Historical Development of Laboratory in the Elementary School Science Program in Turkey

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Introduction

Nowadays the science can be defined as the process of perceiving and recognizing the natural world, studying natural phenomena, thinking about the nature of knowledge, accumulation of knowledge and obtaining information, reaching new information by making use of existing knowledge, and making predictions about events that have not yet been observed. Science has an important place in the development and economic achievement of countries. The race in the world of science and technology has increased the importance of science education. Therefore, countries aim to educate individuals who can produce knowledge and technology to ensure the continuity of progress in scientific and technological developments. In this context, various attempts have been made to improve the quality of science education in the last century. As a result, new curricula have been developed in accordance with the changes in science. Such initiatives which are made to ensure that the educational programs are at the desired level are of great importance for the development of countries. Today the developments in the field of science and technology necessitate the continuous development of the educational program and continuous researches related to this field. Examining the educational programs developed in our country and revealing the mistakes made in the past are important in order to avoid future failures in the development of educational programs. In this context, the review of science education programs, which have been developed to date, in terms of planning, implementation and evaluation stages is especially important in terms of shedding light on the development of future science programs.

The development of science programs in Turkey from the proclamation of the Republic to the present is examined. Science programs in this historical process are discussed in terms of laboratory use. In the preparation of new science programs, it is necessary to reveal missing or incorrect applications determined in previous programs.

Development of science education programs in Turkey

In parallel to the economic, social, political etc. advances and developments in the world, the educational systems of the developing countries are being changed which are directly reflected in their educational programs. As in other countries in the world in Turkey many changes and improvements have been made in the educational programs beginning by the proclamation of the Republic. The innovations and improvements are also made in the science education programs. Such changes have been made for the science education programs for all levels, including primary schools, secondary schools and high schools. In addition, the goals and major contents of the programs are continuously revised. More specifically, the science programs have been revised in the years of 1924, 1926, 1936, 1948, 1968, 1982, 1992 and 2000 (Gürdal ve Önen, 2010 cited in Ersoy, 2013). In 2004 the ministry of national education (MONE) made changes in the educational programs of the primary school courses including Turkish language, mathematics, life sciences, social studies and science and technology (Gömleksiz and Bulut, 2006).

In 2012 a new system for primary and secondary education in Turkey was initiated which is called 4+4+4. Based on this change beginning by 2012 - 2013 school year the educational programs were revised (MONE, 2012). That for science education program was finalized in 2013. It covered the changes for the grades of 3, 4, 5, 6, 7 and 8 (MONE, 2013). The education program was updated in 2018 for these grades (MONE, 2018).

For the science courses there have been eight education programs in Turkey which were developed in the years of 1924, 1926, 1936, 1948, 1968, 2004, 2013 and 2018. These educational programs are discussed below.

First School Education Program (1924)

Following the proclamation of the Republic a new education system was developed. With the law on unification of education called Tevhid-i Tedrisat, which was enacted in 1924 all education institutions were attached to the Ministry of National Education, and the educational programs for all courses were changed (Gözütok, 2003). In the 1924 program there were no stated goals for the courses in a systematical way. Instead, the goals were expressed in different parts of the education program like the goals of other courses. Science course was named as Nature Inspection, Agriculture and Hygiene and was offered three hours per week for the grades 1 and 2 and two hours per week for the grades of 3, 4 and 5. During the Ottoman state the primary education had lasted for six years which was altered to five years. Figure 1 shows the weekly schedule for the course of nature inspection, agriculture and hygiene for the boys' only primary school grades (First school education program, 1924).

Table 1. Weekly Schedule for the Course of Nature Inspection, Agriculture and Hygiene for Primary School

COURSE	1. grade	2. grade	3. grade	4. grade	5. grade
Nature Inspection, Agriculture and Hygiene	3	3	2	2	2

1926 Program:

The 1926 education program is based on Dewey's concepts of "Life Science, collective school and business school" (Wilson and Başgöz, 1973). "In the former education programs the courses were regarded as independent study subjects, and the relationships among them were not emphasized. In recent programs such relationships are frequently taken into consideration and emphasized. It is accepted that all courses should be delivered adopting a collective education approach. Although the courses such as "nature inspection", "social studies", "history" and "geography" were delivered separately in the old education programs, in the new education program these courses are grouped under the course of "Life Sciences" for the first level education. This course will be the backbone of the education system and other courses will be rest on it" (First school education program, 1930). The science course was still named as Nature Inspection, Agriculture and Hygiene, and also, was offered three hours per week for the grades 1 and 2 and two hours per week for the grades of 3, 4 and 5.

The weekly schedule for the course of nature inspection, agriculture and hygiene in the 1926 program is given in Table 2 (MONE, 1926):

Table 2. Weekly Schedule for the Course of Nature Inspection, Agriculture and Hygiene for Primary School

COURSES	1. grade	2. grade	3. grade	4. grade	5. grade
Nature inspection, agriculture and hygiene	3	3	2	2	2

1936 Program

The 1936 education program had significant changes. During this period the revolutions were completed and in use. Therefore, the program fully represented the views of the state on the educational topics. Hence, the 1936 education program is very significant (Kıncal, 1993). In contrast to the 1926 education program the new one had much clearer and plain structure. All expressions about teaching and education were consistent with the premises of educational sciences. In the program the course of life sciences covered the topics related to science for the first level (the first three grades) and such topics were included in the course of "Nature Knowledge" which was delivered to the grades of 4 and 5 for three hours per week.

Table 3. Weekly Schedule for the Course of Life Sciences and Nature Knowledge in the 1936 Education Program

COURSES	1. grade	2. grade	3. grade	4. grade	5. grade
Nature Knowledge	-	-	-	3	3
Life Sciences	5	6	7		

1948 Program

In 1946 Turkey adopted a multi political party system which required the adoption of a democratic education. In order to meet this requirement in 1948 a new education program was developed (Binbaşıoğlu, 1995). In the 1948 education program the goals of each courses were explained and given in terms of the expected teacher behaviors. These statements were expressed in the form of general aims. The program also included the subject list and the teaching materials and equipment for each course. It also covered the basic reasons for taking the courses. Although a separate section for the evaluation was included in the program it was explained through some clues (Tazebay et. al., 2000). The program also included the major goals of national education in terms of "social, personal, interpersonal relations and economical life" (Binbaşıoğlu, 1995). The weekly schedule for the course of natural knowledge included in the 1948 education program is given in Table 4:

Table 4. Weekly Schedule for the Course of Natural Knowledge Included in the 1948 Education Program

COURSES	1. grade	2. grade	3. grade	4. grade	5. grade
Natural Knowledge- Family Knowledge-Agriculture-Business	-	-	-	3	3
Life sciences	5	6	7		

In the 1948 education program the science topics were given under the name of "life sciences" for the first, second and third grades and were covered under the courses of "natural knowledge", "family knowledge" and "Agriculture-Work" for the fourth and fifth grades. In the program it was assumed that "the course of life sciences is a course of observation, experience and practice" and that "this course attempts to make students comprehend the natural and social facts in consistent with their mental development."

