guide	1	4,8

Thus, the findings obtained indicate that both taking necessary precautions and using guides in the experimental process are significant in order to reduce the security-related problems.

Table 6.
Problems related to materials

Themes	Sub themes	f	%
Material	Control	5	23,8
	Cleaning	2	9,5

As can be seen in Table 6 the material-related problems are two types, those related to control and those related to cleaning of materials. More specifically, 23,8% of the participants argued that poor control of materials lead to the problems while 9,5% of them stated that poor cleaning of materials is the couse of the problems. Such views are exemplified as follows: *"Problems occur because of the poor cleaning of the containers used in the experiments."* and *"Poor control of the experiment materials leads to problems."* Cleaning of the materials used in laboratories is very significant for both the health of individuals and for the correct results of the experiments. Therefore, materials should be checked before and after the experiments in order to avoid such problems.

Table 7.
Problems related to laboratory

Themes	Sub themes	f	%
Laboratory	Lack of space	6	28,6
	Irregularity of space	3	14,3

As Table 7 indicates that the physical conditions of laboratories in relation to the problems experienced have two major subthemes; lack of necessary space in laboratories and irregular organization of the environment. Of the participants, 28,6% regarded the lack of necessary space in laboratoriesas the primary reason for the problems whereas 14,3% considered irregular organization of the environment as the main reason for the problems. These views are expressed as follows:*"Problems occur in laboratories since laboratories are not large enough to provide the students with an environment where students can easily move and make their work in a comfortable manner. Therefore, they may collide one another during the experiments.",*and *"Laboratories are very small so that experimental organization cannot be provided as it must be."*

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Students should have a comfortable work place while dealing with experiments to avoid accidents. Chemicals, glass equipments and other tools can be put on shelves in an organized manner and both teacher and students can easily access these materials whenever they need to use them. Such arrangements can reduce the laboratory-related problems.

Uluçınar, Doğan ve Kaya (2008) analyzed the views of teachers concerning difficulties experienced in laboratories in the context of the science education. They concluded that the most frequently reported problems by the participants included lack of necessary materials, poor laboratory conditions, crowded classes, time constraints in employing the laboratories and lack of guides in relation to the practices in the laboratory environment. This finding is consistent with the findings about the laboratory-related problems identified in the current study.

Discussion

The aim of the study is to determine the views of the science and technology teachers about the problems experienced during the activities carried out in laboratories. The findings of the study indicate that for the participants the problems in the laboratories occur due to six major reasons and these are teacher-related problems, student-related problems, practice-related problems, security-related problems, material-related problems and laboratory-related problems.

The participants mostly referred to the lack of care and of necessary precautions during the experimental work as the causes of the problems in laboratories. The rate of the teachers who expressed such views was found to be 47,6%. Nearly half of the participants stated that practices in the laboratories are not realized based on the proper laboratory procedures and that such practices lead to security problems. Therefore, these practices should be carried out in accordance with the rules to be followed before, during and after the laboratory work. Laboratory use techniques are defined as a scientific approach towards the problems experienced in the laboratories. Such problems are related to the safety of teachers, students, equipment and school. These teachniques also include the points about the technical specifications of equipment (Aydoğdu and Candan, 2012).

The next frequently factor stated by the participants regarding the problems in laboratories is about poor professional knowledge of teachers (38,1%). The other frequently factor is poor practical skills of teachers (33,3%). The rate of the participants who considered poor teacher training, students' not following the rules and lack of necessary space in laboratories was found to be 28,6%. The least reported factors were as follows: low income, conducting experiments in large groups, time constraints and lack of guides about the use of chemicals (each 4,8%). Özden (2007) attempted to identify the problems in chemistry courses. In the study it was found that some of the teachers regarded the laboratory work as wasting time due to the poor physical conditions and the lack of materials and equipment, the current educational program and the significance of the central examinations. Teachers also reported that implementation of laboratory work is very difficult to perform. Ekici (2002) found a correlation between the attitudes of biology teachers towards the laboratory work and the laboratory facilities. It was also found teachers who worked at the schools with better laboratory conditions had much more positive attitudes towards laboratory work. The findings of the study carried out by Özden (2007) and Ekici (2002) are consistent with the findings obtained in the present study. It is important to make laboratories research-based learning environments which have the advantages of learning through doing, active participation, meaningful learning, improvement of science process skills (Tatar, Korkmaz and Ören, 2007).

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Conclusions

The obtained findings indicate that in order to reduce the problems observed in the laboratories, the related laboratory usage techniques should be taken into consideration in carrying out experiments. Teachers must do necessary work before, during and after the experiments. The views of other groups of teachers about the problems in laboratories should also be studied. Therefore, similar studies can be carried out with other groups of teachers who also employ laboratories in such courses as physics, chemistry and biology and their views about the accidents occured in laboratories can be revealed. In addition, laboratories may be organized in a manner that there is necessary equipment and tools. Laboratory guides can be developed for the use by teachers and students. In-service training activities can be organized for teachers in relation the use of laboratory-based activities. In the teacher training programs student teachers may be well-equipped in term of the teachniques to be followed in such learning activities.

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