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Analysis of the Studies Done on Laboratories in Turkey

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ABSTRACT

The aim of this study is to determine the trend of studies in the laboratory and put the current situation in Turkey. For this purpose, document analysis technique, one of the qualitative research methods, was used in the research. The data group of the research consists of thesis studies on laboratories in our country between 1999-2017. Theses in the fields of science, physics, chemistry, and biology have been determined and themes and sub-themes have been created through the keywords of these theses. Then, frequency tables were created according to the themes and sub-themes created. According to the findings obtained, it was seen that the traditional laboratory approach and inquiry-based laboratory approaches are compared in the studies. It was determined that the studies were done on physics subjects and it was determined that complementary measurement and evaluation studies performed for performance evaluation were used in very few numbers. In addition, it was concluded that the keywords did not give enough information about the studies. In this context, it can be suggested to examine the effectiveness of these approaches according to each other and experiment types by examining the approaches in which students can be more active in laboratories.

Keywords: Laboratory approaches, performance evaluation, science, theses.

INTRODUCTION

The foundations of contemporary science were laid in the 16th and 17th centuries. Scientists argued that in this process, scientific processes should be used in education (Çepni & Ayvacı, 2010). By the 19th century, British philosophers and writers stated that science was added as an inductive result (Whewell, 1858). In this context, although the laboratories have been the main component of science education in the course of two centuries, their role in science education has not been determined with a definite language (Singer, Hilton & Schweingruber, 2006). As in history and other fields, science lessons at secondary and undergraduate level were planned through lessons and textbooks, and then the information

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was asked to be read and memorized (Rudolph, 2005). In this period, it was expected from the faculty members to give information about science and nature to the students through the presentation and therefore it was observed that science laboratories were not a part of higher education (Karamustafaoğlu, Tezel & Sarı, 2018). In fact, when Benjamin Silliman founded the first chemistry laboratory in Yale in 1847, he paid rent to the college and paid it at his own expense (Whitman, 1898).

In the 1880s, universities in the USA, which were influenced by the German model, used laboratories for advanced scientific research (Singer, Hilton & Schweingruber, 2006). The primary task of these laboratories is to prepare students at universities and university laboratories. The National Education Association (1894) published a report stating the necessity of science laboratories in secondary education programs in order to prepare students for science education. Despite these developments regarding laboratories, in the 1910s, disagreements continued between scientists who emphasized traditionalism and scientists who advocated the necessity of laboratories (Rudolph, 2005). Despite these disagreements, laboratory education has been firmly established and the number of high school teachers has been increased to teach laboratory activities. These positive developments were reflected in the course materials (Brownell & Wade, 1925; as cited in Çelik, 2018). However, it has been observed that laboratories are more successful in evaluating students for targeted teaching materials, understanding students' science concepts, using scientific processes (Irwanto, Rohaeti & Prodjosantoso, 2019) and developing positive attitudes towards science.

According to Çepni and Ayvacı (2010), no science discipline can be taught fully without involving experiments. Because, the fact that the theoretically taught subjects cannot be transformed from abstract to concrete and cannot be connected with daily life causes science teaching to not be effective enough. For this reason, in science teaching, the use of activities based on observations that interact with real objects and materials carefully designed should be adhered to the knowledge of students in daily life (Millar, Tiberghien & Maréchal, 2002). Because science teaching becomes meaningful when students gain emotional development and ideals as well as their cognitive competencies (Nieswandt, 2007).

While students reflect theoretically the knowledge they have learned in the laboratory, they have the opportunity to both positively develop their attitudes towards science and laboratories and to embody abstract expressions (Özmen & Yiğit, 2005). Students' studies in the laboratory enable them to participate in the process of learning and discovering firsthand, ask questions, produce solutions, gain self-regulation and self-assessment skills, work collaboratively, think probabilistic, organize the data obtained, to think based on the cause-effect relationship and to participate in scientific activities where they can explain the results with examples (Kanlı & Yağbasan, 2008). Garnett and Hackling (1995) divided the objectives of the studies carried out in laboratories into four categories. These are classified as conceptual learning, developing technical and manual skills, developing research and problem-solving skills, and obtaining affective products (as cited in Hofstein, 2004).

Karamustafaoğlu and Yaman (2006) classified the benefits of laboratory applications as follows:

- ✓ Teaching becomes more permanent as students use more than one sense organ when conducting experiments.
- ✓ Students acquire research and analysis skills and habits.
- ✓ Laboratory use leads students to think creatively and critically.
- ✓ Laboratories enable students to act like scientists and gain scientific process skills.
- ✓ The information learned through experiments can be applied in real life more easily.
- ✓ Each student can adjust their learning status to their own knowledge and skills.

According to Özmen and Yiğit (2005), laboratories, which are expressed as the environments in which the theoretical knowledge learned in the course is applied, can be used for different purposes. We can express these approaches used in laboratories as follows:

1. *Technical Skills Approach:* In this approach, the promotion and usage of how and how to use the tools and materials generally used in the laboratory are included. It is aimed to provide students with technical skills in terms of cognitive, affective, and psychomotor characteristics in laboratory settings (Özmen & Yiğit, 2005).
2. *Verification (Deduction-Proof) Approach:* It is aimed to prove theoretically learned concepts, principles, laws, or hypotheses in experiments in laboratories. In this experiment approach, how the experiment process is, the result to be obtained as a result of the experiment is clear. The verification approach includes a closed-ended experiment technique in this respect (Ayas, Çepni & Akdeniz, 1994). In this approach, which is expressed as a traditional approach, instructions given from laboratory guides or examples of activities are tried to be followed step by step (Domin, 1999). Students can gain some skills such as setting up experiments, observing, recording data, and matching the results with scientific information.
3. *Induction Approach:* In this laboratory approach, students arrive as a result of their own activities. The experiment is designed by students, the experiment setup is established by students. The experiment is done, the data is collected and interpreted by the students. In the inductive approach, laboratory activities include the open-ended experimental technique. While the students are more effective in this approach, the teacher is a guide (Chiapetta & Koballa, 2002; Çepni, Ayas, Johnson & Turgut, 1997; Domin, 1999; Koç Şenol, 2012).

There are also approaches where the inductive approach is based and the responsibility that the teacher and the student take on is determinative. These can be classified as follows.