1968 Program

Like in the 1948 science education program in the program which was developed in 1968 science-related topics were covered in the course of life sciences for primary students. In the program the following definition was given for the course: "the course is one which is dependent on observation, practice and experiment" which makes it a science course. In the 1968 primary education program, the course was named as "science and natural sciences" which was a combined version of the natural knowledge, agriculture-work and family knowledge. One of the most distinctive feature of the course, science and natural sciences was that the topics taught were regarded as a whole in terms of knowledge and understanding. The program followed the "unite approach". It did not cover an analysis of goals-behavior. An active student participation was recommended. The weekly schedule for the course of science and natural knowledge included in the 1968 education program is given in Table 5:

Table 5. Weekly Schedule for the Course Science and Natural Knowledge Included in the 1948 Education Program

COURSES	1. grade	2. grade	3. grade	4. grade	5. grade
Science and Natural Knowledge	-	-	-	4	4

The goals of the science and natural knowledge course covered in the 1968 education program were to introduce students the environment in which they live and to make them in harmony with it. The program aimed to educate the children in the home and family life as individuals who were familiar with the environment and who were able to meet their needs and help themselves in their environment. In order to achieve these aims the program considered children to be taught the knowledge of science more intensively. This program, which paid much more importance to observation rather than experiments, to knowledge rather than practice and to memorize the content rather than thinking, researching, practicing and questioning it. It was a teacher-centered program and failed to provide an active student participation. The science and natural knowledge program developed in 1968 was revised both in 1974 and in 1977. As result of these revisions the course was renamed as "science", and some content of the units were changed. Çilenti argued that the program put emphasize on the philosophy of social benefits and technology and on the principle of transmitting knowledge to students through scientific process. There were no independent science courses in the first three classes of primary schools. Some science subjects were included in the life science courses in these grades. In the life sciences programs instead of scientific methods to be used in teaching science-related topics the premises of social benefits were emphasized.

In 1992 science education program, the laboratory method began to be used in the courses which was not covered in the science education program of 1968. The aim was to present students the experimental dimensions of the topics and concepts taught. It was thought that learning experience in laboratories would facilitate the understanding and learning of the topics by students. The program of 1992 also stated that the interaction between human beings and their environment is mutual. Both the positive or negative impact of the environment on human beings and the benefit or harm to the environment by human beings are of great importance in this interaction. It was also thought that presenting this knowledge to the student within the framework of science courses would enable them to understand the causes and consequences of human-environment interaction and cause them to become aware of their behavior in relation to environment. This program seems to be much more comprehensive than the 1968 program. But it still emphasized the teaching of the content and this was leading to its failure to teach science taking into consideration its environment dimension.

The science education program developed in 2000 aimed to train individuals who were actively interested in their environment and the world, were able to generate reasonable questions and to collect and analyze the data through experiments, to report their information using appropriate ways, who are responsible, knowledgeable and science literate. It adopted *the constructivist method* and it was developed as a student-centered program. The program was totally different from all science education programs developed until that period. This program was designed to maximize student participation by making them more active, to make teachers to assume the role of a guide and, above all, to learn the content by students' own effort and participation.

In the science program which was put in use in 2005 the approach of "producing science literate citizens" was adopted. It was developed based on the constructivist approach. The task of teachers is not to transmit the information in the textbooks to students, but to guide them to make them as active participants of their learning. This approach assumes that learning is a totally individual activity. Individuals can learn what they want using their own method whenever they want. This program was student-centered and supports the idea that students learn by doing, experiencing and thinking about. Therefore, basic approaches related to the teaching and learning process and evaluation process of the fourth and fifth grade science and technology courses of the 2005 program were completely different from the previous approaches adopted.

The weekly schedule of the science and technology courses of the 2005 program are given in Table 6a and 6b:

Table 6a. Weekly Schedule for the Course of Science and Teachnology for Primary Grades

COURSES	1. grade	2. grade	3. grade	4. grade	5. grade
Science and technology	-	-	-	3	3

Table 6b. Weekly Schedule for the Course of Science and Technology for Secondary Grades

COURSES	6. grade	7. grade	8. grade
Science and technology	4	4	4

The major focus of the program can be stated as follows (MONE, 2005):

- Instead of supporting memorization a new perspective was proposed in which skills and understand were improved and which is based on reasoning. It is aimed to train students who are searching, questioning, examining, critically thinking and making decisions independently.
- It is proposed to give the basic information required in the student's life instead of intense knowledge transfer. Students would obtain this information as a result of their own experiences.

- A student-centered teaching approach was adopted instead of a teacher centered teaching approach which aims at giving information to students. Teachers are just a guide.
- It is proposed to emphasize individual differences of students. Students in a classroom have different individual characteristics and different abilities. They all have a different mental and emotional world. It is aimed that these differences will be emphasized and everyone will learn by experiencing and doing.
- The program content is based on a spiral approach. Therefore, the basic concepts are discussed in each class. However, as the upper classes were passed, the depth of the gains increased and the scope expanded.

Given that the major goal of the science and technology course is not just to provide information to the students, there are seven learning domains which all support the science and technology literacy. Four of them are "Living Beings and Life, Matter and Phase, Physical Events, Earth and Universe". These are about basic science concepts and principles. There are three more learning domains which are directly related to science and technology literacy: Scientific Process Skills, Science-Technology-Society-Environment, Attitudes and Values (MONE, 2005).

In 2012 the educational system of Turkey was modified and it was called 4+4+4 system. In parallel to this change the education programs began to be updated from 2012 - 2013 (MONE, 2012). The education program for science courses was developed in 2013 in consistent with this change. The revised program addressed the grades of 3, 4, 5, 6, 7 and 8 (MONE, 2013). In February 2013 the board of education and discipline of the MONE passed a new regulation naming the course as science course which was first delivered to the fifth grade students from the school year of 2013-2014 and which was delivered to the third grade students from the school year of 2014-2015. The weekly class hours for the 3rd and 4th grades are 3 and for the 5th and 8ht grades is 4 (MONE-TTKB, 2013b). Table 7a and 7b show the weekly schedule for the science courses for primary grades and secondary grades as stated in the 2012 education program.

Table 7 a. Weekly Schedule for the Course Science for Primary Grades

COURSES	1. grade	2. grade	3. grade	4. grade
Science	-	-	3	3

Table 7 b. Weekly Schedule for the Course Science for Secondary Grades

COURSES	5. grade	6. grade	7. grade	8. grade
Science	4	4	4	4

In the 2018 science education program (which addresses the grades of 3, 4, 5, 6, 7 and 8) the interdisciplinary inquiry based learning approach adopted (MONE 2018). A holistic perspective has been adopted in the newly accepted science education program in terms of learning-teaching theories and practices. It is generally dependent on a learning strategy which supports the responsibility of students for their learning and active student participation. This strategy specifically relies on inquiry based learning and the transfer of knowledge. In this process, students undertake the role of the individual who investigates, questions, explains, discusses and transforms the source of knowledge while teachers assume the role of encouraging and guiding. It is aimed to integrate science with mathematics, technology and engineering and to make students investigate the problems from an interdisciplinary point of view. In this context, the primary role of teachers is to provide the students with the guidance to integrate science, technology, engineering and mathematics to reach their potential level of higher-order thinking, product development, invention and innovation. Teachers are the guides who share the value and importance of the science and the responsibility and excitement of achieving scientific knowledge with their students and also direct the research process in their class. Teachers encourage the students to develop the spirit and emotion of research and the scientific way of thinking and encourage them to adopt universal values of ethics, national and cultural values, and scientific ethics in practice. Students will be able to communicate and collaborate effectively with their peers when they investigate the information.

