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The effects of guided inquiry-based learning implementations on 4th grades students and elementary teacher; a case study[1]

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Abstract. This study aimed to examine the effects of guided inquiry-based learning (GIBL) implementations applied to fourth-grade students in a Turkish rural school on both students and an elementary teacher. It was designed as a case study using qualitative data in the form of structured students' views journaled by the teacher, used video recordings, and observations by the researcher. 15 GIBL experiments with 5E learning model in a structured classroom rather than laboratory were conducted with 42 students. The results of student's views showed positive effects of GIBL implementations on the learning of concepts, interest to science, group work and the attitude of their teacher. GIBL implementations helped the teacher to realize her role regarding the students, awareness of the required competencies, skills, and self-confidence.

Keywords: Guided inquiry-based learning, elementary teacher, 4th grades, matter

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INTRODUCTION

Learning based on inquiry has been defined as a student-centered learning approach in which students desire to discover their environment. Inquiry based learning (IBL) with an interdisciplinary perspective in which each student is responsible for their own learning, transferring their knowledge provided by active involvement. Bell, Smetana and Binns (2005) decribed IBL as IBL as an active learning process in which students answer research questions through data analysis" (p. 35). In student-centered science instruction, learning science concepts from experiments based on collaboration in daily life is of utmost importance in the cognitive structuring of the learning. The American National Science Standards [National Research Council (NRC), 2012] described this kind of learning as, "Science is not just a body of knowledge that reflects current understanding of the world; it is also a set of practices used to establish, extend, and refine that knowledge" (p. 26). IBL has been defined as "activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world" (NRC, 2000, p. 23). Also, in science, technology, engineering and mathematic (STEM) practices, NRC (2012) indicated the role of IBL as follows: 'Students will themselves engage in the practices and not merely learn about them second-hand. Students cannot comprehend scientific practices, nor fully appreciate the nature of scientific knowledge itself, without directly experiencing those practices for themselves' (p. 31). Therefore, what new teaching models are invented, IBL is on the agenda being main skeleton of them not just only in science, technology, engineering and mathematic practices, it is considered as well as in social science.

There are many factors influencing the success of IBL practices such as teacher competencies and learning environment. Generally, laboratories in the schools are places in which science is practiced and many studies have shown the positive effects of IBL laboratory practices. For instance, students' level of knowledge increases (Bryant; 2006), they could improve their perceptions and understand the nature of science more easily (Garnett & Hacking, 1995; Dori, Sasson, Kaberman & Herscovitz, 2004; Hofstein & Lunetta, 1982; Hodson, 1990; Lunetta, 1998; Lazarowitz &Tamir, 1994; Tobin, 1990). They acquire, internalize, and change cognitive

[1] This study has been conducted using some data from the thesis of Ayca Demirkiran with a master's degree at Istanbul Aydın University, Social Sciences Institute (2016).

knowledge (Campbell & Neilson, 2009), they develop scientific process skills (Aydın & Sahin, 2009; Throwbridge, Byee, & Powell, 2004) and research type laboratories are very effective in the students' learning of science consisting problem solving and testing hypothesis (Hofstein & Walberg; 1995). In contrast to those results, some research argued that laboratory practices without aim, and motivation didn't provide academic achievement and learning (Duschl & Grandy, 2005; Darling-Hammond, & Hudson, 1990). Furthermore, teachers' failures to explain the results of the laboratory and material problem (Akerson & Dickinson, 2003; Songer, Lee & Kam, 2001) was insufficient, the laboratory studies in IBL being student-centered, give more responsibility to the student, provide scientific process skills, can be used at many levels of education and provide learning in its concepts (Leonard; 1989). The significance of laboratories in science education considering the exotic atmosphere, the smell of acid or bases in the environment, various experimental instruments or animal and plant samples, it should be included as a separate class schools that stimulates the creativity and exploration ability of the students (Lanza, 2007). Unfortunately the physical and economic conditions of the school restrict the construction of separate laboratories or cause limited materials in the laboratory notably schools of urban regions. In this manner teachers competencies have prominent for the IBL implementations such as creating a learning environment that helps students build conceptual science (Lotter, Rushton, & Singer, 2013).

The other competencies of teacher having substantial role during IBL practices are ; content knowledge and the beliefs of teachers (Herrington, Bancroft, Edwards, & Schairer, 2016; Lumpe, Czerniak, Haney, & Beltyukova, 2012; Rushton, Lotter, & Singer, 2011; Thomas & Pedersen, 2003), their conceptual knowledge (Chaney, 1995; Darling-Hammond, 2000; Druva & Anderson, 1983), their education degrees (Ingersoll, 2003; Furtak, 2005), experience (Wenglinsky; 2000), the habits of primary teachers (Abd-El-Khalick et al., 2004), and their self-confidence (Harlen & Holroyd, 1995; Kind, 2009). As a result of the practical implementation, teachers' concern regarding student-centered educational implementation decreased (Gillies & Nichols, 2015), and teachers with a high level of self-competency are more successful at practical implementations (Enderle, et al., 2014; Granger, Bevis, Saka, Southerland, Sampson, & Tate, 2012; Lumpe, Haney, & Czerniak, 2000; Morrison, 2013).

Although there have been many research studies concerning IBL practices, the studies investigating the effects of inquiry-based practices from both students' and researchers' perspectives (Rönnebeck, Bernholt & Ropohl, 2016) were not substantial. In this research, a GIBL approach was implemented in the regulated classroom environment rather than a science laboratory. The insuffient materials, crowded classrooms and labrotory in the schools were one of the reasons of why most of the teachers can't do experiments in thier classroom (Yıldız, Aydoğdu, Akpınar & Ergin, 2006). The teacher has recently graduated and the sample group in one classroom concists of 42 students. The research aim was to determine the effects of GIBL implementations on fourth-grade students and their teacher. The research questions were;

a-What are the effects of GIBL implementations on the students' learning of concepts, interest in science, group work, and the attitude of their teacher?

c-What are the effects of learning environment before and after the GIBL applications on the students?

d-What are reflections of teacher based on her competencies in relation to implementing GIBL?

The research are trying to find a solution to factors which are restricting IBL practices such as learning environment, crowded classrooms and inexperienced teachers to apply it on elementary levels of schools in rural regions.

Theoretical Background

Inquiry-Based Learning and Students

In the mid-nineteenth century, it was discussed that**:** the generalizations about students based on classroom observations were created and that students should learn how to observe in the natural environment and conclude from these observations. The increasing importance of science in modern society and the emergence of mental development in modern life gave rise to the popularity of science. Herbert Spencer (1820-1903), demonstrated the importance of the laboratory in the practical learning of students to draw conclusions based on observations as well as the words in the books. Charles Eliot (1869-1895) indicated that laboratories should aim to develop students' ability to make inferences and obtain knowledge independently. Smith and Hall (1902) argued that all chemistry courses at the university level should be laboratory-based so as to pave a way for the students to learn the basic principles and concepts of chemistry in a meaningful way with the applications in the laboratory. Smith argues that laboratory practice improves students' thinking skills and recognizes the need for ample time for laboratory practice, and suggests that the teacher directs students by asking questions and providing material and suggestions. On the other hand, Hall concluded that the students focused only on the expected results in the confirmatory laboratory practices which did not give them scientific skills. However, in guided discovery applications, it is appropriate for the student to investigate the answer of questions he/she does not know and Hall defined this application as inquiry-based learning.

At the beginning of the 20th century, with the help of John Dewey, it became more important to teach with student-centered, practical skills that enable students to improve as individuals who are sensitive to everyday problems and produce solutions. However, with the increasing need for science in the security and economic fields after the 1950s, the necessity of public interest in science to create a desire to become a scientist began to be discussed while science courses needed reform in schools. IBL was implemented as a teaching and learning model in classrooms by using problem-based, discovery and project-based learning. Schwab (1962) stated that scientific concepts and scientific procedures should not be separated from each other in that the scientific invention should be learned learned in a noteworthy way by working on its own invention rather than by the teacher. Schwab stated that the discussion of the students and the teacher during the practice which was a strong supporter of IBL to deepen and to develop the thought. In 1970, science education aimed to educate individuals who gained scientific knowledge and scientific processes and who could solve problems faced in science literacy and daily life. Herron (1971) argued that how and in what detailed scientific inquiry should be examined for science education. He revealed limitations of the activities as high-level scientific inquiry, limitations of curricular materials which are flexible and specific among different science disciplines and relations of scientific problems with the students' political, sociological and psychological aspects.

Project 2061 (Science for All Americans: AAAS, 1989) aimed to identify criteria for training science-literate students, an objective which was achieved in 1996 through the work of NRC. Therefore NRC clarified roles of IBL on student as indicated below;

> *"Students at all grade levels and in every domain of science should have the opportunity to use scientific inquiry and develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments" (NRC 1996, p. 105).*

Depending on the changing global world requirements and results of economical competitions between countries, standards in the education system of the USA changed again and these standards were designed to help students acquire the ability to learn and understand the natural world and science, use scientific processes to make individual decisions, and use their science literacy skills to increase their productivity in their individual careers. One of the three dimensions of NRC scientific and engineering practices includes asking questions (for science) and defining problems (for engineering), developing and using models, planning and conducting investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations (for science) and designing solutions (for engineering), engaging in argument from evidence, and obtaining, evaluating, and communicating information (NRC, 2012,

p. 16). Therefore, IBL has again major role in new education model which is STEM that involves asking questions, seeking knowledge, discovering something regarding a phenomenon, and making sense of and learning how to connect concepts.