Scientific Process Skills Laboratory Approach: This laboratory approach is carried out to teach students scientific process skills. This laboratory approach should not be completely separated from other laboratory approaches. Each laboratory approach partially teaches the scientific process skills to the student, but this provides complete learning (Chiapetta & Koballa, 2002; Özmen & Yiğit, 2005).

Research-based laboratory approach: In this approach, students use their own methods to find a solution when faced with a problem. It is the student's responsibility to construct a hypothesis related to the problem, to supply the test materials, to prepare the test setup, to save and interpret the data. As a result of the experiment, students accept or reject their hypotheses according to the data (Özmen & Yiğit, 2005). This laboratory approach encourages students to become scientists and contributes to the development of science. It also helps students develop skills such as research, inquiry, and scientific process skills (Chiapetta & Koballa, 2002; Domin, 1999; Karamustafaoğlu & Yaman, 2006; Koç Şenol, 2012).

Integrative-constructivist laboratory approach: In this laboratory approach, students are left with the problem and students prepare experimental setups and collect and analyze the data. Later, he shares the results from here with his friends and creates new ideas. In this approach, the student is active. The process of learning by living by ensuring the permanence of learning is carried out in laboratories that adopt this laboratory approach (Ayas et. al., 2007; Chiapetta & Koballa, 2002; Çepni, Ayas, Johnson & Turgut, 1997; Koç Şenol, 2012).

The more students involve the sensory organs in the learning process, the more permanent the learning is (Dindar & Yaman, 2003; Özmen, 2004; Yalın, 2001). The environment that ensures the permanent learning in science education is the laboratories, and the ones that make the laboratories functional. Experiments are divided into 3 according to the way they are carried out, time and purpose (Çepni & Ayvacı, 2010; Özmen & Yiğit, 2005). The experiments used in science teaching can be tabulated as follows.

Table 1. *Experiments used in laboratories.*

According to how they are performed	**According to when they are performed**	**According to why they are performed**
Individual experiments	Experiments at the beginning of the subject	Closed-ended experiments
Group experiments	Experiments while the subject is going on	Hypothesis testing experiments
Demonstration experiments	Experiments at the end of the subject	Open-ended experiments

Performance evaluation in laboratories

In general, measurement is to observe any quality and to express the result of these observations with numbers or symbols (Turgut, 1994). Bekiroğlu (2004) expresses the same word as the determination of the student's knowledge, skills, and behaviors, in short, its capacity at the academic level. In the science and technology course curriculum updated in 2004, he addressed the following issues regarding assessment and evaluation:

"It has been stated by many scientists in recent years that performance is important in measurement and scoring should be fair. However, it is seen that there is a trend towards the performance model, where the generalization and repetition of measurement is insignificant. It is seen that the measurement and evaluation approaches differ depending on the goals of this change in the programs. Accordingly, traditional measurement and evaluation approaches towards the determined targets have been replaced by alternative measurement and evaluation approaches (Ministry of National Education, 2004)."

The word "performance", which has a foreign origin, is defined as overcoming anything, effectively executing a task given to someone or accomplished behavior (Demirci, 2001). Performance is also defined as the realization of the task and the purposeful product, service or thought within the framework of a certain task, to meet the predetermined criteria (Pugh, 1991). Performance evaluation, on the other hand, is to evaluate how well students can use the basic knowledge they have learned while performing complex tasks in realistic conditions (Kim, 2005; Mehrens, 1992; Wiggins, 1993; as cited in Yener, 2010). In this context, different trends have emerged in the measurement of students as traditional measurement and evaluation methods such as multiple-choice test, open-ended exam, focus on students' exam skills and ignore prior knowledge and thinking skills (Zollman & Jones, 1994; as cited in Yener, 2010).

Performance evaluation is concerned with how the student completes a task and why, and in order to achieve this purpose, students can be assigned tasks to use high level thinking skills such as composition writing, designing an experiment, writing a report, problem solving (Airasian, 2001; Çepni, 2007; Logan, 1996; Wortham, 2001; as cited in Yener; 2010). For this reason, it can be said that complementary measurement and evaluation techniques that can measure students 'skills and performances should be used instead of traditional measurement and evaluation techniques performed to measure students' knowledge in laboratories. Before performing these performance measurements, it is necessary to determine the issues such as the suitability of the measurements in the class, how much data should be collected, how much the measurement time will be (Yener, 2010). Bekiroğlu (2004) states the steps to be considered in performance measurement as follows:

1. Determining the purpose of performance measurement
2. Setting the goals
3. Determining the suitability of the performance measurement for the specified targets
4. Determining which skills students should use to perform the given task
5. Determining students' behaviors to be observed

6. Clarifying exactly what is being asked from students
7. Giving problems that are not previously given to the students and that are complex and preferably have more than one solution
8. Deciding which stages of the given task will be measured and analyzed
9. Determining the criteria, preparing the registration plan, and preparing the score plan
10. Determining the student's level by determining which criteria the students comply with
11. Giving feedback to the student about his performance.

Scientists use various criteria when determining the goals and capacities of students used to measure performance. The most comprehensive and common of these criteria is the classification made by Bloom et al. and used with the changes made today (Krathwohl, 2002; Yener, 2010). This classification, which is the most accepted in studies in the field of education, can be grouped under three main headings. The main topics of the classification made by Bloom et al. are cognitive skills that express students' mental skills and abilities, affective skills related to students' emotional structure such as interest, motivation, attitude, self-confidence, tolerance, and psychomotor skills that express students' body coordination. Teachers who want to measure the performance of students can scale according to the performance they will observe if they know the cognitive, affective, and psychomotor capacities of the students (Bekiroğlu, 2004).

Performance measures created by teachers can be applied to students individually or as a group. While developing the tool to be used in performance measurement, the highest performance should be considered at the grade level or graduation level from the school (Yener, 2010). In this context, scales such as anecdotal assesment, holistic and analytical evaluation scale, proportioning scale, which are alternative measurement scales, can be used for an objective evaluation. The difference of learning styles makes it necessary to use alternative assessment and evaluation techniques. Knowing how student performances can be measured and target achievements, teachers know that students' course success is better. Alternative measurements and evaluations combine these two facts (Yener, 2010).