Field specific skills are included in the Science Course Curriculum published in 2018 are as follows:

a) Scientific Process Skills

b) Life Skills (Analytical Thinking, Decision Making, Creative Thinking,

Entrepreneurship, Communication, Team work)

c) Engineering and Design Skills (Innovative thinking)

According to the 2018 science education program, the weekly science course schedules in the primary and secondary Schools are shown in Table 8a and Table 8b:

Table 8a. Weekly Science Courses of Primary Schools

COURSE	1. grade	2. grade	3. grade	4. grade
Science	-	-	3	3

Table 8b. Weekly Science Courses of Secondary Schools

COURSES	5. grade	6. grade	7. grade	8. grade
Science	4	4	4	4

An analysis of the science education programs in terms of activity patterns

The 1968 science education program did not include any information about experiments and teaching activities During the lessons, what activities would be done was left to the teacher. The units covered some problems related to the subjects. Teachers were asked to make observations and experiments on these problems. In the program, it is stated that experiments and observations should be done in three ways (continuous, when needed and immediately) and the explanations about the activities are given as follows:

1. Each unit should be introduced with an interesting problem to ensure that the students work on their own. The topics should be prepared in advance.

2. Students who have acquired a certain level of knowledge and skills should be given homework in advance for examinations, observation and experiments. They should collect information about the topics assigned and bring it to the class.

3. The summary of the subjects covered in this course should be written by students. Children should enrich them as much as possible by making drafts, sketches, graphics, cut pictures, and flat samples and use them in the collections that they will be asked to prepare.

4. These studies should be carried out in the garden of application in order to ensure that the agricultural studies covered in the Science and Natural Knowledge are taught and learned in the desired way.

5. In their work, the teacher should benefit not only from his / her knowledge and skills but also from the people in the immediate environments who have the best and most advanced knowledge, and s/he should make it possible to get help from them.

When we look at the activity descriptions given in the program, it is seen that there is not so much room for both research and questioning. Providing students with a certain knowledge and skill instead of all students reduces the participation of students in the course.

The laboratory dimension was added to the activities with the 1992 program. Therefore, students would have a chance to learn by experiencing the concepts and the unit title. The students would be able to record the findings of the laboratory studies, the results of their observations and would have information and experience about the use of the data. In addition, they would comprehend the significance of using equipment and tools and their skills would be improved. They would also comprehend the importance of studying in a planned way and have an ability to plan their studies. The activities included in the 1992 program were designed from the activities covered in the 1968 program. Here all experimental processes are discussed in detail. Those students who dealt with the process of hypothesis development and testing; identifying and controlling variables; identification; model creation; experiment editing would both observe teacher and do themselves. Therefore, they would better comprehend the problem. Students were more actively involved in the teaching and learning activities of the 1992 science education program than those of the 1968 science education program. However, the activities covered in this program were mostly science-based.

The activities included in the 2000 science education program were somewhat different from those included in the 1992 science education program in that these activities began to emphasize technological topics in addition to science related ones. The teaching and learning activities were included in the program as well as the flexibility of the teacher was left to make changes in these activities if necessary. On the other hand, the activities in this program were mostly student-centered. Students realize what they are doing as well as acquire the information themselves, and therefore, what they learn becomes permanent. In addition, different methods and techniques were adopted in this program to make all students comprehend the topics covered in the courses.

Although the Science and Technology education program which was developed in 2004 covered many innovations, it is similar to the education program which was developed in 2000. The 2004 education program adopted and followed an understanding which centered on students just like the 2000 education program. As can be seen in the pre-1992 educational programs, the educational philosophy in which the student is a passive recipient of knowledge and teacher is dominant was adopted. According to this philosophy, transferring cultural heritage to future generations constitutes the basic aim of education. In the fundamentalist philosophy of education, there is the teacher at the center of education, and the student is the passive recipient of knowledge. The information that the teacher transmits to students is certain and accurate. This information, which is memorized, aims to convey the culture of the society from generation to generation (Küçükoğlu & Bay, 2007).

The 2004 education program is based on the “constructivist approach” and the 2013 education program is dependent on the inquiry based learning approach” which is based on the constructivist approach. The vision of both programs, on the other hand, is the same. It states that the goal is to educate science literate individuals independent of their unique individual differences. The inquiry based learning approach which is based on the constructivist theory helps students develop an understanding of ”learning to learn and high-level thinking” skills (critical thinking, creative thinking, reflective thinking, analytical thinking). It allows the students to actively participate in the learning process.

Science education is a field which pays importance to experiments, observation and discoveries as well as to the questions asked by students, student research, hypotheses and their interpretation of the results (Çilenti, 1985; Odubunni & Balagun, 1991). Science education has been delivered using distinct teaching and learning methods and techniques. One of these methods is the use of laboratories by first hand in science education (Lawson, 1995; Hofstein, Nahum & Shore, 2001; Hofstein & Lunetta, 2003; Hofstein & Naaman, 2007; Kirschner & Meester 1988).

History Of Laboratory Use in Science Education

Laboratories can be regarded as places where experimental studies with various equipment and devices and analyses as well as observations are carried out. In the last century the number of laboratories increased and nearly all disciplined had their own laboratories. In Turkey almost all high and secondary schools have their physics, chemistry and biology laboratories and universities also have highly specialized versions of them.

In the USA science education was first regarded as the study of nature philosophy (Elliott, Stewart, & Lagowski, 2008). Early American leaders such as Franklin and Jefferson partly emphasized the significance of science education (Fay, 1931; Newell, 1925). Laboratory education and laboratory methods were not used in the USA until the mid-19th century. The history of laboratory education informs us about its development. Although there are chemistry laboratories both in the USA and in Europe, the use of laboratories for educational purposes originated in Germany (Good, 1936). There were education laboratories at the end of the 1700's in the USA, but the influence of German scholar Justus Von Liebig made the laboratory education much more widespread (Browne, 1941; Fay, 1931; Fife, 1975; Sheppard & Horowitz, 2006; Sheppard & Robbins, 2005).

Reforms about the improvement of science education programs in the USA soon affected the science education in Europe and similar educational activities began to be used. Such reforms covered the improvement of the contents of science and mathematics courses. Following World War I, a discussion about the necessity of laboratories for educational purposes was started. This discussion focused on the following questions: "should questions do experiments at the laboratories to learn?" and "Could students learn science only through the technique of demonstration?". Following World War II the questioning of the use of laboratories for educational purposes became uncommon. At the same time the significance of science education was again recognized. It was assumed that laboratories were one of the valid and valuable teaching methods in science education. Probable reason of these actions are significant scientific findings during war. Questions about laboratory evaluated as how is laboratory education should be. Based on these views educational programs were revised around 1960's and laboratories began to be part of these programs.