According to the literature, the effectiveness of IBL was indicated in many kinds of research. With IBL practices, students develop conceptual learning (Aydın & Sahin, 2009; Ates, 2005; Hassard, 2005; Hofstein et al., 2001; Blank, 2000; Renner, Abraham, & Birnie, 1998; Lawson, 1995), adopt concept-based practices (Wilke & Straits, 2005; Mayer, 2004), are better able to learn about the nature of science (Campbell & Neilson, 2009, p. 4), and are provided with different kinds of learning opportunities (Wu & Hsieh;2006). Students also develop interest in and positive attitudes toward lessons (Gillies & Boyle, 2010; Kask & Rannikmäe, 2006; Abd-El-Khalick, et al., 2004 ; Duschl & Grandy, 2005; Hofstein, Nahum, & Shore, 2001). At the same time, experimental practices develop students' communication skills (Aydın, 2016; Duschl & Grandy, 2005; Trowbridge, Bybee & Powell, 2004), critical thinking (Hofstein et al., 2001), creativity, collaborative learning (Gillies & Nichols, 2015; Russell & Weaver, 2011), and manipulative skills, which are all currently defined as 21st-century skills (Lanza, 2007; French & Russell, 2002).

In addition to the many positive effects of IBL on student learning, there are some arguments about the efficiency of models of IBL applications; confirmative, structured, guided and open inquiry. In the confirmative inquiry, the teacher gave questions and procedure, and generally results were known. It can be implemented to a certain goal, for instance, to teach collecting data, recording data or to experience certain ideas like gravity or presence of air pressure. In the structured inquiry, questions for investigation and procedure are given again by the teacher but the explanation of results is done with the findings and conclusion of students. In the guided inquiry different than confirmative and structured inquiry, the only investigated research question is given. The procedure of research, results, and explanations are the responsibility of students. In the open inquiry questioning, investigation, testing, obtaining data, analyzing and comprehension of results were taken place by students, contributing a high level of thinking and discussions of students (Banchi & Bell 2008). The role of teacher and the responsibility of students in GIBL argued in that one group underlined the role of teachers as only giving the materials and problem solving (Colburn, 2000) and the other group pointed out the formation of hypothesis and testing (Farrell, Moog & Spencer 1999). In fact, Schwab (1960) and Herron (1971) explained the levels of inquiry applications in the laboratory environment many years ago. Depending on the classification of inquiry levels; if all the steps of scientific method are given in the applications, it implies the level 0 that means confirmatory inquiry. If question and procedure are given by the teacher, it is called level 1 which means structured inquiry, and when the only problem is given it was called as level 2 being guided inquiry (Buck, Bretz & Towns, 2008). In contrast to other levels' problems, hypothesis, procedure, data collection, and analysis of data and conclusion of results were all done by students in level 3 which is open inquiry. Banchi and Bell (2008) explained the role of students in GIBL where students have had numerous opportunities to learn and practice different ways to plan experiments and record data. In addition to this, each student didn't individually get to manipulate the variables, the direction of the investigation, including the procedure and data analysis were directed by the students collectively.

Depending on the kinds of inquiry scientist explained the results of experiences. In this condition, Mayer (2004) indicated that open IBL that only consisted of hands-on activities was not adequate in students' learning science concepts and he recommended IBL activities that contained scientific concepts. This was echoed by the findings of Roth and Carnier (2006), who compared the science lessons in Czechoslovakia, Japan, Australia, the Netherlands and the United States based on the TIMMS (1999) results and determined that learning only through activities was not sufficient; it was necessary to present concepts in theoretical background. Aydın & Sahin (2009) indicated that there was no significant difference regarding the scientific process skills between 8th grade student groups that were applied with GIBL activities and open IBL activities on both photosynthesis and respiration units but they also investigated that the group that was applied GIBL learned concepts dealing with photosynthesis better than the group with open IBL.

Kirschner, Sweller & Clark (2010) commented that the use of scientific concepts and content knowledge was dependent on the student needs during the activities.

Thefore, students in sample of this research have only experience with confirmative and structured inquiry practices with experiments, they have no experiences with GBL to produce hypothesis, to construct procedure of experiment, to collect data, to analyze and to conclude data in other words scientific process skills and also depending on arguments in literature scientfic concepts given by the teacher during applications were compared before and after the applications to see the effect of GBL on students. Teacher in this research hasn't got ample experiences about practicing high level IBL so GIBL was chosen.

Inquiry-Based Learning Environments

The educational philosophy of Johann Heinrich Pestalozzi underlies many current reform movements in education as follows:

> *Education should be based on the natural development of the cognitive skills of children. The role of educators is to determine how these cognitive competencies will be developed and to carry out education in the way that enables this natural development. Compared to memorizing, research and experiments, and compared to passive listening, being involved with activities are more effective. The main aim of education should be to support independent working. The classroom environment should be arranged in such a way as to provide the individuals to discuss their knowledge and understanding. The lessons should not be conducted in a form that encourages memorizing. The teacher's role should not be to listen to what the students memorized and then evaluate it, but it should be to provide the knowledge and skills to handle materials and so as to evaluate their cognitive development* (as cited by Keller, 2001, p.162).

Using the tools and resources in the classroom environment to promote the interaction of the students with each other and to provide multiple learning strategies rather than using them for demonstration supports student learning in the class (Puntambekar & Hubscher, 2005). In other words, the classroom environment affects the achievement and attitudes of the students (Fraser, 1998) and interactive inquiry-based classrooms engage students in practices and enables them to understand more concepts, generate better explanations and it increases their productivity with their classmates (Eslinger, White, Frederiksen & Brobst, 2008; Metz, 2004; White & Frederiksen, 1998, Wolf & Fraser, 2008). Lin, Hong & Cheng (2009) indicated that students are more involved in learning, asking questions and responding to them in structured classrooms implementing inquiry-based practices. Whether the classroom environment or laboratories are more appropriate for inquiry structured learning environment is a question to be considered. By the mid-19th century, debates had begun concerning the difference between science and other classes in that the former involve the development of generalizations based on observation, which means that students need to learn how to observe nature and arrive at conclusions from their observations. Science eventually gained significance, and the modern world emphasized mental development, thus adding to the popularity of science. Then, in the 19th century, Herbert Spencer (as cited by Flick & Lederman, 2004) demonstrated the importance of laboratories, which in addition to words in books assist students in learning through practice so that they can infer based on observation. He argued that students learn science better when they observe directly and make inferences about objects and phenomena themselves. Arguing that laboratory practices improved students' thinking skills, Charles Eliot (as cited by Flick, Lederman, 2004) noted that laboratories should improve students' inference skills and their ability to obtain knowledge independently. In contrast, Hall (as cited by Flick, Lederman, 2004) concluded that students simply focus on expected outcomes in laboratory applications that validate previous experiments, but this fails to help them acquire scientific skills. He maintained that students should investigate and discover answers to their questions in directed discovery, by themselves, a practice he called IBL (Flick & Lederman, 2004).

During the 1990s, science course practices emerged from the classroom and laboratory; students' social environments gained importance along with improvement in their critical thinking, communication skills, and pedagogical motivation (Duschl & Grandy, 2005). It is the reality that if the aim of science education is to teach students that 'how scientist work' separate laboratories or classrooms environment are required to promote support student's observations, engaging experiments, getting data, group work, using computers. Sun, Looi & Xie (2017) engaged different learning environment in which computer-supported collaborative guided inquiry were used about osmosis and diffusion to provide activity design, employs modelling and visualization tools and they attained computer-based collaborative inquiry promoted students' conceptual understanding. Thomas & Meldrum (2018) used undergraduate physics laboratories for GIBL and students were stimulated the cognitive processes of scientific inquiry. Whitworth, Maeng & Bell (2013) mentioned the differentiation of planning of IBL depending on needs and readiness of student, learning environment, cirruculum, assesment and management of students. In our country, when the teachers are asked why they don't do any experiments in science courses, mostly the reasons are short class duration time, over-populated classrooms, the low capacity of the students, and the lack of laboratory materials (Yıldız, Aydoğdu, Akpınar & Ergin, 2006). Therefore, in the current study, by solving the problems of inadequate materials, crowded classrooms, and laboratories, we aimed to see the effects of GIBL in clasrrom environement on both students and teachers.

Teacher's Role in Inquiry-Based Classrooms

The teacher is the most significant factor in obtaining the expected results in IBL practices. Zuckerman, Chudinova, and Khavkin (1998) described three practices for science instruction with inquiry: (a) instruction begins by introducing ideas that are central and general to the discipline, (b) students invent and adapt cultural tools for thinking about these ideas (models, schemes, and symbols designed by students under the teacher's guidance), and (c) problems are solved in cooperation with peers, helping students to present explicitly their own naive theories and see the phenomenon from others' point of view (p. 202). The most fundamental factors for IBL are initially teachers' competency in concepts and content knowledge, experience, their pedagogical attitude toward students, their own learning style, and their willingness. According to the research concerning the teacher dimension of IBL practices, while a positive relationship is posited between the teacher's competency in conceptual knowledge and students' concept learning (Kind, 2009; Appleton, 2003; Appleton, 2002; Darling-Hammond, 2000; Harlen,1997; Chaney, 1995; Druva & Anderson, 1983), the suggestion that a teacher's higher level of conceptual knowledge, such as a master's degree, will be more successful in IBL practices has been disproved by Ingersoll (2003) and Furtak (2005). Ingersoll noted that although 42% of American science teachers have a master's degree, the underlying factor behind the lack of success in supporting the students' development is that, among other factors, teachers have too many classes and insufficient time for preparation. Wenglinsky (2000) indicated that increased professional experience, particularly laboratory skills, using and having students use models, utilizing technology in lessons, and frequently assessing students with quizzes help students to become more successful. Eick and Reed (2002) stated that factors leading teachers to use IBL are their learning styles and experiences as students. In a study including opinions of six science teachers conducting IBL practices, Wallace and Kang (2003) collected teachers' comments that some students lack the maturity to conduct IBL activities, students are lazy, laboratory activities can be canceled when the program time is insufficient, and that the school culture is not suitable for IBL practices. Another study found that 'it was difficult for teachers to change their habits, that middle and secondary teachers' laboratory usage level is higher than that of primary teachers' (Abd-El-Khalick, et al., 2004, p. 13), and that when both experimental and traditional methods are applied together during IBL practices, there was not enough time (Booth, 2001; Borko, 2004; Robertson, 2006). While researchers have noted that for teachers to be successful at IBL practices, they need to receive training (Posnanski, 2010; Crawford, 2007; Morrison, 2013), three experienced teachers with master's degrees and IBL training answered all questions during IBL practice that should have been researched by students (Furtak, 2005). This was because these trained teachers understood very little about IBL in terms of implementing their classroom practices (Wee, Shepardson, Fast, & Harbor, 2007); thus, teachers should be experienced in IBL practices in the classroom.