In this context, when studies on laboratories in our country are analyzed, the number of studies on laboratory approaches and performance evaluation in laboratories is remarkable. For this reason, it was aimed to see the trend of the studies on laboratories and to reveal the current situation. For this purpose, answers to the following questions were sought.

1. What is the tendency of the branches, learning areas, environments in which studies are conducted, learning approaches and teaching techniques in the studies on laboratories in our country?
2. What is the tendency of studies on performance evaluation in laboratories in our country?

When we look at the studies about the laboratory, it is seen that there are studies involving laboratory approaches especially in 2008 and afterwards (Kanlı & Yağbasan, 2008; Uluçınar, Doğan & Kaya, 2008). In general, it is seen in these studies that traditional laboratory approach and integrative laboratory approach, and laboratory approaches to scientific process skills are compared. (Akben & Köseoğlu, 2010; Aydoğdu & Ergin, 2010; Baysal, Mutlu & Winter, 2019; Cerit Berber, 2013; Ceylan & Saygıner, 2017; Duru, Demir, Önen & Similar, 2011; Kanlı & Yağbasan, 2008; Karslı Baydere & Şahin Çakır, 2019; Kurt & First Confer, 2017; Şimşekli, 2018; Uluçınar, Doğan & Kaya, 2008; Yıldırım, 2016).

In these researches conducted in the form of comparing two different approaches, the effects of teaching techniques such as V diagrams, different experimental techniques, POE method (Demirci & Çınkı, 2009), interactive applications, simulations on the achievements of the participants, the attitudes towards the laboratories, on the acquisition of scientific process skills. , it is seen that there are studies examining the opinions of the participants about the laboratories (Aydoğdu & Ergin, 2010; Ceylan & Saygıner, 2017; Çelik, Katrancı & Çakır, 2017; Duru, Demir, Önen & Similar, 2011; Şimşekli, 2018; Tiftikçi, Yüksel, Koç & Çıbık, 2017; Ulukök, Çelik & Sarı, 2013; Yıldırım, 2016). In addition, in these studies on laboratories and laboratory approaches, it is seen that there are also researches on scale development in order to identify and eliminate the misconceptions that exist in the participants and to develop laboratory applications in teaching programs and to apply them in laboratory settings (Aydoğdu, 2018; Deveci, 2018; Karslı & Ayas, 2013 ; Mohair, Yüksel, Koç & Çıbık, 2017; Yüksel & Ateş; 2019).

When studies conducted abroad, it is seen that studies similar to those carried out in our country are carried out. Apart from the studies expressing the classification of laboratory approaches (Chiapetta & Koballa, 2002; Domin, 1999), it is observed that there are also studies examining the scientific process skills acquisitions, academic achievements, attitudes towards laboratories, metacognitive skills of the participants (Antonio, 2018; Berg, Bergendahl , Lundberg & Tibell, 2003; Chang & Mao, 1999; Irwanto, Rohaeti & Prodjosantoso, 2019; Myers & Dyer, 2005; Sandi-Urena, Cooper & Stevens, 2012; Sun, Lin & Yu, 2007).

METHODS

In this study, which we conducted in order to determine the tendency of the studies on laboratories in our country, document analysis from qualitative research designs was used. The document review (Yıldırım & Şimşek, 2016), which covers the examination of written materials containing information about the situation or facts that are aimed to be investigated, constitutes the data collection and analysis technique of this study. Document review is an important source of information that should be used effectively in qualitative research (Büyüköztürk, et al., 2012; Creswell, 2016; Johnson & Christensen, 2014).

a) Data Collection and Analysis

The data group of this research consists of thesis studies on laboratories that are open to access between 1999-2017 at the Counsel of Higher Education (CoHE) thesis center. After reaching 348 theses that are open to access, 162 theses in the field of physics, chemistry, biology, and science laboratories, other than areas such as shipbuilding and ship machinery engineering, textile engineering, mechanical engineering, were determined.

For these theses that do not have a keyword (1999-2005), the copyright pages were created by researchers in such a way that they could create information about the studies such as participant group, working environment, research method used, data collection tools, research subject, learning areas. Keywords and phrases are classified separately by two researchers. According to this classification, codes and themes were created separately. The themes and sub-themes created were compared by two science teachers and two field experts in science education, and their level of compatibility with each other was examined. The consistency between the themes and sub-themes created as a result of the comparison made by the researchers and the field specialist (Miles & Huberman, 2015) was calculated as 80%. The researches of these themes and sub-themes were analyzed separately by the researchers and the findings of this research were created. The findings obtained from the content analysis were compared and evaluated by the researchers and the field specialist. With this evaluation, the compliance of the findings with each other and the purpose of the study was examined. The reliability of the research was provided by comparing the compatibility of the findings with each other (Creswell & Miller, 2000), and the validity of the research was obtained by comparing the suitability of the findings with the purpose of the research (Creswell & Miller, 2000).

The data in the findings were prepared by determining 1131 keywords and imprint from 162 theses accessed. The frequencies in the tables indicate the frequencies included in this keyword or tag. Since the keywords are not expressed in the same way in every thesis, frequencies do not show the number of theses.

FINDINGS

As a result of the classification made in order to examine the tendency of the studies on laboratories in our country on the basis of key words and created identities, the following tables have been created and the following findings have been reached.

a) Findings for the First Sub-Problem

Table 2: *Distribution of areas studied in laboratories as branches (1999-2017)*

Key Word	Theme	Sub-Theme	Number	Frequency (%)
Science Education	Field Education	Science	40	45,45
Physics Education	Field Education	Physics	17	19,32
Biology Education	Field Education	Biology	11	12,50
Chemistry Education	Field Education	Chemistry	10	11,36
In-Service Training	Field Education	Teacher Training	8	9,09
Biotechnology Education	Field Education	Biotechnology	2	2,27
Total			**88**	**100**

According to the data in Table 1, it is seen that 45.45% of the studies carried out in the laboratories are made on the field of science. This is followed by physics with 19.32%, biology with 12.50% and chemistry with 11.36%. In addition, it is observed that in-service trainings are provided to teachers in laboratory studies with 9.09%.