The educational programs developed in Turkey before 1992 were based on the essentialist educational philosophy. In this approach teacher is in the center of the teaching process and students are passive recipient of teaching. The knowledge transmitted by teachers is accurate and correct. It is mostly memorized by students and aims at transmitting the culture from one generation to another. The educational programs developed and implemented before 1992 did not include the laboratory work. With the use of the 1992 science education program the laboratory method began to be used unlike the 1968 science and nature education program. Thanks to this change, the students would be able to see the topics and concepts they learned in the course from an experimental aspect. The laboratory method was continued to be used in all the programs prepared later. However, it should be noted that in the 1992 science education program teachers were still at the center. The 2005 science and technology education program was developed based on the "constructivist approach". This approach assumes that teachers should be the guides of the teaching and learning process and students should be active participants of the process (MONE, 2005). The 2013 science education program was developed based on the "Inquiry-Based Learning" which is part of the constructivist approach (MONE, 2013).

In the new educational programs students were at the center of the teaching and learning process, and these programs emphasized learning through "experiencing and thinking". The current educational program which attaches importance to experiential learning and inquiring, emphasizes that permanent learning will be more in the learning environments where the individual actively participates. Experiments, observations and learning activities in which the scientific process steps are followed contribute to the development of the psycho-motor skills of individuals as well as helping to improve their high-level thinking skills. In short, the importance of laboratory practices in the application of theoretical knowledge to the practice of science, which is an applied discipline and heavily based on experiments and observations, is an undeniable fact. The new educational programs focus on the laboratory method. In last decade where scientific studies and technological developments are increasing and developing day by day, the primary aim is not to produce individuals who only consume but to train those who develop new knowledge and employ it in technological processes. Today the information production is at the highest level. Therefore, individuals should be trained to keep up with such advances and changes. In order to achieve this, it is needed to provide learning environments where experiential learning is implemented, where individuals can work freely and make decisions, and where science laboratory applications are predominant (Böyük, Demir & Erol, 2010). Laboratory practice is an integral part of science education and encourages students to questioning and scientific thinking. Laboratory applications improve students' skills such as observing, classifying, collecting data, making explanations and designing and testing experiments. These applications give students the ability to explain and interpret the events around them (Aydoğdu and Kesercioğlu, 2005). Laboratory applications have an important place in achieving the stated goals of the science courses. However, research suggests that the use of laboratory in science courses is not sufficient. For instance, the importance of laboratory activities in science courses is not emphasized enough due to following reasons; teachers' lack of adequate laboratory practices, lack of laboratory equipment and chemical materials, the idea that the experiments may be dangerous, the insufficient knowledge of waste disposal, the inability of the use of the laboratory due to the crowded classes, the inadequacy of laboratories and the large number of class sizes (Akkuş & Kadayıfçı, 2007; Kılıç, Keleş & Uzun, 2015; Çepni, Kaya, & Küçük, 2005; Aydoğdu, 1999; Demir, 2016; Aydoğdu & Şener, 2016). A number of innovations have been made in the laboratory approaches as a result of the changing educational programs. Teachers need in-service training to improve themselves in order to follow these changes and to keep up with this innovation. Therefore, it is important that teachers should be informed about innovations and changes about laboratory usage techniques and laboratory safety (Kılıç, Keleş & Uzun, 2015). Safety is the most important issue that should not be forgotten while performing any activities in the laboratory. Safety measures taken during laboratory practice should be provided not to restrict practical work, but to enable teachers and students study in a safe environment (Yılmaz & Morgil, 1999).

Accidents and Safety at School Laboratories

Laboratory work is the basis for and indispensable part of science education and all technological research. Individuals could only use their theoretical knowledge of science in laboratories which makes their learning much more permanent. Research indicates that laboratory work is necessary for successful science education, but that laboratory work is not at the desired level (Erten, 1991; Aydoğdu, 1999; Gürdal, 1991; Alpaut, 1993; Ayas et. al., 1994; Ekici, 1996). There are many factors of ineffective laboratory work. Such factors include negative school and laboratory environment, lack of necessary equipment and devices, crowded classes, teachers' lack of necessary information about teaching and learning materials and about laboratory work. Another factor contributing to underachievement in science education is related to teacher training programs, which could not produce qualified teachers (Nakiboğlu and Sarıkaya,1999; Nakiboğlu and İşbilir, 2001; Çallıca et. al., 2001; Güven et. al., 2002;

Stephenson vd., 2003; Uluçınar, Cansarar and Karaca, 2004; Kaya and Böyük, 2011; Raju, T. J. M. S., & Suryanarayana, N. V. S. 2011; Aydogdu, 2015). In addition to these difficulties there occur many accidents during the laboratory work, which cause physical injury and even death (Aydogdu, 2015; Aydoğdu, & Yardımcı, 2013; Aydoğdu, & Pekbay, 2016).

Alcohol Burst

21 Kasım 2006

At The Primary School Laboratory In Bolu A Tube Filled With Spirit Exploded During The Experimental Study Of The Fifth-Grade Students And Three Students Were Wounded.

It is reported that at Ayşe Yılmaz Becikoğlu basic education school in Doğancılar village students and their teacher İ. A. were conducting an experiment in which they were observing the power of steam resulted from boiling water. When science teacher İ.A. poured ethyl alcohol on fire alcohol tube exploded. As a result of the explosion the fifth-grade students M.İ., B.K. and D.K. were burnt and wounded. Students were taken to Bolu İzzet Baysal Hospital. Parents rushed into the hospital and wounded students said "We were conducting an experiment. Suddenly an explosion occurred. We did not understand what happened.". It is reported that they had no life-critical situation.

Source: http://www.habervitrini.com/haber.asp?id=248562-21 Kasım 2006

Tube Explosion at Science Lab, Two Students Wounded

18.12.2008

In Kazan at the science laboratory of Tahsin Şahinkaya basic education school experiment tube was exploded during the experiment. Hands of two students were wounded as a result of the explosion. They were taken to a hospital in Ankara. Kazan district governor Özlem Bozkurt Gevrek reported that they were taken there to control their situation.

Source:http://www.cnnturk.com/2008/turkiye/12/18/okulda.deney.tupu.patladi.2.yarali/505307.0/index.html-18.12.2008

Thinner Poured into Stove Killed

In 2003 a student poured thinner into the stove at the Ortadirek village basic education in Ağrı Doğubeyazıt district and it caused explosion. Although most of the students were in the garden during the explosion, the student poured thinner into the stove was killed. The school administrator who threw the can full of thinner and another person who tried to help both seriously injured in the explosion. The student poured the thinner in to the stove. The school administrator Kayalar (23), who saw the event tried to help but she was also burnt. The teacher Uysal (25) was also burnt. Another teacher Elif Tezcan broke the window to help the other students in the classroom. Injured people were taken to the hospital in Diyarbakır. However, the student died on the way to hospital.

Source:http://blog.milliyet.com.tr/yanginlar-icinde-yuregim--aysun-veburcin%20ogretmen/Blog/?BlogNo=215461

They Were Burning During Experiment

21.11.2006

The alcohol caused explosion during the experiment. In the event four students were injured. In Doğancı village basic education school in Bolu province the fifth-grade students were conducting an experiment with their teacher in the course of science and technology. The alcohol used in the experiment burst into flames. The students

Murat İpek, Burcu Koçak, Deniz Koç and İsmail Okay were injured. They were taken to theme village clinic. Then they were taken to a hospital in Bolu. Three students received outpatient treatment at the hospital. The other one treated at the ambustion service. Ten-year old Murat İpek injured from hands and face reported that they were conducting an experiment which shows how steam moves wheels. İpek reported: "We would heat the water in tubes using water. We tried to fire, but we could not manage. Finally, we did it, but the fire died down. The teacher poured alcohol on it and an explosion occurred."