Another significant factor in helping teachers to be willing to attempt IBL practices is that students should also be experienced in IBL (Lotter, Rushton, & Singer, 2013; Newman, Abell, Hubbard, McDonald, Otaala, & Martini, 2004). Teachers implementing inquiry lessons have a greater effect on the students' performance (Rönnebeck, 2016). Therefore, the primary teachers have an important role to improve the student's attitude and interest in learning science. The factors which affect the elementary teacher teaching science are self-efficacy, which is the combination of feelings and beliefs about their knowledge, abilities and experiences (Van Aalderen-Smeets, Molen &Asma, 2012) and self-confidence consisting of science knowledge, skills related to daily lives of individuals, and familiarity with science (Appleton, 2002; Mulholland & Wallace, 1996). However, reflecting the changes in negative self-efficacy in classroom teaching requires long–term practices (Palmer, 2006). Even though pre-service teachers learned and practiced IBL, they have not learned how to adapt inquiry practices in an actual class environment, which requires a different process of planning and preparation from the traditional model and orchestrating the students takes more time and effort more than traditional instruction (Crawford, 1999; Fradd & Lee, 1999). In this research, the first question was 'what are the effects of GIBL experiments on students and elementary teachers', and researcher was undertaken by elementary teacher and experiments were carried out in a classroom environment with 42 students rather than in a laboratory. It is also unique in that an experienced teacher (researcher) was involved in the practice of counseling and supervision of the academics, and in the evaluation of teachers' and researcher's practices in their findings.

METHODS

Research design

The research was conducted as a case study Case study is a methodology in qualitative studies and Yin (2009) defined a case study as: "an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (p.18). Examining GIBL practices with 42 students was the phenomenon and students in a public school without laboratories with newly graduated teacher were considered in a real life-context. The use of qualitative methods in case studies have the ability to bring a deep understanding of a case and to provide intrinsic knowledge and details regarding a problem or issues of interest to a researcher (Stake, 1995). According to Creswell & Clark (2007), it is a qualitative approach where the investigator reports a situation or multiple situations in detail using multiple data collection tools. The GIBL experimental applications were implemented in one group in a real-life context, and the data were obtained from various sources, such as observations, drawings, and views before, during and after the implementations. the research is situation analysis being another form of case study (Bogdan & Biklen,1998) and instrumental case study was used to detect the effects of GIBL on both students and teacher to understand the ways of solutions to reduce the limitations of GIBL practices to attain all students in elementary education (Stake, 2005). The qualitative data about views, feelings, thought process, emotions in details about GIBL (Strauss and Corbin, 1998) were used to respond to the research questions.

Participants

The participants consisted of 42 students comprising 18 females, and 24 males, in the fourth grade of a public school in a rural area of Istanbul province. This class was selected through purposeful sampling, which was suitable for the research purpose and provided continuity in attendance. In purposeful sampling, "the researcher selects individuals and sites because they can inform about and provide understanding of the study's research problem and central phenomenon" (Buyukozturk et al., 2014, p. 125). Purposeful sampling enables in-depth research by selecting substantial cases in terms of knowledge based on the research's purpose

(Buyukozturk et al., 2014; Maxwell, 2008). In the research, typical purposeful sampling was used because students, teacher and learning environment represent the similar properties observed in many elementary school, students and teachers in Turkey (Patton, 2002). The teacher who implemented GIBL practices was a new graduate from elementary education and she has attended a master's program with the advantage of recently gained knowledge and the disadvantage of a lack of experience. During the research, she continued her master's program attending a 14-week course entitled applying GIBL practices in science, nature and human behavior. She and author prepared experiments together and they did experiments before the implementations with students.

Implementation

The research was conducted during 12 continuous weeks depending on the science course curriculum. The GIBL applications were conducted with nine groups of five students; however, due to the continuity of student attendance at all lectures, the data from 42 students were used. Before the implementations, a pilot study was conducted with the most familiar experiment of germination. The students tried to discover the requirements for a seed to germinate such as water, light, heat, oxygen during the six lecture hours within the given problem using the 5E learning model. It is a learning model that first took place in the American Science Education programme in 1960 as a 3E model, and later on, Bybee and Landes developed as a 5E learning model. It is based on a constructive approach. This model consists of five stages which are engage, explore, explain, elaborate, and evaluate (Bybee and Landes, 1990). In this pilot study the students encountered the topics of what hypothesis is, how they should observe, what control group is, the importance of gathering data, and how sharing responsibilities affects the experimental results.

In line with the GIBL collaborative learning model, 15 experiments were conducted after the pilot study. In the collaborative learning model, each member had a role of group leader, assistant, reporter, technician, or presenter (Luckie, Maleszewski, Loznak & Krha, 2004). The responsibilities of the different roles were as follows; the group leader ensures that all the work of the group members is completed on time; technicians collect the materials and cleaning of class after the experiments; reporters write up the hypothesis, observations, results and the experiment report; assistants help the leader; and the representatives explain the results of experiments and conclusions to the other group members. In each experiment, the role of the group member's changes, and after five experiments, the groups are disbanded and completely new groups are formed. Collaborative learning assists students in learning cognitive learning strategies (Salovaara, 2005) and influences their lgaining knowledge earning by being active and explaining things to each other (Scholer & Hatton, 2008). Low prior knowledge and minimally guided instruction have a negative effect on the student learning process in inquiry-based applications (Yang, Lin, She & Huang, 2015; Kirschner, Sweller & Clark, 2010); thus, before the experimental application, nine lecture hours were spent on the theoretical explanations of concepts, content knowledge, referring goals, objectives and concepts stated in the curriculum.

In favor of learning the science concepts and fulfilling the concept errors, according to the findings, starting a class with activities rather than the words, asking questions to the students to draw attention on the concepts, coming up with explations, making simple presentations, while conducting the activity checking students whether they get the concepts clearly at the end of the activity or another part of the activity, and repeating the concepts frequently during the process are the important factors. (Trowbridge, Byee & Powell, 2004; Ekborg, 2003). In light of eliminating the concept errors, the students' attitudes toward the class and social stimulants are more effective than cognitive stimulants (Leach & Scott,1999; Hewson, 1981), furthermore, the studies based on the learning cycle are helpfull for fulfilling the concept errors (Krantz, Barrow, 2006; Balcı, Çakıroğlu & Tekkaya, 2006; Wilder & Shuttleworth, 2005), and getting the knowledge of the concepts (Atkin & Karplus, 1962; Ateş, 2005; Blank, 2000; Lawson,1995; Renner, Abraham & Birnie,1998).

The 15 experiments implemented with GIBL and their objectives are presented in Table1 and the lesson plan with the 5E learning model is given in Appendix1. The target school had no science laboratory to accommodate these applications; therefore, the researcher brought some laboratory materials from the university such as beaker, graduated cylinder, test tubes, and magnets into the classroom and regulated students' tables for group work, hanged banners related with matter on the walls for GIBL experiments. This unit was selected because it allowed sufficient time for the GIBL application to be implemented. Also, students could have many misconceptions, such as the molecular structure of matter (Griffiths & Preston, 1992; Nakhleh & Samarapungavan,1999) and dissolutions (Calık, Ayas, Unal, 2006) along with providing daily life experiments with simple materials, thus allowing the topics to be easily integrated into daily life (Appendix 2, 3, 4). Colburn (2000) suggested undertaking inquiry-based activities for young students by orienting activities toward concrete, observable concepts, centering activities around questions that students can answer directly via investigation and emphasizing activities using materials and situations familiar to the students and choosing activities suited to students' skills and knowledge to ensure success in aspects, such as dissolution and solution along with providing daily life experiments with simple materials, and thus the topics can be integrated into daily life easily.

Table 1. *The name and objectives of GIBL experiments*

Exp. No	Experiment name	Objectives
1	How do we get to know matter?	Explanation of matter by using the five sense organs
2	Which materials do magnets like?	Magnetization property of matter
3	Floating or sinking	Floating and sinking characteristic of matter
4	Did the material absorb water?	Water absorption properties of matters
5	Let us measure mass	Mass and volume are the common characteristics of matter
6	Our world is filled with air.	Gas has certain volume
7	What substance comes out of the bottle?	Movement of gas molecules
8	Let us measure volumes of liquids	Measuring volume of liquids
9	How is the volume of solids measured?	Measuring volume of solid materials
10	Measure the temperature	Using thermometer and learning measurement
11	How did the temperature change?	Heating and cooling
12	Do all materials melt?	Melting property of matter
13	Let us make ice-cream	Freezing property of matter
14	Let us make a drink	Differentiation of pure matters and mixtures
15	Does the dissolved material disappear?	Separation of mixtures

Data Gathering Tools

In order to undertake an in-depth investigation of GIBL experiments' classroom implementations on the students and the teacher in this study; more than one type of qualitative data was gathered; this is referred to as *triangulation*. The aim of gathering qualitative data based on different sources is designed to eliminate the risk of the researcher's 'systematic error' (Maxwell, 2008). In addition, "a key strength of the case study method involves using multiple sources and techniques in the data-gathering process" (Soy, 1997, p. 2). The triangulation in this research is the data obtained on the implementations of the GIBL experiments in classroom environment on students who drew pictures before and after applications, student's views and journal notes of researcher.

Student Drawings

Before the implementation and at the end of the research, to identify changes in perceptions of the learning environment including teacher and students, the students were asked to express their opinions through drawings (Thomas & Pedersen, 2003). The researcher asked students the following questions about the key points on drawings: What are the learning materials and where are they? What is your teacher doing? Where is she in the classroom? and What are you doing during the activity? A key aspect of the drawing activity is that emotions and opinions are used as a tool for expression. For children, it is not easy to express with words what they know, see, experience, feel and think. Since the students are unrestricted in the way they draw, this offers a way in which they can express their emotions and opinions about the activity in which they were engaged. In a child's world, there is a vast freedom in terms of view and understanding, where rules cannot enter, everything can be an expression of the child's desire (Arnheim, 2007). In this research, information was gained concerning how the implementation of GIBL in changed learning environment and the role of the teacher with the help of the students' drawings.