Table 3: *Emphasis on skill learning area*

Key Word	Theme	Sub-Theme	Number	Frequency (%)
Scientific Process Skills	Skill Learning Area	Scientific Process Skills	22	56,41
Experimental Design	Skill Learning Area	Scientific Process Skills	3	7,69
Material Recognition and Using Skill	Skill Learning Area	Scientific Process Skills	2	5,13
Inquiry	Skill Learning Area	Scientific Process Skills	2	5,13
Reflective Thinking	Skill Learning Area	Life Skill	2	5,13
Creative Thinking	Skill Learning Area	Life Skill	2	5,13
Critical Thinking Tendency	Skill Learning Area	Scientific Process Skills	1	2,56
Graphics Drawing and Interpretation Skills	Skill Learning Area	Scientific Process Skills	1	2,56
Decision Making Skill	Skill Learning Area	Life Skill	1	2,56
Self-Regulation	Skill Learning Area	Life Skill	1	2,56
Reflective Reasoning	Skill Learning Area	Scientific Process Skills	1	2,56
Reflective Journal Writing	Skill Learning Area	Life Skill	1	2,56
Total			**39**	**100**

When the studies carried out in laboratories are evaluated in terms of skill learning area (MEB, 2013), 56.41% of keywords emphasize their scientific process skills. Scientific process skills follow the general title of “experimental design” with 7.69% and “ability to recognize and use materials” with 5.13%. This is followed by concepts such as reflective thinking (5.13%), creative thinking (5.13%) and self-regulation (2.56%), especially in studies conducted in 2013 and beyond (Table 3). In these studies, carried out in the laboratories, it was observed that the concepts such as attitude, perception, motivation and readiness in the field of affective learning were emphasized mostly on attitude (71.43%), and the attitudes of the participants towards the laboratories were examined.

Table 4: *Knowledge learning area*

Key Word	Theme	Sub-Theme	Number	Frequency (%)
Simple Electric Circuits	Knowledge learning area	Physical Events	1	5,26
Regular Structure of Plants Consisting of Cells, Tissues and Organs.	Knowledge learning area	The Living and Life	1	5,26
Reproduction, Growth and Development in Living Things	Knowledge learning area	The Living and Life	1	5,26
DNA Technologies	Knowledge learning area	The Living and Life	1	5,26
Electricity	Knowledge learning area	Physical Events	3	15,79
Gases	Knowledge learning area	Matter and Its Nature	1	5,26
Genetic Engineering	Knowledge learning area	The Living and Life	1	5,26
Cells	Knowledge learning area	The Living and Life	1	5,26
Force and Motion	Knowledge learning area	Physical Events	2	10,53
Matter	Knowledge learning area	Matter and Its Nature	1	5,26
Mechanics	Knowledge learning area	Physical Events	2	10,53
Temperature	Knowledge learning area	Matter and Its Nature	4	21,05
Total			**19**	**100**

When the subjects studied in the laboratories are examined, it is seen that the topic of temperature (21.05%) is the most repeated topic. This topic is followed by electricity with 15.79%. According to Table 4, the topics studied in the laboratories are generally in the disciplines of chemistry (heat and temperature, matter, gases, etc.) and physics (electricity, force and motion, simple electrical circuits, etc.). Studies in the field of biology (reproduction, growth, and development in living things (5.26%), cell (5.26%), structure of plants consisting of cells, tissues, and organs (5.26%) etc.) found to be less compared to studies in the field of chemistry and physics.

When the studies are examined, it is seen that the subjects in the courses held in the laboratories are generally about electricity and heat-temperature (21.05%), which is within the scope of the physics course.

Table 5: *Work environments*

Key Word	Theme	Sub-Theme	Number	Frequency (%)
Curriculum Laboratory School	Work environments	School	20	29,41
Physics Laboratory	Work environments	Physics	12	17,65
Primary School	Work environments	School	8	11,76
General Chemistry Laboratory	Work environments	Chemistry	7	10,29
Secondary Education	Work environments	School	7	10,29
High Education	Work environments	School	3	4,41
Biology Laboratory	Work environments	Biology	2	2,94
Support Courses	Work environments	Out of School	2	2,94
Active Learning Environment	Work environments	General	1	1,47
Ankara	Work environments	Province	1	1,47
Science and Art Education Center	Work environments	Out of School	1	1,47
Industrial Vocational High School	Work environments	School	1	1,47
Kutahya	Work environments	Province	1	1,47
Turkish Standardization Institute	Work environments	Out of School	1	1,47
Regional Boarding Primary Schools	Work environments	School	1	1,47
Total			**68**	**100**

When the literature is examined, it is determined that the studies carried out are mostly carried out in “curriculum laboratory schools”, which started in 1990 and ended in 2011 (29.41%, Table 5). In addition to the physics, chemistry and biology laboratories, it is seen that studies are carried out in areas such as Science and Art Education Center (1.47%), out-of-school courses (2.94%).

Table 6: *Learning approaches and strategies used in laboratories*

Key Word	Theme	Number	Frequency (%)
Laboratory Supported Education	Teaching Method (Strategy, Approach)	25	30,86
Computer Aided Education	Teaching Method (Strategy, Approach)	11	13,58
Inquiry Based Instructional Strategy	Teaching Method (Strategy, Approach)	10	12,35
Constructivist Learning Theory	Teaching Method (Strategy, Approach)	9	11,11
Cooperative Learning	Teaching Method (Strategy, Approach)	7	8,64
Traditional Method of Narration	Teaching Method (Strategy, Approach)	5	6,17
the argumentation	Teaching Method (Strategy, Approach)	4	4,94
Problem Based Learning	Teaching Method (Strategy, Approach)	2	2,47
Life Based Learning	Teaching Method (Strategy, Approach)	2	2,47
Peer Education	Teaching Method (Strategy, Approach)	1	1,23
Meaningful Learning	Teaching Method (Strategy, Approach)	1	1,23
Context Based Learning	Teaching Method (Strategy, Approach)	1	1,23
Multiple Intelligence Theory	Teaching Method (Strategy, Approach)	1	1,23
Programmed Teaching Method	Teaching Method (Strategy, Approach)	1	1,23
Project Based Learning Method	Teaching Method (Strategy, Approach)	1	1,23
Total		**81**	**100**

In studies conducted in laboratories, especially after 2006, emphasis was placed on learning constructivist-learning theory (11.11%). The method to be followed in order to teach a subject within the scope of constructivist learning theory is a teaching strategy that is used in laboratories with a 12.35% percentage.