Source:http://www.yenisafak.com.tr/gundem/?t=21.11.2006&q=1&c=1&i=15970&Deney/yaparken/yanıyorlardı/

Test Tube Exploded: 2 Students Wounded

09.12.2011

Experiment tubes used in the experiment in Yüzüncü Yıl Atatürk basic education school in Kocaali exploded. Two students were wounded and taken to the hospital. The sixth-grade students Mert Erkan K. and Furkan T. were conducting an experiment in the course of technology and design. During the experiment, experiment tubes exploded due to the student mistake. They were taken to the hospital. Furkan T. received an outpatient treatment, but Mert Erkan K. İs still at the hospital. The father of Mert Erkan K. Özgür K. reported that the explosion occurred during the experiment.

Source: takvim.com.tr /09.12.2011

Unfortunate Accident in School Lab

21 November 2015

*Ten students wounded in the acid-caused explosion at chemistry lab of a private high school in Tunceli. It is reported that ten students wounded in the acid-caused explosion at chemistry lab of a private high school in Tunceli. According to the reports the tenth-grade students at Private Özel Munzur science high school were doing an experiment at the chemistry laboratory when an explosion occurred. It was due to acid use. In the explosion ten students were wounded. They were taken to Tunceli Public Hospital through ambulances. **"seven of wounded students were discharged** Tunceli local education director Ali Eyyüpkoca reported that the tenth-grade students at Private Özel Munzur science high school were doing an experiment at the chemistry laboratory when an explosion occurred.*

Source:http://www.trthaber.com/haber/turkiye/okul-laboratuvarinda-talihsiz-kaza-217446.html

Experiment at the School Made a Student Blind: My Tears Hurt Me

21 December 2014

*As a result of the accident during the experiment at a school in İstanbul eyes of a student aged 11 were burned! As a result of the accident during the experiment at a school in Uskudar district of İstanbul eyes of a student aged 11, **Mert Öztoprak**, were burned. Mert stated "I could not see anything. I always cry and my tears hurt me. I will never forgive my teacher who darkened my future". According the **news by Gökhan Karakaş** in*

Milliyet newspaper, on 3 December the sixth-grade students at Ali Fuat Başgil secondary school in Uskudar district of Istanbul were doing an experiment in the laboratory in science course. Science teacher Mehmet Aslan told the students that he would explain the mixture of zinc and mercury using an iron tube. The teacher added that a metal container would be used since the resulting substance could melt a plastic container. The teacher, Mehmet Aslan, asked 11-year-old Mert Öztoprak to help him. He gave the iron tube to Mert and began to pour the zinc and then the liquid mercury. While the student was mixing them using the iron tube the teacher blowed the iron tube. Then it caught fire.

'I will never forgive him.'

Mert had four operations in a week. When he learned that if he used a glass of which price was five liras this event would not, his sorrow increased. Mert reported "While the teacher were pouring mercury into zinc he blowed the iron tube. Then it was exploded in my hand. I recognized that my eyes burned and I extinguished the fire on my hair. He told us that he was a bit clumsy and that he burned his jacket or apron in the experiments. But he fired my future this time."

Source:http://t24.com.tr/haber/okuldaki-deney-kor-etti-gozyaslarim-bile-bana-aci-veriyor,281120

Explosion During an Experiment at a Private School: Two Wounded

03.12.2014

An explosion occurred during the experiment at the science laboratory of a private school in Üsküdar. Teacher Mehmet Aslan and 11-year-old student Mert Öztoprak were injured in the explosion.

The event occurred yesterday at 17.00. The explosion of which the reasons are not clear wounded both the teacher Mehmet Aslan and the student Mert Öztoprak who were helping his teacher. They were both taken to Haydarpaşa Eğitim ve Araştırma Hospital. The face of the teacher burned and he treated at the hospital. The student was wounded from his face and eyes and he was transferred to Kartal Eğitim ve Araştırma Hospital. His treatment is still going on and it is learned that he will had an operation.

Mert Öztoprak's parents and relatives came hospital whenever they heard the accident. His mother Ayşe Öztoprak said "I just sent my son to the school, not to the war. I will sue those people who responsible for his injuries." She added "My son's eyes burned. One his eyes may not see again. How an experiment is this? Students do not use gloves and glasses at the laboratory. Why was my son so near to the experiment? Not my son but another student may be injured at the laboratory. I will sue those people who responsible for his injuries."

Source:http://www.hurriyet.com.tr/ozel-okulda-deney-sirasinda-patlama-2-yarali-27699269

Explosion at the Laboratory During the Experiment

04.03.2015

During an chemistry experiment at the laboratory of Yalova Vocational and Technical Anatolian High School an explosion occurred. Teacher Mustafa Keskiner was injured in the explosion. Parents called for the steps to be taken in order to avoid accidents and wanted that until these steps are implemented all dangerous experiments at the laboratories should be cancelled.

It is reported that the explosion occurred when sodium was contacted with water. Due to the explosion teacher Mustafa Keskiner was injured from his hands and face. He was taken to the hospital. The students were affected by the smoke.

Source:http://www.hurriyet.com.tr/deney-yapilan-laboratuvarda-patlama-28361081

Explosion at a Basic Education School: 6 Wounded

04.06.2012

Spring festival was organized at a basic education school in Kağıthane district of Istanbul. One of the activities covered in the festival was an experiment work. It is reported that an explosion occurred during the experiment. Six students were injured in the experiment. Teachers working at Zuhal basic education school organized a spring festival near to the end of the semester. One of the activities covered in the festival was an experiment work. It is reported that an explosion occurred during the experiment. Six students were injured in the experiment.

Source:http://www.hurriyet.com.tr/ilkogretim-okulunda-patlama-6-yarali-20689960

Therefore, studies at laboratories have some certain risks. It requires that at laboratories there should be a safe working environment (Yılmaz, 2005). Research strongly suggests that necessary information about chemicals should be given before their use in the experiments (Long 2000; Yılmaz 2004a and İdin, Ş. and Aydoğdu, C. 2016). It is certain that safety is the key consideration in all experiments. Safety-related rules are developed and employed not to limit the practical work, but to provide a safe working environment at laboratories (YÖK, 1997). Laboratory safety include the following topics: taking steps to eliminate all kinds of threats towards equipment, machines and tools, teachers, students and school facilities during experiments and other related activities and adopting a scientific approach towards all potential problems (Canel, 1995**).**