Students Views

The data in the current research was gathered from structured views with students after implementations to examine the effect of GIBL experiments on the basis of their learning, the process of the experimental implementation, difficulties faced and the role of teacher in relation to the students. The student's views form comprised five questions prepared by researcher and two experts in the science education field based on the literature and research of Baskurt (2009), Feyzioglu and Demirel (2013). As a pilot study, the questions on paper was administered to 40 students in a different school, and the necessary adjustments were made. The following items were included in the form;

1. Please write your opinions regarding the implementation of the unit on matter with experiments.
2. How were the experiments conducted in this unit, 'We get to know matter', different from those conducted in other units?
3. Please write about what you liked when you were conducting the experiments in the unit?
4. Please write about what you did not like when you were conducting the experiments in the unit?

5. What is your opinion of the guidance provided by your teacher when you were conducting the experiments?

Journal entries

To obtain data on the GIBL application, the teacher was asked to maintain a journal and write up her observations after each lesson. The researcher asked the teacher to respond to the following questions when taking notes in her journal: what did you learn about your competencies in applying GIBL and what did you notice about the changes in the students' concept learning, interest to science, feelings, and behavior? In addition to the journal entries of the teacher, video recordings and the researcher's notes were used to obtain detailed effects of the GIBL. The researcher being participant observer directly witnessed the activities and reactions of both the teacher and students and used her own knowledge, experiences and expertise to analyze the information (Merriam, 2013). Also, the researcher collected the missing data in relation to the research problems from the teacher and evaluated the results. To collect all data, legal permission was obtained from the students, school manager and related institutions.

Data Analysis

Depending on Marshall and Rossman (2011) credibility, transferability and dependability are the main issues to determine the trustworthiness of qualitative study. In order to ensure the trustworthiness of this study; the checking of data codes was done by three experts other than researcher and used video records, researcher notes, teacher's diary, pictures and views for internal and external consistency to answer the research questions to provide the reliability of the analysis (Patton, 2014). Triangulation were carried out by collecting data continuously from various sources (Lincoln & Guba, 1985). The basic process of content analysis is to bring together similar data within the framework of certain concepts and themes and present them in a form that the reader can understand (Yıldırım & Simsek, 2012). The categorized content analysis and frequency analysis were carried out together (Bilgin, 2014). In terms of transferability, Merriam (1998) indicated that the findings of a qualitative study should be applied to other or broader areas. The unit 'matter' was chosen that was common unit for both and science teachers, implemented experiments with GIBL could be used by teachers and teacher candidates and also the outcomes of research would be the reasons of improvements in teacher education program. The researcher having 20 years teaching experiences and academic studies about inquiry managed the collection of data from both teacher and students to ensure confirmability.

The research achieved construct reliability by gathering triangulated data, and the expert analysis of each data source provided external reliability. The validity of research was provided by the use of different data tools and to eliminate the risk of the researcher's systematic error (Maxwell, 2008), and the research data were collected from different sources, including the students, teacher and researcher, and the students' views were produced with the help of the literature, expertise and pre-test results. The aim of systematically gathering qualitative data was to discover a theory on completion of the research (Glaser & Strauss, 1967). Therefore, observations of researcher, video records and diary entities of the teacher provided for continuous data collection during the implementation period.

In this study, the reliability of the codes for all three data groups was determined using the Miles and Huberman (1994) formula: reliability = Consensus / (Consensus + Disconsensus), and the drawing analyses' reliability was calculated as an average of 90%. This result indicated that codes of the research were reliable. The experts coded the student views separately, and determined the frequency values of the obtained categories. The categories were generally defined using the question number and initial letters of the theme. For example, 1TH: The teacher helped us. The 1 is the question number and the first letters of teacher 'T' and helped 'H'.

The student drawings were analyzed by the researcher, an assistant professor, and a professor with expertise in drawing analysis. First, they examined all the pictures to observe the differences between pictures that were produced before and after the implementation. They produced a rubric consisting of three categories; teacher's position, student's position, and experiment materials as shown in Table 3. Later, they defined the themes for each category; for example, the first category was dealing with teacher's position and it was divided into themes, such as the teacher is / next to / behind the table, the teacher is in front of the board, the teacher is at her table with experiment materials, the teacher goes around the groups, and the teacher's table is in the middle of the classroom. Depending on the themes, if a student's drawing included the teacher sitting at her table, the analyst would add +1 for the pre-test of student rubric paper and if it was not considered on the post-drawing, 0 was given on the rubric of same student. Finally, the total points were calculated for the rubric results of both pre- and post-implementation drawings.

The teacher's journal and video recordings of the 15 experimental applications and the researcher's observation notes during eight lessons are purposefully selected samplings. Three experts coded and evaluated them through content analysis, under the following subtitles: *content knowledge*, *conceptual knowledge*, *asking questions*, *problem-solving ability*, *transferring knowledge to daily life*, *IBL application skills*, *and science teaching methods and techniques*, and *classroom management*. Teacher journal notes were coded as N, video recordings as V, and the researcher's notes as A; lessons were then given number codes, for instance, N5, V5, and A8. In the coding of themes, P was used for IBL practices, A for attitude, and E for teacher's self-evaluation. For example, in the teacher's daily journal for the fifth lesson, data on student attitude was coded N5A, data regarding IBL practices during the researcher's eighth lesson observation was coded A8P, and the teacher's self-evaluation in the fifth lesson video recording was coded V5E. From the data received from three sources in the teacher dimension, the teacher's daily journal notes were considered as the focus data; however, the researcher's observation notes and each lesson's video recordings were also coded and evaluated according to themes. Inter-theme relation obtained from the three data groups was conducted.

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RESULTS

This section includes results of the data obtained to determine student’s views, changes in student perceptions about the learning environment and the teacher’s reflections regarding guided inquiry implementations.

Results of GIBL applications on students

The categories, themes and percentages on data from student views are displayed in Table 2.

Table 2. *Student views regarding GIBL applications*

Categorizes	Themes	Samples	f	%
	Easy unit	1LE: We learned it very well by experiment.	17	41%
Student interest to science lecture	Learn well	1LF: The topics were a lot of fun.	9	21%
	Fun lesson	1EU: It was a very easy unit.	9	21%
		3DE: We enjoyed doing different experiments.	21	50%
	Enjoy experiments	2CL: We learned the concepts regarding matter.	19	45%
	Learning	2EL: Our learning is meaningful when we do experiments.	15	36%
Learning concepts with experiments	Names of materials	3DM: We made experiments using different materials.	10	24%
		2LM: We learned the names of the experiment materials.	8	19%
	Group work	3GW: We enjoyed working with classmates	6	14%
		3TG: Our teacher guided us during the experiment.	5	12%
	Difficulties of group working	4ND: There is nothing I do not like.	15	36%
Collaborative working		4NM: Some of our friends did not bring the experiment materials to class	14	33%
	Enjoy group working	4DC: The class got dirty and disordered.	9	21%
		4GG: There were too many students in the groups.	4	10%
		5EB: It was very beneficial.	24	57%
Teacher’s role	Helping students	5TH: The teacher helped us in every way and spends an effort for this.	19	29%
		5TP: The teacher helped us to conduct the experiments.	6	14%

Four categories regarding the GIBL applications emerged from the student data obtained from the student’s views. As shown in Table 2 the category, student interest to science course, 41% of students gave the response; we learned it very well by doing experiments overall**.** For example,

“1LE- *Experiments on matter are conducted and we understand better. … this is the first time that I really understood a science topic.* “

Of the students, 21% stated that: “*it was an easy unit and that the topics were a lot of fun*.” The following extracts indicate that students enjoyed the lessons like;

“1LF-*Doing the experiment and measuring it was fun. We enjoyed it a lot. It is very nice to get to know matters by smelling and touching them with your eyes closed*.”

Other students (17%) used expressions similar to the extract below which revealed that they were affected by the teacher's role in GIBL applications such as,

"1TH- *Our teacher asked us questions and we asked her questions, she helped us and this was very useful*. *Our teacher helped us when we weren't able to do something. "*

The second category of learning concepts with the experiments; students' frequent (50%) attitudes of enjoyment as displayed by the following samples:

"3DE- *we enjoyed different experiments very much. Doing experiments was a lot of fun. Each group made a different experiment. We made different experiments in each lesson. I enjoyed it very much. I liked the experiments that we made with our teacher*.

The students (45%) expressed that they had learned concepts for instance:

"2CL-*we learned melting and freezing. We learned the words solid, liquid, and gas. I learned the difference between boiling and evaporating*. "

In differentiating the unit from others, the results showed meaningful learning (36%) and recognizing experiment materials (19%), for example:

"2EL-*We tried to validate the topic we are learning by doing. I can keep the unit 'Let us get to know matter' better in my mind. We made the experiments for better understanding*. "

While most experimental materials were from daily life, equipment, such as test tubes, beakers, and spirit lamps, provided from the university greatly attracted students' attention, and they expressed this as follows:

"*2LM- It was very enjoyable to see corn pop in the test tube. It was very nice to see different experiment materials." "3DM—I liked it very much to do experiments using equipment.* "Thus, using various experimental materials in lessons is effective for students.

The sentence *"3GW-having group work with my friends and adding more knowledge to the science lesson*" indicates that students found group work useful (14%). The teacher's effective guidance during experiments (12%) was expressed as follows:

"3TG—I liked the experiments we did with my teacher. My teacher was very helpful and I liked this very much."

Regarding the third category, Difficulties students encountered with applications**,** 36% of the students stated there was nothing they disliked in the unit; for example,

"4ND—*in the unit 'Let us get to know matter,' there is nothing I did not like about the experiments*."

Some dissatisfaction with other students' failure to bring experimental materials was expressed (33%); for instance;

"*4NM—our classmate [X] did not bring experiment materials. The person who was going to bring the lemon did not come to school that day*." Some students (21%) cited disadvantages of GIBL applications as the classroom being untidy and dirty after the experiments and that some students did not behave cooperatively:

"4DC— I do not like that they make the classroom dirty and do not help those who clean it, and they misbehave during the experiments. Additionally, 10% of students expressed discomfort in the crowded student groups:

"4GG—when the groups were overcrowded, sometimes there was disorder. I was disturbed by the noise because we were too crowded."