When the teaching methods in the studies are examined at the level of keywords, it is seen that the most used teaching methods are laboratory supported education (30.86%), computer supported education (13.58%) and collaborative education (8.64%). In addition, it has been observed that methods such as argumentation (4.94%), problem-based learning (2.47%), life-based learning (2.47%), multiple intelligence theory are used in laboratory studies at a low level.

Table 7: *Teaching techniques used in laboratories*

Key Word	Theme	Number	Frequency (%)
5E Model	Teaching Technique	6	13,95
Web Supported Laboratory Teaching	Teaching Technique	5	11,63
7E Model	Teaching Technique	3	6,98
Experimental Learning	Teaching Technique	3	6,98
Prediction-Observation-Explanation	Teaching Technique	3	6,98
Teaching Analogy	Teaching Technique	2	4,65
Scientific Process Skills Laboratory Approach	Teaching Technique	2	4,65
Constructivist Laboratory Approach	Teaching Technique	2	4,65
Learning with Self-Regulation	Teaching Technique	2	4,65
3E Learning Ring	Teaching Technique	1	2,33
Expression Method	Teaching Technique	1	2,33
Science Writing Tool (SWH)	Teaching Technique	1	2,33
Merged Group	Teaching Technique	1	2,33
Learning Together	Teaching Technique	1	2,33
Confirmatory Laboratory Method	Teaching Technique	1	2,33
Demonstration Experiment Method	Teaching Technique	1	2,33
Group Experiment Method	Teaching Technique	1	2,33
Group Discussion	Teaching Technique	1	2,33
Jigsaw Technique	Teaching Technique	1	2,33
Metaphor	Teaching Technique	1	2,33
Engineering Design Based Science Education	Teaching Technique	1	2,33
Reading-Writing-Application	Teaching Technique	1	2,33
Writing for Learning	Teaching Technique	1	2,33
Science Learning Approach by Writing and Doing	Teaching Technique	1	2,33
Total		**43**	**100**

Considering the teaching techniques used to teach a subject in laboratories, Table 7 was created. According to this table, the most used teaching technique in laboratories is the 5E learning model (13.95%). In addition, when the laboratory approaches are analyzed, it is seen that approaches such as scientific process skills laboratory approach (4.65%), confirmatory laboratory approach (2.33%), constructivist laboratory approach (4.65%), web supported laboratory teaching (11%) are used.

In addition, it has been determined that the techniques such as merged group technique, learning together technique, jigsaw technique, group discussion in the cooperative learning method are used in laboratories. In addition, it can be stated that the effects of science, engineering and entrepreneurship practices stated in the Science

Education Curriculum updated in 2018 in our country have been observed in studies conducted in laboratories (Engineering Design Based Science Education (2.33%), Table 7).

b) Findings for the Second Sub-Problem

Table 8: *Complementary measurement and evaluation techniques used in laboratory studies*

Key Word	Theme	Number	Frequency (%)
V-diagram	Complementary measurement and evaluation	2	28,57
Peer Review	Complementary measurement and evaluation	1	14,29
Experiment Evaluation Rubric	Complementary measurement and evaluation	1	14,29
Rubric	Complementary measurement and evaluation	1	14,29
Self-assessment	Complementary measurement and evaluation	1	14,29
Performance evaluation	Complementary measurement and evaluation	1	14,29
Total		**7**	**100**

Considering the studies on laboratories in our country, it can be said that complementary measurement and evaluation techniques, which were included in the curriculum in 2004 and emphasized since 2006, are not considered in laboratory settings. Because when we look at Table 7, the fact that only 7 of them are on complementary measurement and evaluation techniques in 1131 keywords determined from the studies, shows the scarcity of the studies on complementary measurement and evaluation. This situation can be interpreted as the researchers do not pay attention to the performances of the students while working on the effectiveness of the method or technique.

In addition, when the keywords in the studies are examined, 28 of them are directed towards the concepts of attitude, anxiety and perception within the affective learning area. There are 192 keywords that indicate the participants of the studies. The number of scales, tests and surveys used for data collection is 253. Apart from these themes, there are 233 other keywords that emphasize the school climate, keywords such as school-parent cooperation, university-school cooperation, qualification theme that indicates the competence of students or laboratories, and general theme such as ISO-9001, total quality management. However, the tables of these keywords are not included in the study because they are too short or too long.

DISCUSSION and CONCLUSION

Consedering distribution of areas studied in laboratories as branches, considering the concentration of key concepts on science, it can be interpreted that the majority of the studies are carried out at primary level. This situation is followed by secondary and higher education levels. In addition, according to the table 2, it can be stated that there are studies on laboratories and their uses with teachers who are active. It can be said that when the literature is examined at national and international level, the studies carried out support this finding (Akben & Köseoğlu, 2010; Aydoğdu & Ergin 2010; Demirci & Çınkı, 2009; Mashita, Norita & Zurida, 2008; Stephenson & Sadler-McKnight, 2016).

According to the findings in the table 3, it can be stressed that in the implementation of scientific process skills, which was emphasized by the change in the science education curriculum in 2004, it was tried to pay attention to the lessons conducted in the laboratories. In addition to this, it is seen that emphasis on life skills has been done after the year of 2013 (Çelik, Katrancı & Çakır, 2017; Kanlı & Yağbasan, 2008; Karslı & Ayas, 2013; Morgil, Güngör Seyhan & Seçken, 2009; Myers & Dyer, 2005; Sandi- Urena, Cooper & Stevens, 2012; Şahin Pekmez, Aktamış & Can, 2010).

When the studies are examined, it is seen that the subjects in the courses held in the laboratories are generally about electricity and heat-temperature (21.05%), which is within the scope of the physics course (Table 4). Considering the studies on misconceptions in our country, there are studies on the determination and elimination of misconceptions in physics subjects of these studies (Aydın, 2010; Demirezen, 2010; Huyugüzel Çavaş, 2004; Sert Çıbık, 2011). Based on the studies on misconceptions, it can be said that subjects that may take time to learn both in the classroom and in the laboratories, or create misconceptions when not taught during their teaching (Akben & Köseoğlu, 2010; Aydın, 2010; Aydoğdu & Ergin 2010; Sert Çıbık, 2011).