Although having information about experiment equipment and tools and about the use of chemicals, it is also important to take steps to mark and store chemicals. Research emphasizes that protecting from dangerous effects of chemicals and from potential danger is significant not only for human safety but also for laboratory facilities and materials (Richards-Babb, Bishoff, Carver, Fisher, & Robertson-Honecker 2009; Wu, Liu, & Lu 2007; West, *Westerlund*, Nelson, Stephenson, & Nyland 2002; Yılmaz 2005; Yılmaz 2004). Yılmaz, Uludağ and Morgil (2001) concluded that undergraduate students do not have higher levels of information about the toxic effects of some solutions and materials and about the protection in organic chemistry laboratories. Therefore, basic education should be much more cautious in work at laboratories. At the laboratories of basic education schools and high schools not many chemicals should be used. Instead, other familiar materials can be used in these experiments to avoid accidents. It is seen that the major reason for accidents at school laboratories is teachers. Teachers should have and adopt a well-established and proper approach towards accidents and risks at laboratories and have necessary education and training on the subject. In order to achieve it teacher training programs may cover courses on laboratory safety and norms. In addition, textbooks should inform both teachers and students about materials to be used in experiments covered. Yılmaz (2005) analyzed the experiments included in chemistry textbook for the first grade of high schools and reviewed the information given regarding these experiments in terms of laboratory safety, chemicals and other relevant points. It was found that textbooks provide no information concerning laboratory safety and about the safety notes on chemicals. Laboratory use techniques include information about the characteristics of chemicals to be used in experiments, safety rules, how to take steps to avoid accidents at laboratories and how to react when an accident occurs at laboratories. It can be defined as a way to be familiar with the characteristics of chemicals to be used in experiments, safety rules, how to take steps to avoid accidents at laboratories and how to react when an accident occurs at laboratories and the scientific approach towards each of these points (Aydoğdu and Candan, 2012).

Laboratories are one of the most effective environments in the schools where experimental studies are carried out and permanent learning is realized by doing. It is thought that laboratory applications positively contribute to the development of psycho-motor skills and meaningful and permanent structuring of the knowledge learned. Such activities encourage students to make research and solve problems. At the same time, it is known that these activities contribute to the use of manual skills and development of communication skills (Hofstein ve Lunetta, 2004). Experimental accidents are among the top events that reveal the importance of laboratory safety. By identifying the characteristics of different experimental accidents that may occur in the laboratory, the awareness about these accidents will be provided in addition to contributing to the development of taking measures against risks.

Şener (2017) analysed the accidents occurred in science laboratories of schools during the years between 2000 and 2016. The study found the data on such accidents by the education level. Table 1 shows the frequency and percentage of these accidents as follows.

As can be seen in Table 1 In 52 news on accidents a total of 63 accidents was reported. By educational levels it is seen that ***8% of these accidents occurred at university level, 24% of these accidents occurred at high school***, ***27% of these accidents occurred at secondary schools and 41% of these accidents occurred at primary schools.*** The rate of the accidents in laboratories of basic education constitutes ***68%*** of all accidents. These findings suggest that both primary school teachers and secondary school teachers should be trained in relation to laboratory practices.

Table 9. Frequency and Percentage Showing the Occurrence of the Accidents in Schools According to Educational Levels

Educational Levels	*F*	*%*
Elementary School First Level (1-5)	17	27
Elementary School Second Level (6-8)	26	41
Highschool	15	24
University	5	8

Note: In 52 news on accidents a total of 63 accidents was reported.

Table 2 indicates the relationship between the educational programs modified and the laboratory accidents at different educational levels.

Table 10. Statistical Relationship between the Educational Programs Modified and the Laboratory Accidents at Different Educational Levels

Educational Programs	Elementary School First Level	Elementary School Second Level	Highschool	University	Total Accidents
2000 – 2004	2	—	—	—	2
2005 – 2012	7	16	6	3	32
2013 – 2016	8	10	9	2	29
Total Accidents	17	26	15	5	63

Note: In 52 news on accidents a total of 63 accidents was reported.

As Table 2 shows that of 52 accidents there were only two laboratory accidents at primary school between 2000 and 2004. During the same period there was no news on laboratory accidents at high schools and university. During the period between 2005 and 2012 there were seven accidents at primary schools and 16 accidents at secondary schools. The highest number of accidents was during ths period at basic education institutions. In the primary school the accidents were mostly reported to occur due to mercury poisoning. During this period there were six laboratory accidents at high schools and three accidents at universities. Of 52 accidents 32 occurred during this period. Between 2013 and 2016 there were eight laboratory accidents at primary schools, ten accidents at secondary schools, nine accidents at high schools and two accidents at universities. From 2005 to 2012 there were 23 laboratory accidents at basic education institutions and six accidents at high schools. During the years between 2012 and 2016 there were 18 laboratory accidents at basic educaton institutions and nine accidents at high schools. It is seen that the laboratory accidents decreased at basic education institutions during the period analysed while these accidents increased at high schools.

Tekbıyık et. al. (2017) analysed the laboratory accidents and experiment-related accidents in Turkey between 2001 and 2017. They found out 34 accidents occurred in laboratories. It was also found that the highest number of experiment-related accidents occurred at the course of eightht grade science and technology courses. The highest number of accidents occurred in 2012.

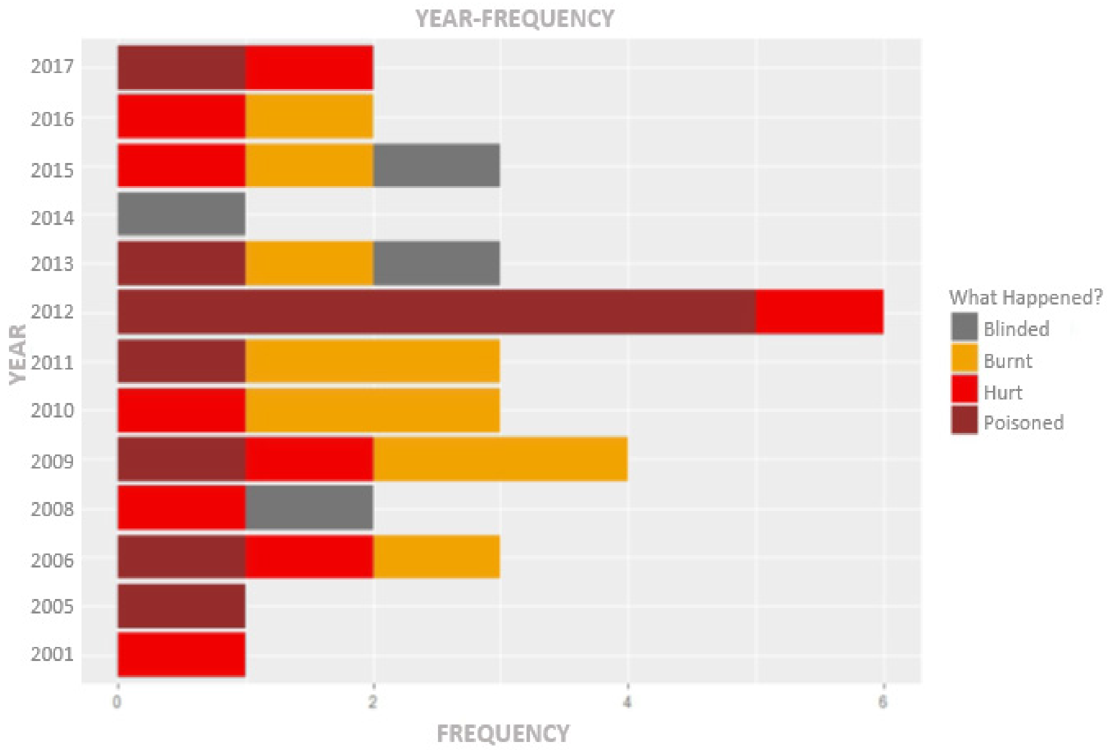

Figure 1. Changes in Health Problems Caused by Accidents Over The Years (Tekbıyık et. al., 2017)

As can be seen in Figure 1 the accidents that resulted in poisoning have occurred the most frequently and burning and injury cases were also experienced intensively. In addition, the accidents that resulted in loss of vision also occured. The most frequent reason for accidents was found to be test tube explosion. These accidents caused serious health problems such as burning, injury and vision loss. In addition, there were also cases of injury as a result of contact with mercury poisoning and burning of fumes in the stove. These cases were also frequent.