The students' opinions on the fourth category, Teacher's role during GIBL applications were 'very good' (57%) indicating that the teacher helped with every aspect and showed great effort (29%) and now they could do experiments with the teacher (14%)

"*5TH-Good, because she behaves very nicely; I like my teacher very much. She asked what we were doing, and I liked this very much. "*5TP-*Our teacher's help during the experiments was very useful. Now I can do the experiments. "The role of teacher was pointed out as the help she gave during the experimental practices*."

Results on effects of GIBL experiments in student drawings dealing with learning environment

Data from drawings were analyzed according to three main themes: teacher's position, students' position and experimental materials. Student drawings prior to applications were coded as 1 and those after applications as 2.

Table 3. *Results regarding analyses of the student drawings about the learning environment*

Categorizes	Theme	1st Drawing		2nd. Drawing	
		f	%	f	%
Teacher's position	The teacher is / next to / behind the table	18	42.9	3	14.3
	The teacher is in front of the board	10	23.8	2	4.8
	The teacher is at her table with experiment materials	0	0	18	42.9
	The teacher walks round the groups	0	0	19	45
	The teacher table is in the middle of the classroom	0	0	1	2.4
Student's position	Experiment materials on student tables	1	2.4	13	7
	The students walk around	4	9.5	0	0
	The students sit at their desks	16	38	5	12
	The student is at the board with the board pen	8	19	0	0
	The student is in front of the teacher table	5	12	0	0
	Students are doing the experiment at each table	0	0	20	4.8
	Students are observing the teacher	0	0	5	12
	Students are cleaning the classroom	0	0	4	9.5
Experiment Materials	Laboratory materials (beaker, spirit lamp, test tube, clamps, magnet, scaled cylinder, sandglass)	0	0	37	88
	Daily life materials (orange, lemon, jug, clock, milk, coke, juice, corn, salt, sugar, balloon, water container, paper boat, glass, fruit press, stone etc.)	3	7	42	100
	Experiment book	0	0	12	28.6
	The name of the experiment, materials, how it is done and the results are written on the board	0	0	8	19

Table 3 shows that the teacher's position and classroom perceptions changed with the applied GIBL experiments. In initial drawings, the teacher's position was determined in relation to the teacher's desk and the board (42,9%), but in the final drawings, experimental materials were depicted on the teacher's desk (42, 9%), and she was consulting with groups (45%), which shows the change in the teacher's role from the student perspective. In the initial drawings, the teacher figure was less prominent than in the final drawings, in which the student perspective of GIBL applications (f = 28) gave the teacher figure greater prominence (45%), thus underlining positive results. The examination of the students' position in drawings reveals the transfer from teacher-centered to student-centered instruction with the GIBL applications; in the initial drawings, 16 students are sitting at their desks, but this figure drops to 6 in final drawings. In the initial drawings, students were shown at the board (19%), in front of the teacher's table (12%), and moving around the classroom (12%). In final drawings, students are conducting experiments at each table (4, 8%), the experimental materials are on the teacher's table (7%), and the students are at the same desk as their group members, thus indicating GIBL experiment applications including collaboration and concrete materials. While in initial drawings, daily-life experiment materials appeared in only three drawings, they were included in 42 of the final drawings. Similarly, no initial drawings included laboratory materials that the researcher brought to the classroom; however, of the final drawings, 77.08% included laboratory materials. Furthermore, instructional methods and techniques different from those used in traditional science instruction attracted students' attention and affected their attitudes. Using laboratory materials in the classroom environment was effective; students did not focus on experimental materials in initial drawings, but they did in final ones.

Results of GIBL applications on the teacher

Table 4. *The reflections of GIBL experiments implementation on teacher*

Categorizes	Themes	Examples
Practicing GIBL	Content knowledge Conceptual knowledge Asking questions Problem solving ability Science teaching methods and techniques Transferring knowledge to daily life Class management	N5P: While doing the experiment, they saw that sugar was not melting, but blackening. When their estimation was not correct at the end of the experiment, they experienced conceptual contradiction. In this situation I understood that I should support the lesson with mind maps, conceptual texts. A7P: The teacher also has a misconception in melting and dissolving concepts.
Awareness of the changes in student attitude	Motivation Creativity	N3A: The students did not want to leave the experiments when I told them the lesson was over and each group should put the materials together. None of the students felt a need to go out for the break and continued the experiments.
Teacher's self-evaluation	Need to do research Reduce misconceptions Content knowledge Need to read Self-esteem Practicing experiments	N8E: Some questions that my students asked led me to make detailed research on science subjects. I obtained more knowledge on mixtures such as cologne. I have understood that I need to read articles, books and journals and do research regarding the experiments for the coming weeks.

Based on the data presented in Table 4, the teacher seemed to have misconceptions about some concepts in the unit and lack of knowledge in the field; "*N5P-I asked the students: Have the materials dissolved in water kept their characteristics in the water? They answered that they did not see materials such as sugar and salt in the water. Upon asking the reasons, after a variety of answers, using the clues, they stated that the granular materials broke up into small particles and dispersed. When I asked them whether they lost their characteristics, they answered that they did not as we still could taste them. I asked the students what concept dissolution was. They answered if it gets lost in the water, as sugar and salt dissolved in our experiment, it is dissolution. However, when I asked about lemon juice and orange juice, they thought a lot but could not find the solutions. Afterwards, they understood that they also dissolved in the water, looking at the drinks they had made. But when I asked about chickpeas, they answered easily and said that they did not dissolve. In order to confirm that the students understood the concept solution, I asked about the drinks to exemplify the solutions. This time, using the definition of dissolution, they answered 'water with sugar' and 'water with salt'"*

*"V7P-A7P—in the mixture experiments, one group put juice into milk and made a mixture. The juice stayed on top of the milk. When it was stirred, they dispersed into each other. When it was shaken, it foame*d. The teacher asked the reason for this event. [X] Answered*: " there is acid in milk; therefore, it effervesced. "*The teacher did not ask how he knew there was acid in the milk [in order] to correct the misconcept. The same teacher's journal regarding the lesson said, "G7P—… *It effervesced when it was shaken. When I asked about the reason, [X] said there was acid in the milk and a factor for effervescing was acid. "*

Science experiments in the classroom environment based on research do not only allow the comprehension of an experiment, but they also help establishing relations with other subjects for the students. In other words, the teacher did not realize that students had not learned the acid–base concept and that she herself lacks in-depth knowledge regarding matter. The teacher's lack of content knowledge also caused her to have difficulties creating and answering questions to guide students, for example: "*A7P-during the melting, dissolving experiments, a student asked, V7A: 'Teacher, then is tea a solution?'* The teacher had difficulty answering. Additionally, the datum "*N7P—Today I had difficulty answering some student questions; I should have made more detailed research on materials such as cologne indicates that the teacher needed content knowledge for GIBL practices".* In addition to this, the following examples indicated that the teacher needs to use other science instructional methods and techniques along with experimental applications, "*9NP—in the experiment 'Does all matter dissolve?' each group put a little sugar in the test tube. Before heating it, they were asked to guess what would happen to the sugar. They said it would dissolve. In the experiment, they saw that sugar did not dissolve, but blackened. When their estimations were not correct at the end of the experiment, they faced contradictions in the concepts. In this case, although initially I was teaching theoretically, I understood that I should support the lesson with mind maps and concept texts in the experiments*. "*1NP: At the end of the experiment, 'How Do We Recognize Matter?', the students made componential analysis tables on the characteristics of matter. These tables, which are an alternative assessment technique necessary for research-based learning, were useful for the students."*

Additionally, based on the following, certain necessary information should be provided at the appropriate time during the experiment: "*A5P—in the experiment 'Let us Measure the Volume of Liquids', the teacher realized that the students did not have any previous knowledge of how to use the graduated cylinder during the applications. She told them about the graduated cylinder and explained how it is used. "* As for classroom management: "*3NP—although the groups were crowded, giving different tasks to each student made it easier to control the class*. "The reflections about lack of experience came from "*N1P—when some students did not bring the materials, I had difficulty in arranging the groups. I could not decide whether I should do the experiment with three groups or whether I should divide the whole class into three groups*. " Concerning preparation: "*4NP—As I had not done the experiment 'Did it absorb the water?' before, I had difficulty in classroom management*. "

While GIBL applications develop students' positive attitudes toward science lessons, they can also increase the teacher's application experience and raise their motivation to create solutions for their problems. Students' positive attitudes increase the teacher's motivation as well. Sample data are as follows; ""*N5A—When I told them the lesson was over and asked each group to put the materials together, the students did not want to leave the experiments. For the first time, they did not feel the need to go out for their break and continued with the experiments. Although today I have some problems in science experiments based on research, I believe in the future I will not experience these*. "A12A—"*The experiment environment in the laboratory to be created in the classroom was a big event for them. They observed the evaporation of the water without blinking an eye.* "*N12A—I brought beakers, test tubes (5), and clamps to the classroom. Students' focus was on these materials*." The materials had great significance for catching the attention level of the lesson. "*N2A—Some students drew the results in the experiment books in drawings. I had never thought of this. I observed that the drawings in experiment books helped them to develop positive attitudes towards the science course*." "*N2A—Today the students did experiments with iron powder and magnets, very creative experiments that I was not expecting at all… and I had as much fun as they did."* Here, it can be said that creating an experimental environment in the classroom positively affected students' interest in and attitudes toward the lesson. Teacher evaluated themselves on GIBL applications in the following: raising awareness of conducting experiments with daily-life materials at schools without laboratories, doing more research, raising awareness of the need for in-depth knowledge, gaining various pedagogical skills such as effective listening, and of the significance of guidance and empathy. Sample data regarding more research: "*2NE—from the aspect of teaching career, since the first day up to today, I have found opportunities to read more articles in the field of Science and Technology and to rearrange the*

experiments by adding more creativity to them. N10E—with the feedback from my students watching the experiments on TV more [video recordings of experimental lessons], and I enabled them to become more science and technology literate in their daily lives.N8E—some questions my students asked led me to make more detailed research on science topics. I obtained more information on mixtures such as cologne. I realized that I need to read a lot of articles, books, and journals and make research regarding the experiments in the coming weeks. "Sample data on the teacher needing to perform experiments herself before classroom application are as follows:
A *4E—in the 'Did it absorb the water?' experiment, the teacher had difficulties both with the questions and also classroom management because she had not done the experiment beforehand. N4E—my limitations in this subject caused difficulties in classroom management, as I had not done the experiments beforehand."* The teacher questioned herself in her daily journal, citing reasons for her lack of experience, and the results of this, and what she should do. For example;
N3E—at my university education, we could not do experiments, as there were not sufficient materials. Since I was unable to practice with learning based on inquiry, I had difficulties with the applications in the beginning. I also had some difficulties in linking the topics to real-life examples. I believe the reason for this is that I do not read enough scientific books.
This indicates that besides benefitting students, GIBL applications help make teacher aware of self-evaluation and development. " *N5E—I believe that after today's experiment, I can make the applications more easily. My self-esteem has increased*. "In other words, the teacher used applications more easily as she practiced; thus, as she gains experience, applications will become easier and more productive.