In order to provide a quality education in our country in 1990, the National Education Development Project, under an agreement made between the Republic of Turkey and the World Bank of 23 provinces in 208 schools Curriculum Laboratory School were selected and activities related to this school (Gurel & Hesapçıoğlu, 2002). CLS, which was a 7-year project in the first place, was repealed with the "Directive on the Dissemination of the Curriculum Laboratory School Practices of the Ministry of National Education" published in the Journal of Papers in 2011 (MEB, 2011). It can be said that the realization of the studies carried out in the Curriculum Laboratory Schools was carried out in order to reveal the efficiency and results of this project, which started in 1990 and ended in 2011. In addition, it can be stated that the fact that more studies have been conducted in physics laboratories compared to other laboratories according to Table 5 confirms the information in Table 1 and Table 3 in the findings of this study.

When we look at the teaching approaches and strategies used in laboratories, it is seen that generally, laboratory supported education is used. In these studies, it can be said that the traditional laboratory approach is compared with the laboratory approach based on explanation-questioning and the effectiveness of computer-aided training method (Ceylan and Saygıner, 2017; Çelik, Katrancı and Çakır, 2017; Kanlı and Yağbasan, 2008; Myers and Dyer 2005; Sandi -Urena, Cooper & Stevens 2012; Mohair, Yüksel, Koç and Çıbık 2017).

Considering the teaching methods and techniques used in the studies, it can be said that the studies conducted are compared with the traditional laboratory approaches and the studies in which the students are more active or can transfer more sense organs to the learning environment (Chiapetta & Koballa, 2002; Çepni & Ayvacı, 2010; Domin, 1999; Nieswandt, 2007; Özmen & Yiğit, 2005).

As a result, according to the findings obtained from the research, it can be stated that there is a wide range in our country in the field of science education in general. It is seen that studies on laboratories are generally on physics subjects. The fact that the subjects in physics cannot be concretized after being taught theoretically may cause incomplete learning and misconceptions in students. For this reason, it can be stated that the subjects covered in the laboratories are expected to be on the lessons and subjects that may be learned incompletely in students or cause misconceptions. Because, as Çepni and Ayvacı (2010) stated, the fact that the theoretically explained subjects cannot be translated from abstract to concrete and cannot be related with real life causes science teaching to be not effective enough. In addition, the fact that the most studies in the field of science education takes place in the disciplines of science, physics and chemistry, which was revealed during the literature review studies conducted in certain periods in our country, support this conclusion (Doğru, Gençosman, Ataalkın & Şeker, 2012; Kiras, 2019; Şenkal & Dinçer, 2016) .

In addition to this, the scientific process skills included in the science teaching program organized in 2004 and implemented until the next regulation since 2006 are also carried out with the aim of providing students with basic skills and increasing their perceptions and attitudes towards laboratories at the level of students, prospective teachers and teachers. It was seen that it was made. From the point of view of the environments in which the studies are carried out, it can be interpreted that some of the studies are carried out in the Curriculum Laboratory Schools, and both the quality of education and the effectiveness of the innovations in the field of education in our country are aimed to explore. In general, when the studies are analyzed, it is seen that the studies are compared with the traditional teaching method techniques and the constructivist and the techniques in which students participate more actively. This result can be interpreted as the similarity between the studies carried out in our country in the classroom and the laboratory settings (Doğru, Gençosman, Ataalkın & Şeker, 2012; Kiras, 2019).

In addition, when studies are considered, the scarcity of studies conducted to evaluate the performance of students in laboratory environments is remarkable. This situation can be expressed as the fact that our teachers do not know the complementary assessment and evaluation techniques, or they cannot apply these techniques completely. It can be said that the keywords in theses are not arranged in a way to provide sufficient information about the thesis. Especially theses without a keyword between 1999-2005 can be cited as an example

Suggestions

According to the results, the following suggestions can be made for new studies and laboratory applications:

▶ Rather than comparing traditional approaches to laboratories where students are more active, laboratory approaches where students are active can be compared amongst and reported.

▶ The importance of these evaluations can be stated by providing necessary training to prospective teachers and active teachers on performance evaluation in laboratory settings. Then, the performance evaluation practices of our teachers in the classes can be examined.

▶ Studies on performance evaluation can be carried out in chemistry and biology laboratories, and studies can be conducted on the development of necessary evaluation tools and trials of these tools can be done.

▶ Studies can be conducted on whether the keywords in the new studies are sufficient according to the content of the study. In addition, the importance of keywords - if they are not included university curriculums - can be emphasized for graduate students.

REFERENCES

Airasian, P. W. (2001). *Assessment in the classroom a concise approach*. Boston: McGraw-Hill.

Akben, N. & Köseoğlu, F. (2010). Laboratory activity sample based on inquiry on the subject of elementary education fifth grade density. *e-Journal of New World Sciences Academy Education Sciences,5*(3), 1281-1289.

Alkan, F. & Koçak, C. (2015). Chemistry laboratory applications supported with simulations. *Procedia- Social and Behavioral Sciences,* (176), 970-976. https://doi.org/10.1016/j.sbspro.2015.01.566

Antonio, V. V. (2018). Science laboratory interest and preferences of teacher education studies: Implications to science teaching. *Asia Pacific Journal of Multidisiplinary Research*, *6*(3), 57-67.

Aydın, M. (2010). *The compare effect of using prediction-observe-explain method on students' achievement in science and technology of remediation of misconceptions*. [Unpublished Master's Thesis]. Zonguldak Kara Elmas University.

Aydoğdu, B. & Ergin, Ö. (2010, November 11-13). *Effects of different experimental techniques used in science and technology lesson on students' learning approaches.* [Conference presentation]. International Conference on New Trends in Education and Their Implications, Antalya.

Aydoğdu, C. (2018). Historical development of laboratory in the elementary school science program in Turkey. Education Research Highlights in Mathematics, Science and Technology, Iowa: ISRES Publishing.

Baysal, Y. E., Mutlu, F. & Kış, A. (2019). The effect of laboratory applications based on modern approaches on the attitudes of the students in turkey in laboratory courses: a meta-analysis study. *Bolu Abant İzzet Baysal University Journal of Education Faculty, 19*(3), 802-817. https://doi.org/10.17240/aibuefd.2019.19.49440-531395

Bekiroğlu, F. O. (2004). *How successful? classical and alternative measurement-evaluation methods and applications in physics.* Ankara: Nobel Publications.