In 2009 the General Directorate of Pharmaceuticals and Pharmacy of the ministry of health reported “the introductions of mercury thermometers into the market and their use were hazardous to health and safety for measuring body temperature” and their sales were banned (URL-1). This announcement was also transmitted to the ministry of national education and the higher education institution stating ‘’in case of inhalation of mercury vapor, it is not possible to expel from the body; mercury vapor can easily pass through the cell membrane to reach the brain and mercury vapor may accumulate in tissues over time and lead to irreversible neurological findings.”

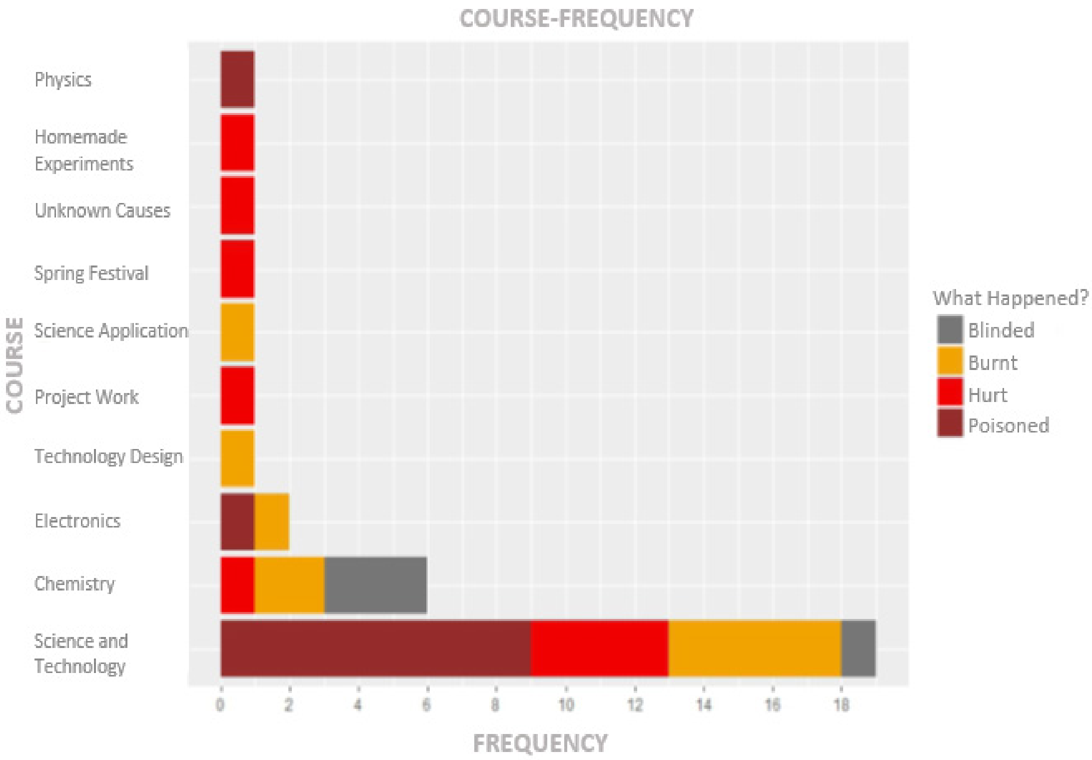

Figure 2. Changes in Health Problems Caused by Accidents by the Courses (Tekbıyık et. al., 2017)

Therefore, it was demanded "mercury thermometers should not be employed on patients, by health-care workers and by students and teachers in school laboratories in terms of health and safety concerns." (URL-1). In addition, the ministry of health declared the necessary steps to be taken in order to avoid mercury poisoning (Ministry of Health, 2013). However, the cases of mercury poisoning are still experienced suggesting that such warnings are not taken into consideration.

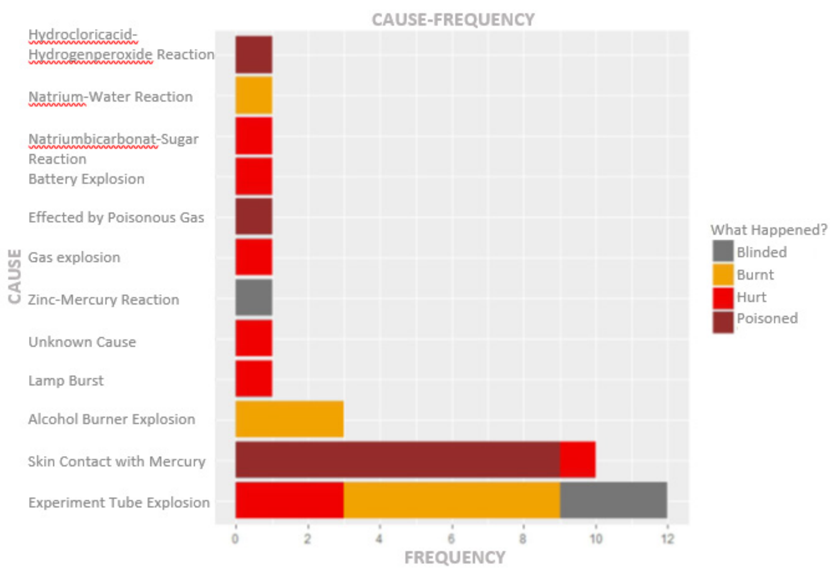

Figure 3. Changes in Health Problems Caused by Accidents Over the Causes of the Accidents (Tekbıyık et. al., 2017)

Laboratory safety

Laboratory safety refers to the process in which necessary steps are taken to avoid hazardous events at school laboratories, to arrange the space in accordance with safety concerns and to solve problems scientifically (Canel, 1995; Bayraktar, Erten & Aydoğdu, 2006; Aydoğdu & Şener, 2016; Aydoğdu, 2017).

In order to work at laboratories in a safe manner students should be informed by teachers about the potential dangers and the steps to be taken in order to avoid accidents and safety guidelines. For this purpose, teachers first should be informed about this points and if necessary, they should be informed about these guidelines through in-training activities and seminars (Hamurcu, 1998).

There are some rules that students in the laboratory should know and adhere to. Hasenekoğlu (2003) listed these rules as follows:

- Safe working in the laboratory should be given importance and it should be a habit of students.
- Individuals working in the laboratory should also pay attention to the safety of their peers.
- They should be knowledgeable about and careful against the dangers that may occur in laboratories.
- They should be informed about what to do when an emergency is encountered.
- These persons should report the dangerous situations and accidents in the laboratory to those concerned.