GIBL applications help teacher gain many skills in pedagogical approaches besides teaching science. From the researcher's notes, these skills are as follows: A15E—*after the applications finished, I asked the teacher what the applications helped her gain. She answered that she gained skills of effective listening, guidance and helping, feelings of empathy, making up her deficiencies regarding the concepts of the experiments, and also they helped her develop her self-confidence.* This is also indicated in the following teacher notes*:* G15E—*when the class was too crowded, I had difficulties in managing all the groups. However, changing the organization from the traditional arrangements, different experiment materials, and the activities I engaged in with the students particularly motivated my students whose academic achievement was not very good.*

DISCUSSION and CONCLUSIONS

GIBL practices with experiments improved some competencies related to science teaching and the teacher's pedagogical attitudes (Avraamidou & Zembal-Saul, 2010) as shown in the responses of the students. In this study, the most important outcomes resulting from the GIBL experimental practices, the students gained learning of concepts significantly through experiments (Aydın-Parim & Sahin, 2009; Ates, 2005; Hassard, 2005; Hofstein et al., 2001; Blank, 2000; Renner et al., 1998; Lawson, 1995), they learned while having fun, and the teacher helped them perform experiments. Furthermore, the students stated that they learned the names of experimental materials they had not seen before. They understood concepts regarding matter (e.g., melting, dissolution, burning) more concretely with experiments in which they actively used their five senses (Campbell & Neilson, 2009, p. 4). Students liked following the unit's experiments: in which the experiments differed, but sometimes were related, and they discussed this with the other students (Aydın, 2016; Duschl & Grandy, 2005; Trowbridge et al., 2004), they conducted experiments in groups (Gillies & Nichols, 2015), and the teacher guided them through the experimental process. However, some students commented on negative aspects concerning group members not bringing the required experimental materials to school, the classroom being untidy and dirty after experiments, and too many students in a group. The most significant and prominent concepts in student responses were that they liked the experiments very much and had a lot of fun, indicating that GIBL practices increased their interest in the lesson and their motivation (Gillies & Boyle, 2010; Kask & Rannikmäe, 2006; Duschl & Grandy, 2005; Abd-El-Khalick et al., 2004; Hofstein et al., 2001). The students' drawings reflected the classroom's different arrangement (Llewellyn, 2002), their participation in a new practice, their use of experimental materials (e.g., a scaled cylinder, beaker glass that they had not seen before), keeping an experimental notebook, being involved in group work, and the changes in the teacher's role (Table 4). When the teacher rearranged the learning environment and used different practice materials, she saw that this made students willing to learn, aroused their curiosity, and attracted their attention (Schunk, 2014, p. 140). Therefore, GIBL experiments can provide changing learning environments that motivate students learning (Lin, Hong, Cheng, 2009; Eslinger, White, Frederiksen, & Brobst, 2008; Fraser; 2008; Wolf & Fraser, 2008; Metz, 2004; Puntambekar & Hubscher, 2005; White & Frederiksen, 1998). The implementation of guided inquiry-based activities with the fourth-grade students in undertaking the experiments in a controlled classroom environment, had the effect of increasing their curiosity and their attention to what would happen at the end of experiments. While doing experiments, the students asked questions and engaged in different experimental designs which had not been proposed by the teacher. In this way, the students supported the development of the teacher.

This research demonstrated that the students' willingness and motivation also increased the teacher's motivation (Newman, Abell, Hubbard, McDonald & Martini, 2004). For example, the teacher was not expecting the students to experiment with iron powder and magnets (Gilles & Nichols, 2015) and the students engaged in other experiments that were not planned by the teacher. Even though the class had ended, the students did not want to end their experiments and they identified experiments as fun game.Furthermore, in this research, even though there wasn't any science laboratory in the school and the class population was crowded, it could be seen that students' interest, attention, and curiosity towards science class increased when the teacher planned activities that students could directly take an active role and involve in discussions, design their own experiments and rearrange the learning environment accordingly.

The significant experience that the teacher acquires from the practices is that although at the beginning she treats the subjects theoretically, she can integrate different methods and techniques in experimental practices. This could be exemplified as follows: the students estimated sugar would melt as a result of burning, but when they saw it blackening, the teacher used a concept map. Also, she used a componential analysis table with regard to characteristics of matter and showed results with the drawings in students' laboratory notebooks, she watched the video-recorded experiments for feedback that she used to link experiments to real-life situations. However, as she experienced difficulties in responding to student questions during practices, she did not ask an in-depth question requiring inquiry. Instead, she inferred that in GIBL, students not only learn concepts of the experiment they are performing, but also establish relationships to other concepts. In addition, to having difficulties in asking and answering questions, the teacher also had misconceptions about dissolving, mixing, and melting. She had not performed the 'absorbing water' experiment in advance and because she had not experienced GIBL in a classroom environment, she had difficulties forming and answering questions. For successful GIBL practices, the teacher must create questions to guide students toward meaningful, in-depth learning and develop their creativity and thinking skills to discover and answer such questions themselves (Aydın & Sahin, 2009; Howes, Lim, & Campos, 2009). According to data obtained from these practices, the teacher had difficulty asking questions due to lack of experience, and lack of contextual and conceptual knowledge (Cheung, 2008; Appleton, 2003; Appleton, 2002; Darling-Hammond; 2000; Druva & Anderson, 1983; Hmelo-Silver, Duncan, & Chinn, 2007; Wee, Shepardson, Fast & Harbor, 2007; Furtak, 2005; Kind, 2009; Wenglinsky, 2000). The fact that acceptance to elementary teacher training faculties based on entrance examination scores in mathematics and literature often means that the pre-existing science knowledge of the teacher candidate is deficient. During undergraduate education, teacher candidates receive only 30 hours of physics, 30 hours of chemistry, and 30 hours of biology. This period of time is not sufficient for learning all science topics in depth. Similarly, as in the example of science and technology practices, many universities experience problems in applied training. For a teacher to have only just adequate conceptual knowledge and only no misconceptions, is not enough for GIBL practices to be successful. Teacher need to research for all science topics, be able to utilize various resources such as journals and cartoons, and they should be science literate.

For example, when the student said that milk was acid, the teacher needed to know the acid and base concepts that were not covered in the 'Matter' unit.

Another difficulty for the teacher was classroom management. According to student opinions and data from teacher notes, the reasons for classroom-management problems were lack of experience, the crowded classroom, and students neglecting to bring experimental materials. In crowded classrooms and in schools without laboratories (Cheung, 2008), asking students to bring experimental materials has caused difficulties in GIBL practices for the teacher and students. Similar to that found in the literature, Alake-Tuenter, Biemans, Tobi, Wals, Oosterheert, and Mulder (2012) explained, 'Teacher have to also understand and respond to individual pupils' needs and to context variables such as available time, space, location and materials' (p. 27). As can be understood from the data, the problems of asking questions, answering questions and classroom management were generally presented in the initial practices, and the examples reveal how she evaluated herself regarding the reasons for this situation. It was observed that as the teacher's practical implementation increased, she relaxed and her belief in her self-confidence changed positively. Their negative beliefs were the result of insufficient content knowledge and experiences (Herrington et al., 2016; Gillies & Nichols, 2015; Morrison, 2013; Rushton et al., 2011; Van Aalderen-Smeetset. at al., 2012; Enderle et. al., 2014; Granger et al., 2012; Lumpe et al., 2012; Eick & Stewart, 2010; Palmer, 2006; Appleton, 2002; Lumpe et al., 2000; Mulholland & Wallace, 1996).

Instructional outcomes made the teacher aware of her deficiencies, and it was likely that she ameliorated these deficiencies as she observed the effect of her role on the students. Finally, as reported, she became aware of the need to gain new skills and self-confidence; in fact, she reflected that she obtained some skills during the research period and this was observed by the researcher. Unfortunately, two years after this research was conducted, the researcher asked the teacher who participated in this research whether she was engaging in inquiry-based experiments in her courses, her answer was '***No'*** and she gave the reason as '*I was too tired to plan and undertake it in class*.' I was shocked by the this answer. The other reason different than that I mentioned before may be the changing properties of the new generation who did'nt want to take over compelling the body and to change her self beliefs is not possible with practices.

Implications

For elementary teachers to be successful in implementing and continuing GIBL practices, they need to have specific competencies (Alake-Tuenter et al., 2012). Despite the issues of a crowded classroom, absence of a laboratory, and the teacher being inexperienced, this research showed that elementary school students enjoyed performing experiments in group work and they showed their learning achievement by using the term 'easy unit'. Thus, even in schools in areas of very low socioeconomic levels, although it may be difficult for the teacher, GIBL can be implemented. However, to be successful and sustainable from the instructional viewpoint teacher training should increase theoretical science lessons and offer applied science courses. Furthermore, teacher candidates should implement practices with a scientist or a mentor in the classroom with the students. Furthermore, at the beginning of the inquiry practices, teacher candidates should receive applied training, particularly in collaborative learning, communication skills, and pedagogical approaches since this is an important factor changing their negative self-beliefs and self-confidence and adopting a positive approach. Along with a high level of social skills, teachers themselves should possess skills in inquiry, critical thinking, creativity and problem solving.