Berg, C. A. R., Bergendahl, V. C. B, Lundberg, B. & Tibell, L. (2003) Benefiting from an open-ended experiment? A comparison of attitudes to, and outcomes of, an expository versus an open-inquiry version of the same experiment, *International Journal of Science Education, 25*(3), 351-372. https://doi.org/10.1080/09500690210145738

Brownell, H. & Wade, F. B. (1925). *The teaching of science and the science teacher*. New York: Century Company.

Büyüköztürk, Ş., Kılıç Çakmak, E., Akgün, Ö. E., Karadeniz, Ş. & Demirel, F. (2011). *Scientific research methods* (8th ed.), Ankara: Pegem Academy. https://doi.org/10.14527/9789944919289

Cerit Berber, N. (2013). The relationship of the physics laboratory based on deductive approach with the critical thinking tendencies of prospective teachers. *Journal of National Education*, (197), 228-243.

Ceylan, E. & Saygıner, Ş. (2017, October 27-28). *An alternative to traditional laboratory practices in science and mathematics education: PhET simulations.* [Conference presentation]. International Educational Technologies Symposium. Sivas.

Chang, C. & Mao, S. (1999). Comparison of Taiwan Science Students' outcomes with inquiry-group versus traditional instruction, *The Journal of Educational Research, 92*(6), 340-346. https://doi.org/10.1080/00220679909597617

Chiappetta, E. L., & Koballa, T. R. (2002). *Science education in the middle and secondary schools* (5th edn.) Upper Saddle River. NJ: Merrill Prentice Hall.

Creswell, J. W. & Miller, D. L. (2000). Determining validity in qualitative inquiry. *Theory into Practice, 39*(3), 124-131. https://doi.org/10.1207/s15430421tip3903_2

Creswell, J. W. (2016). *Research pattern. Qualitative, quantitative, and mixed method approaches* (2nd ed.). Ankara: Eğiten Kitap.

Çelik, H., Katrancı, M. & Çakır, E. (2017). The effect of the open-ended enquirer-inquiry laboratory approach to creative thinking skill in science teaching. *Turkish Journal of Primary Education*, (2), 1-10.

Çelik, H. (2018). Science teaching with laboratory approaches. In O. Karamustafaoğlu, Ö. Tezel, & U. Sarı (Eds.), *Activity supported science teaching with current approaches and methods* (1st ed., pp.239-283). Ankara: PegemA Academy.

Çepni, S & Ayvacı, H. (2010). Laboratory supported science and technology teaching. In S. Çepni (Ed). *Science and technology teaching from theory to practice* (pp. 177-237). Ankara: PegemA Academy. https://doi.org/10.14527/9786053186496.08

Çepni, S. (2007). *Introduction to research and project studies,* (3rd ed.). Trabzon: Celepler.

Çepni, S., Ayas, A., Johnson, D. & Turgut, F. (1997). *Physics teaching.* Ankara: CoHE/World Bank National Education Development Project Pre-Service Teacher Education.

Demirci, N. (2001). The *effects of a web-based physics software program on students' achievement and misconceptions in force and motion concepts*. [Unpublished Doctoral Thesis]. Florida Institute of Technology.

Demirci, N. & Çınkı, A. (2009). The effect of using V-Diagrams on the success of primary school 6th grade students in science experiments. *Journal of Ondokuz Mayıs University Faculty of Education, 28,* 23-36.

Demirezen, S. (2010). *Effect of 7e model on electric circuits on students' success, development of scientific process skills, conceptual achievements, and permanence levels.* [Unpublished Doctoral Thesis]. Gazi University.

Deveci, İ. (2018). Middle school science laboratory academic risk-taking scale: validity and reliability study. *Elementary Education Online, 17*(4), 1861-1876.

Dindar, H. & Yaman, S. (2003). The status of instructional technology in the primary schools and classroom teachers' level of using these technologies. *Pamukkale University Journal of Education, 13*(13), 167-176.

Doğru, M., Gençosman, T., Ataalkın, A. N., & Şeker, F. (2012). Analysis of the postgraduate and doctoral theses conducted on sciences education *Journal of Turkish Science Education, 9*(1), 49-64.

Domin, D. S. (1999). A review of laboratory instruction styles. *Journal of Chemical Education, 76*(4), 543-547

Duru, M.K., Demir, S., Önen, F. & Benzer, E. (2011). THE effects of inquiry-based laboratory applications to preservice science teachers' laboratory environment perceptions, attitudes and scientific process skills. *Marmara University Atatürk Education Faculty Journal of Educational Sciences,* (33), 25-44.

Garnett, P. J. & Hackling, M. W. (1995). Refocusing the chemistry lab: A case for laboratory-based investigations. *Australian Science Teachers Journal, 41*(2), 26-32.

Gürel, C., & Hesapçıoğlu, M. (2002). THE evaluation of curriculum laboratory schools from the viewpoint of physics education. *Marmara University Atatürk Education Faculty Journal of Educational Sciences*, 15, 137-150.

Hofstein, A. (2004). The laboratory in chemistry education: thirty years of experience with development, implementation and research. *Chemistry Education: Research and Practice, 5*(3), 247-264. https://doi.org/10.1039/b4rp90027h

Huyugüzel Çavaş, P. (2004). *Processing of the electrical unit directing our life in primary science course according to the learning cycle*. [Unpublished Master's Thesis]. Ege University.

Irwanto, Rohaeti, E., & Prodjosantoso, A. K. (2019). Analyzing the Relationships between Pre-Service Chemistry Teachers' Science Process Skills and Critical Thinking Skills. *Journal of Turkish Science Education, 16*(3), 299-313.

Johnson, B. & Christensen, L. (2014). *Educational research* (4th ed.). Ankara: Eğiten Kitap.

Kanlı, U. & Yağbasan, R. (2008). The efficacy of the 7E learning cycle model based on laboratory approach on development of students science process skills. *Gazi University Journal of Gazi Education Faculty, 28*(1), 91-125.

Karamustafaoğlu, O. & Yaman, S. (2006). *Special teaching methods in science education I-II*. Ankara: Anı.

Karslı, F. & Ayas, A. (2013). Is it possible to eliminate alternative conceptions and to ımprove scientific process skills with different conceptual change methods? 'an example of electrochemical cells'. *Journal of Computer and Educational Research, 1*(1), 1-26.