People should be aware of the dangers that may occur in the laboratory as well as necessary steps to be taken. In addition, they should do what to do in undesirable conditions. All procedures should be completely and correctly implemented (Bulduk, 2014). Therefore, the following points should be taken into account:

- The characteristics of the chemicals to be used should be well known. People should be careful while working at laboratories.
- The operating instructions of the tools and equipment must be read carefully and followed.
- People working at laboratories must have sufficient knowledge and skills against hazards arising from tools and equipment.
- First aid to be applied at the time of the accident should be done quickly and in accordance with the method (MONE, 2008).

Ergin, Pekmez and Erdal (2005) listed the materials required for laboratory safety in the school laboratories as follows:

- Emergency kit
- Fire extinguisher tubes
- Sand bucket
- Fire blanket
- Suitable places for eye wash
- A shower to be used in case of danger
- Safety glasses
- Smock
- Heat resistant gloves
- Protective gloves from chemicals

Label Reading and Safety Data Sheets

In order to be able to work safely in the laboratory, it is necessary to know ”label reading”. It is necessary to know the properties of the chemicals to be used and the risk pictograms on the chemical flask to prevent accidents. A regulation on the Classification Labelling and Packaging (CLP regulation) was published on 30 December 2008 concerning the classification, labelling and handling of chemicals and mixes, and it came into force on 20 January 2009. The CLP regulation aims to provide a high level of protection for human health and the environment against the risks that may arise from the harmful properties of chemicals and to ensure the free movement of substances, mixtures and articles.. Aydoğdu ve Şener (2016) produced a comparison of old hazard symbols and new risk pictograms provided by the CLP regulations as given in Figure 4.

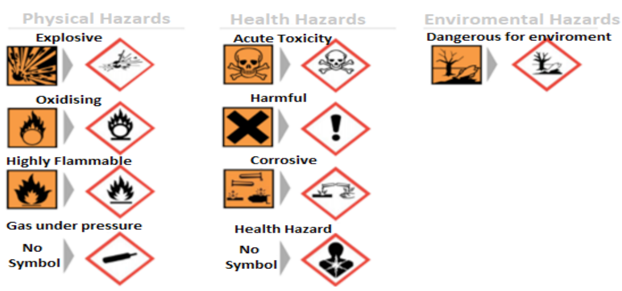

Figure 4. A Comparison of Old Hazard Symbols and New Risk Pictograms

To have more information on the chemicals used, it is possible to use the chemical safety data sheet. These forms contain the following information:

- Information about the producer
- Danger information about the product
- Content of the product
- Health and environmental measures to be taken if the product is exposed
- Measures to be taken during transport, storage and use of the product
- Classification of the product
- Things to do in case of fire and accidents
- Waste disposal information
- Toxicology and ecotoxicology information about the product

Readers of safety data sheets have complete information about the product they use. They will also know how to handle, how to store, how to handle, and how to behave if they are exposed. (Aydoğdu & Şener, 2016).

Storage of chemical substances

In the laboratory and the places where the chemicals are stored, the most frequent accidents usually occur in the form of fire and explosion. In order to prevent these accidents that may occur the characteristics of chemicals must be known, and storage should be done accordingly.

Figure 5 shows how chemicals should be stored based on the risk pictograms. In storing the chemicals th following points should be taken into consideration to avoid any accidents;

- ✓ Chemicals must never be stored in alphabetical order.
- ✓ Instead, chemicals should be stured based on chemical and physical characteristics.
- ✓ Containers in which substances are placed for proper storage must be properly labeled.
- ✓ Some chemicals require storage in a cold environment, some in a dry environment, some in a humid environment, and some in a light-free environment.

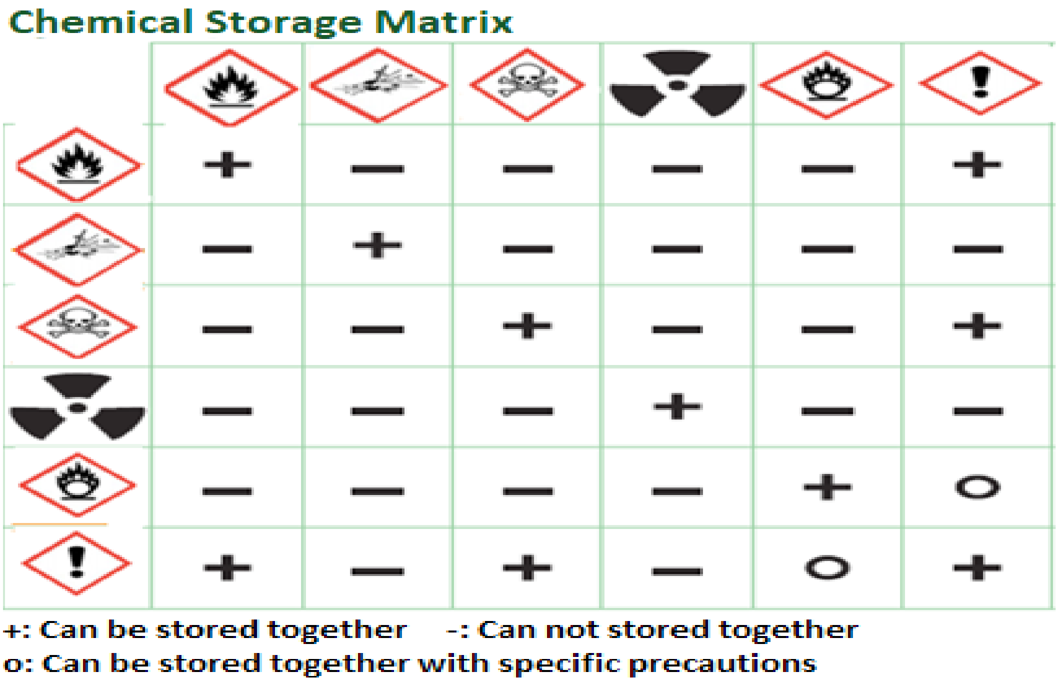

Figure 5. Storing Matrix for Chemicals

- Warehouses must be equipped with systems such as ventilation, fire fighting, alarm and insulation against heat.
- Shelves where chemical substances are placed should not be made of wood. Shelves made of materials such as iron and aluminum can cause fire by giving exothermic reactions as a result of chemical substances. It is appropriate to place more inert substances on such shelves.
- Rack heights should not exceed 2 m for easy use, should be wall mounted, and the front of the shelves should be surrounded by protection strips.
- Chemicals should be placed on the shelves according to their class codes.
- Flammable and explosive substances should be stored in fire and explosion-proof warehouses.
- An inventory system should be prepared to record all chemicals.
- Gas and smoke detector and fire warning system must be built in warehouses.
- Bottles and packages containing all chemicals must be labeled.
- Light-degradable substances should be stored in such a way that they are kept away from light and sun.
- Explosive and flammable materials should be stored away from other explosive and flammable materials.

- Materials such as white phosphorus and sodium, potassium should be stored in liquid paraffin in appropriate bottles.
- Hazardous chemicals should be kept away from sources of fire in a well-ventilated, moisture-free environment and be away from matches and lighters, etc.
- Chemicals that should never come into contact with each other should never be placed side by side on the same shelf.

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