REFERENCES

Abd-El-Khalick, F.,Boujaoude, S., Duschl, R., Lederman, N. G., Mamlok-Naaman, R., Hofstein, A. &Tuan, H. L. (2004). Inquiry in science education: International perspectives. *Science Education*, 88(3), pp.9-13. doi:10.1002/sce.10118

Akerson, V. L., & Dickinson, L. E. (2003). Using GIS technology to support K-8 scientific inquiry teaching and learning. *Science Educator*, 12(1), 41. 12.03.2009 retrived from https://search.proquest.com/docview/228707159/fulltextPDF/D6B976613C634B5BPQ/1?accountid=15572

Alake-Tuenter, E., Biemans, H. J., Tobi, H., Wals, A. E., Oosterheert, I., & Mulder, M. (2012). Inquiry-based science education competencies of primary school teachers: A literature study and critical review of the American National Science Education Standards. *International Journal of Science Education*, 34 (17), pp.27. doi: 10.1080/09500693.2012.669076

Appleton, K. (2003). How do beginning primary school teachers cope with science? Toward an understanding of science teaching practice. *Research in science education*, 3(1).https://doi.org/10.1023/A:1023666618800

Appleton, K. (2002). Science activities that work: Perceptions of primary school teachers. Research in Science Education, 32(3), 393-410. https://doi.org/10.1023/A:1020878121184

Arnheim, R. (2007). *Visual thinking, Ogdul (Ed.),* Istanbul, Metis Press.

Ates, S. (2005).Improvement of prospective teacher's ability on defining and controlling variables, *Journal of Gazi Education Faculty*, 25(1), 21-39.

Avraamidou, L., & Zembal-Saul, C. (2010).In search of well-started beginning science teachers: Insights from two first-year teachers. *Journal of Research in Science Teaching*, 47(6), 661 686.doi:10.1002/tea.20359

Aydın, G. (2016). Reflections of inquiry-based laboratory experiments on prospective teachers' communication skills. *International Online Journal of Educational Sciences.* doi:10.15345/iojes.2016.02.005

Aydın, G. &, Sahin, F. (2009). *The effects of inquiry learning on photosynthesis and respiration concepts, scientific process skills and achievement of 8th grade students*. pp. 2-3. Dissertation Doctorate Thesis, Marmara University, Istanbul, Turkey.

Banchi, H., & Bell, R. (2008). The many levels of inquiry. *Science and children*, *46*(2), 26. Retrieved from https://search.proquest.com/docview/236901022?pq-origsite=gscholar on December,2019

Baskurt, P. (2009). *The effects of activities which were done with simple materials about force and motion unit at 8 grades students on their attitude, achievement and meaningful understanding*. Dissertation Master Thesis, Gazi University Educational Science Institute, Ankara, Turkey.

Baxter, J. A., & Lederman, N. G. (1999). Assessment and measurement of pedagogical content knowledge. In J. Gess-Newsome & N. G. Lederman (Eds.), Examining pedagogical content knowledge (pp.147–161). Dordrecht, The Netherlands: Kluwer.

Bell, R. L., Smetana, L., & Binns, I. (2005). Simplifying inquiry instruction. The Science Teacher, 72(7), p.35. Retrieved from https://knilt.arcc.albany.edu/images/archive/6/6f/20090424031839!Simplifying_inquiry_instruction.pdf on May 2017.

Bilgin, N. (2014). *Content Analysis in Social Science*. Political Press, Ankara.

Blank, L.M. (2000). A metacognitive learning cycle: a better warranty for student understanding. *Science Education*, 84, 486–506.doi: 10.1002/1098-237

Bogdan, R. C., & Biklen, S. K. (1998). Qualitative research in education: An introduction to theory and methods (3rd ed.). Needham Heights, MA: Allyn & Bacon.

Booth, G. (2001). Is inquiry the answer?. *The Science Teacher,* 68 (7), 57. Retrieved from http://search.proquest.com/openview/450b2d2f405fb6cad59463dad84ce8ed/1?pq-origsite=gscholar.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational researcher*, 33(8), 3-15.doi: 10.3102/0013189X033008003

Bryant, R. (2006). Assessment results following inquiry and traditional physics laboratoryactivities.*Journal of College Science Teaching*, 35(7), 56-61.Retrieved from https://search.proquest.com/openview/1d3c2e9d4119f8bdf1a5aebb967779d6/1?pq-origsite=gscholar&cbl=49226

Buck, L. B., Bretz, S. L., & Towns, M. H. (2008). Characterizing the level of inquiry in the undergraduate laboratory. *Journal of College Science Teaching*, 38(1), 52-58.Retrieved from https://pdfs.semanticscholar.org/e24a/3028f7c279e3b8c4ab609970753bd7089991.pdf

Buyukozturk, S. (Ed) (2014). *Research Methods (15th ed*). Ankara: Pegem Academy Press,pp.80 125

Bybee, R., & Landes, N. M. (1990). Science for life and living: An elementary school science program from Biological Sciences Improvement Study (BSCS). *The American Biology Teacher*, 52(2), 92-98. https://www.jstor.org/stable/pdf/4449042.pdf?refreqid=excelsior%3A62e64e1ced4b2bf938ab8cbfa1e40d7a

Calık, M, Ayas, A, Unal, S. (2006). Determination of student conceptions related to concept of consciousness: An age comparison study. *Journal of Turkish Educational Sciences*, 4 (3), 309-322. Retrieved from http://dergipark.gov.tr/tebd/issue/26119/275161on April 2016

Campbell, T. & Neilson, D. (2009). Student Ideas & Inquiries: Investigating Friction in the Physics Classroom. *Science Activities: Classroom Projects and Curriculum Ideas*, *46*(1), p.4. Retrieved from https://doi.org/10.3200/SATS.46.1.13-16

Chaney, B. (1995). Student outcomes and the professional of 8Th grades teachers in science and mathematics. Prepared for NSF grant RED9255255. Rockville, MD: Westat

Cheung, D. (2008). Facilitating chemistry teachers to implement inquiry-based laboratory work. International *Journal of Science and Mathematics Education*, 6(1), 107-130.doi: 10.1007/s10763-007-9102-y

Colburn, A. (2000). An inquiry primer. *Science scope*, *23*(6), 42-44. Retrieved from http://www.experientiallearning.ucdavis.edu/module2/el2-60-primer.pdf on May 2017

Cresswell, J. W., & Plano Clark, V. L. (2007). *Designing and conducting mixed methods research.* Thousand Oaks, CA: Sage Publications.

Crawford, B. A. (1999). Is it realistic to expect a preservice teacher to create an inquiry-based classroom?. *Journal of Science Teacher Education*, *10*(3), 175-194. https://doi.org/10.1023/A:100942272

Crawford, B. A. (2007). Learning to teach science as inquiry in the rough and tumble of practice. *Journal of Research in Science Teaching*, 44(4), 613–642.doi: 10.1002/tea.20157

Grossman, P. L. (1990). The making of a teacher: Teacher knowledge and teacher education. New York: Teachers College Press.

Darling-Hammond, L. (2000).Teacher quality and student achievement. *Education Policy Analysis Archives*, 8, 1. doi: http://dx.doi.org/10.14507/epaa.v8n1.2000

Darling-Hammond, L., & Hudson, L. (1990). Chapter 4: Precollege science and mathematics teachers: Supply, demand, and quality. *Review of research in education*, *16*(1), 223-264.

Dori, Y. J., Sasson, I., Kaberman, Z., & Herscovitz, O. (2004). Integrating case-based computerized laboratories into high school chemistry. *The Chemical Educator*, *9*(1), 4-8.

Druva, C.A. & Anderson, R.D. (1983). Science teacher characteristics by teacher behavior and by student outcome: A meta-analysis of research. *Journal of Research in Science Teaching*. 20,467-479.doi: 10.1002/tea.3660200509

Dusch, R.E. & Grandly, E., R. (2005).*Reconsidering the character and role of inquiry in school science: framing the debates*. Inquiry Conference on Developing a Consensus Research Agenda, New Brunswick, Rutgers University.

Eick, C. J., & Reed, C. J. (2002). What makes an inquiry-oriented science teacher? The influence of learning histories on student teacher role identity and practice. Science Education, 86(3), 401-416. doi: 10.1002/sce.10020

Eick, C.J., & Stewart, B. (2010).Dispositions supporting interns in the teaching of reform-based science materials. Journal of Science Teacher Education, 21, 783–800.doi: 10.1007/s10972-009-9174-3

Ekborg, M. (2003). How student teachers use scientific conceptions to discuss a complex environmental issue. *Journal of Biological Education. 37*(3), 126-133. https://doi.org/10.1080/00219266.2003.9655867

Enderle, P., Dentzau, M., Roseler, K., Southerland, S., Granger, E., Hughes, R., & Saka, Y. (2014). Examining the influence of RETs on science teacher beliefs and practice. *Science Education*, 98(6), 1077-1108.doi: 10.1002/sce.21127

Eslinger, E., White, B., Frederiksen, J., & Brobst, J. (2008).*Supporting inquiry processes with an interactive learning environment: Inquiry Island. Journal of Science Education and Technology*, 17 (6), 610–617. https://doi.org/10.1007/s10956-008- 9130-6

Fansa, M. (2012). Investigation of the effect of research based learning method on academic achievement, attitude towards science lesson and scientific process skills of 5th grade students in the exchange and recognition of material. *Master thesis, Hatay, Mustafa Kemal University Social Science Institute.*