Karslı Baydere, F. & Şahin Çakır, Ç. (2019). The effect of laboratory practices based on scientific process skills on pre-service teachers' self-efficacy in scientific process skills. *Online Science Education Journal, 4*(2), 117-130.

Kiras, B. (2019). *Subject Orientation and Methodological Analysis of Science Education Thesis Theme in Turkey*. [Unpublished Doctoral Thesis]. Bolu Abant İzzet Baysal University.

Koç Şenol, A. (2012). *Robotic Supported Science and Technology Laboratory Applications: Robolab*. [Unpublished Master's Thesis]. Erciyes University.

Krathwohl, D. R. (2002) A Revision of Bloom's Taxonomy: an overview. *Theory into Practice, 41*(4), 212. https://doi.org/10.1207/s15430421tip4104_2

Kurt, S. & Birinci Konur, K. (2017). Pre-Service Primary Teachers' Impressions towards Chemistry Experiments Based on Constructivist Laboratory Approach. *Inonu University Journal of the Faculty of Education, 18* (3), 145-161. https://doi.org/10.17679/inuefd.296545

Miles, M, B., & Huberman, A. M. (2015). *Qualitative data analysis: An expanded Sourcebook.* Thousand Oaks, CA: Sage.

Millar R., Tiberghien, A. & Maréchal J. F. (2002). Varieties of Labwork: A Way of Profiling Labwork Tasks. In. Psillos, D., Niedderer H. (Eds.). *Teaching and Learning in the Science Laboratory*. *Science & Technology Education Library,* Dordrecht: Springer. https://doi.org/10.1007/0-306-48196-0_3

Milli Eğitim Bakanlığı (MEB). (2004). Primary school science and technology lesson (6th, 7th, and 8th grades) curriculum. Ankara.

Morgil, İ., Güngör Seyhan, H. & Seçken, N. (2009). Investigating the effects of project-oriented chemistry experiments on some affective and cognitive field components. *Journal of Turkish Science Education, 6*(1), 89-107.

National Education Association. (1894). *Report of the Committee of Ten secondary school studies*. New York, American Book Company.

Nieswandt, M. (2007). Student affect and conceptual understanding in learning chemistry. *Journal of Research in Science Teaching, 44*(7), 908-937. https://doi.org/10.1002/tea.20169

Özmen, H. (2004). Learning theories and technology supported constructivist learning in science education. *The Turkish Online Journal of Educational Technology*, *3*(1), 100-111.

Özmen, H. & Yiğit, N. (2005). *Laboratory use in science education*. Ankara: Anı.

Pugh, C. (1991). The globalisation of finance capital and the changing relationships between property and finance – 1. *Journal of Property Finance, 2*(2). https://doi.org/10.1108/09588689110033027

Rudolph, J. L. (2005). Epistemology for masses: The origins of the "scientific method" in American schools. *History of Education Quarterly*, *45*(2), 341-376. https://doi.org/10.1111/j.1748-5959.2005.tb00039.x

Sandi-Urena, S., Cooper, M. & Stevens, R. (2012). Effect of cooperative problem-based lab instruction metacognition and problem-solving skills. *Journal of Chemical Education*, (89), 700-706. https://doi.org/10.1021/ed1011844

Singer, S. R., Hilton, M. L. & Schweingruber, H. A. (2006). *America's lab report: Investigation in high school science*. Washington, DC: National Academies Press.

Sun, K., Lin, Y. & Yu, C. (2008). A study on learning effect among different learning styles in a Web-based lab of science for elementary school students. *Computer & Education*, (50), 1411-1422. https://doi.org/10.1016/j.compedu.2007.01.003

Şahin Pekmez, E., Aktamış, H. & Can, B. (2010). The effectiveness of science laboratory course regarding the scientific process skills and scientific creativity of prospective teachers. *Inonu University Journal of the Faculty of Education, 11*(1), 93-112.

Şenkal, O & Dinçer, S. (2016). The trend of the work done in the field of physics education in Turkey. *Journal of Çukurova University Institute of Social Sciences, 25*(2), 57-70.

Şimşekli, Y. (2018). Investigation of the experiment design skills of biology and science teachers and preservice teachers. *Journal of Education and Training Studies, 6*(9), 199-207. https://doi.org/10.11114/jets.v6i9.3564

Tiftikçi, H. İ., Yüksel, İ., Koç, A. & Çıbık A. S. (2017). The effect of laboratory applications based on prediction observation explanation method to eliminate the misconceptions about electrical current and on success. *Journal of Ahi Evran University Kırşehir Faculty of Education, 18*(Special ed.), 19-29.

Turgut, M. F. (1994). *Measurement and evaluation methods in education.* Ankara: Yargıcı.

Uluçınar, Ş., Doğan, A. & Kaya, O. N. (2008). Views of elementary teachers on science teaching and laboratory. *Kastamonu Education Journal, 16*(2), 485-494.

Ulukök, Ş., Çelik, H. & Sarı, U. (2013). The effects of computer-assisted instruction of simple circuits on experimental process skills. *Journal of Theoretical Educational Science, 6*(1), 77-101.

Whewell, W. (1858). *The history of inductive sciences, from earliest to the present time* (3rd). New York: Appleton.

Whitman, F. P. (1898). The beginnings of laboratory teaching in America. *Science, New Series 8* (190), 201-206.

Yener, D. (2010). Determining the effectiveness of the rearranged experiment papers for performance evaluation in physic laboratories. [Unpublished Doctoral Thesis]. Selçuk University.

Yıldırım, A. & Şimşek, H. (2016). *Qualitative research methods in the social sciences* (10th ed.). Ankara: Seçkin.

Yıldırım, N. (2016). Opinions of pre-service classroom teachers towards laboratory using in science instruction and their preferences towards laboratory approaches. *Journal of Education and Training Studies, 4*(3), 208-222. https://doi.org/10.11114/jets.v4i3.1304

Yıldız Feyizoğlu, E. & Tatar, N. (2012). An analysis of the activities in elementary science and technology textbooks according to science process skills and structural characteristics. *Education & Science, 37*(164), 108-125.

Yüksel, İ. & Ateş, S. (2019). Developing scientific reasoning skills test. *Cumhuriyet International Journal of Education, 8*(3), 635-650.