Feyzioglu, E. Y., & Demirci, N. (2013). Class and science teachers' knowledge awareness and opinions about the 5E learning, *Mustafa Kemal University Journal of Social Sciences Institute*, 10(24), pp. 131-163.
Flick, L. & Lederman, N. G. (2004). Scientific inquiry and nature of science. *Contemporary Trends And Issues in Science Education*.doi:10.1007/978-1-4020-5814-1
Farrell, J. J., Moog, R. S., & Spencer, J. N. (1999). A guided-inquiry general chemistry course. *Journal of Chemical Education*, *76*(4), 570. https://doi.org/10.1021/ed076p570
Fradd, S. H., & Lee, O. (1999). Teachers' roles in promoting science inquiry with students from diverse language backgrounds. *Educational Researcher*, 28(6), 14-42. https://doi.org/10.3102/0013189X028006014
Fraser, B. J. (1998). Classroom environment instruments: Development, validity and applications. *Learning Environments Research*, 1(1), 7-34. https://doi.org/10.1023/A:100993251
French, D., & Russell, C. (2002). Do graduate teaching assistants benefit from teaching inquiry-based laboratories?. *Bio Science*, 52(11), 1036-1041.doi:10.1641/0006-3568(2002)052
Furtak, E.M. (2005). The problem with answers: An exploration of guided scientific inquiry teaching. *Science Education*, 90, pp.453-467. doi:10.1002/sce.20130
Garnett, P. J., Garnett, P. J., & Hackling, M. W. (1995). Students' alternative conceptions in chemistry: A review of research and implications for teaching and learning., *Studies in Science Education*, 25:1, 69-96, doi: 10.1080/03057269508560050
Gillies, R. & Boyle, M. (2010). Teachers' reflections on cooperative learning: Issues of implementation*.* *Teaching and Teacher Education*, 26, 933–940.doi: 10.1016/j.tate.2009.10.034
Gillies, R. M., & Nichols, K. (2015). How to support primary teachers' implementation of inquiry: teachers' reflections on teaching cooperative inquiry-based science. *Research in Science Education*, 45(2), 171-191.doi: 10.1007/s11165-014-9418-x
Glaser, B.G. & Strauss, A.L. (1967). The Discovery of Grounded Theory: Strategies for Qualitative Research. Chicago, IL: Aldine.
Granger, E. M., Bevis, T. H., Saka, Y., Southerland, S. A., Sampson, V., & Tate, R. L. (2012).The efficacy of student-centered instruction in supporting science learning. *Science*, 338(6103),105-108.doi: 10.1126/science.1223709
Griffiths A.K. and Preston, K.R. (1992). Grade-12 students' misconceptions relating to fundamental characteristics of atoms and molecules. *Journal of Research in Science Teaching*. 29(6), 611-628. doi:10.1002
Grossman, P. L. (1990). The making of a teacher: Teacher knowledge and teacher education. New York: Teachers College Press .
Harlen, W., & Holroyd, C. (1995). Primary Teachers' Understanding of Concepts in Science and Technology. Interchange 34. *Scottish Council for Research in Education*. Retrieved from https://files.eric.ed.gov/fulltext/ED462251.pdf on May 2007.
Harlen, W. (1997). Primary teachers' understanding in science and its impact in the classroom. *Research in Science Education*, *27*(3), 323-337. https://doi.org/10.1007/BF02461757
Hassard, J. (2005). *The art of teaching science*. Oxford University Press. New York.
Herron, M. D. (1971). The nature of scientific enquiry. *The school review*, *79*(2), 171-212.
Herrington, D. G., Bancroft, S. F., Edwards, M. M., & Schairer, C. J. (2016). I want to be the inquiry guy! how research experiences for teachers change beliefs, attitudes, and values about teaching science as inquiry. *Journal of Science Teacher Education*, 27(2), 183-204. doi: 10.1007/s10972-016-9450-y
Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark (2006). *Educational Psych*ologist, 42(2), 99-107.doi: 10.1080/00461520701263368
Hofstein, A., & Lunetta, V.N. (1982). The role of the laboratory in science teaching: neglected aspects of research, *Review of Educational Research*, *52*(2), 201-217.https://doi.org/10.3102/00346543052002201
Hofstein, A., & Walberg, H. J. (1995). Instructional strategies. *Improving science education*, 70-89. Chicago: The University of Chicago Press.
Hofstein, A., Nahum, T. L., & Shore, R. (2001).Assessment of the learning environment of inquiry-type laboratories in high school chemistry. *Learning Environments Research*, 4(2), 193- 207. doi: 10.1023/A: 1012467417645
Howes, E.V., Lim, M., & Campos, J. (2009). Journeys into inquiry-based science:literacy practices, questioning, and empirical study. *Science Education*, 93, 189–217.doi: 10.1002/sce.20297
Ingersoll, R. M. (2003). *Who controls teachers' work? Power and accountability in America's schools.* Cambridge, MA: Harvard University Press.

Kask, K., & Rannikmäe, M. (2006). Estonian teachers' readiness to promote inquiry skills among students, *Journal of Baltic Science Education*,1 (9).
Keller, J. T. (2001). *From theory to practice: creating an inquiry-based science classroom,* pp.162. Unpublished Master Thesis, University of Pacific Lutheran. Retrieved from https://www.academia.edu/7381945.
Kind, V. (2009). A conflict in your head: An exploration of trainee science teachers' subject matter knowledge development and its impact on teacher self-confidence. International Journal of Science Education, 31(11), 1529-1562. doi: 10.1080/09500690802226062
Kirschner, P., Sweller, J. & Clark, R. E, (2006). Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching, *Educational Psychologist*, 41:2, 75-86,doi: 10.1207/s15326985ep4102
Lanza, J. (2007). *Classroom tips for teaching inquiry labs*, Environmental Literacy Council. Retrieved October 12, 2007, from http://www.enviroliteracy.org/article.php/1271.html
Lawson, A. E. (1995). *Science teaching and the development of thinking*. Wodsworth Publishing Company, USA.
Lazarowitz, R., & Tamir, P. (1994). Research on using laboratory instruction in science. Handbook of research on science teaching and learning, 94-130.
Leach, J. & Scott, P. (1999). Learning science in the classroom: Drawing on individual and social perspectives. *The European Association for Research on Learning and Instruction*, Gothenburg, Sweden, August 1999.
Leonard, W. H. (1986). An experimental test of an extended discretion laboratory approach for university level biology. *Journal of Research in Science Teaching*, 23:807-814. https://doi.org/10.1002/tea.3660260108
Lin, H. S., Hong, Z. R., & Cheng, Y. Y. (2009). The interplay of the classroom learning environment and inquiry-based activities. *International Journal of Science Education*, 31(8), 1013-1024. doi: 10.1080/09500690701799391
Lincoln, Y. S., & Guba, E. G. (1985). Naturalistic inquiry. Thousand Oaks, CA: Sage.
Llewellyn, D. (2002). Inquiry within: Implementing inquiry-based science standards. Thousand Oaks, CA: Corwin Press.
Lotter, C., Rushton, G. T., & Singer, J. (2013). Teacher enactment patterns: how can we help move all teachers to reform-based inquiry practice through professional development. *Journal of Science Teacher Education*, 24(8), pp.4.doi: 10.1007/s10972-013-9361-0
Luckie, D.B., Maleszewski, J.J., Loznak, S.D., & Krha, M. (2004). Infusion of collaborative inquiry throughout a biology curriculum increases student learning: A four-year study of teams and streams. Advances in Physiology Education, 28(4), 199-209. doi: 10.1152/advan.00025.2004.
Lumpe, A. T., Haney, J. J., & Czerniak, C. M. (2000).Assessing teachers' beliefs about their science teaching context. *Journal of Research in Science Teaching*, 37(3), 275- 292.doi: 10.1002/ (sici) 1098-2736(200003)37:33.0.co; 2-2
Lumpe, A., Czerniak, C., Haney, J., & Beltyukova, S. (2012). Beliefs about teaching science: the relationship between teachers' participation in professional development and student achievement. *International Journal of Science Education*, 34(2), 153-166. doi:10.1080/09500693.2010.551222
Lunetta, V. N. (1998). The school science laboratory: Historical perspectives and contexts for contemporary teaching. International handbook of science education, 1, 249-262.
Marshall, C., & Rossman, G. B. (2011). Managing, analyzing, and interpreting data. C. Marshall & GB Rossman, *Designing Qualitative Research*, 5, 205-227.
Mayer, C. L. (2004). *An analysis of the dimensions of a web-delivered problem-based learning environment.* Dissertation Thesis. University of Missouri, Columbia.
Maxwell, J. A. (2008). *Designing a qualitative study*. The SAGE handbook of applied social research methods, 2, 214-253.
Merriam, S. B. (2013). Qualitative research. A Guide for Design and Application, (Trans, Edit; Selahattin Turan). Ankara: Nobel Press.
Merriam, S. B. (1998). Qualitative research and case study applications in education. San Francisco: Jossey-Bass.
Metz, K. E. (2004). Children's understanding of scientific inquiry: Their conceptualization of uncertainty in investigations of their own design. *Cognition and Instruction*, 22(2), 219-290. https://doi.org/10.1207/s1532690xci2202_3
Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis*: An expanded sourcebook. Sage.

Morrison, J. A. (2013). Scientists' participation ın teacher professional development: the impact on fourth to eighth grade teachers' understanding and implementation of inquiry science. *International Journal of Science and Mathematics Education*, 12(4),pp.16. doi: 10.1007/s10763-013-9439-3

Mulholland, J., &Wallace, J. (1996). Breaking the cycle: Preparing teachers to teach science. *Journal of Science Education,* 8, 17 – 38. https://doi.org/10.1007/BF03173739

Nakhleh, M. B., & Samarapungavan, A. (1999). school children's beliefs about matter. Journal of Research in science Teaching, 36(7), 777-805. doi:10.1002/(SICI)1098-2736(199909)36:7<777::AID-TEA4>3.0.CO;2-Z

National Committee on Science Education Standards and Assessment [NRC], (1996). *National science education standards*, Washington, DC: National Academy Press. p.105.

National Research Council [NRC]. (2000). *Inquiry and The National Science Education Standards: A Guide for Teaching and Learning*.pp.23.Washington, DC: National Academy of Sciences.

National Research Council [NRC]. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. pp. 16-23-26-31-60.Washington, DC: National Academy Press.

Nespor, J. (1987). The role of beliefs in the practice of teaching. Journal of Curriculum Studies, 19(4), 317–328. doi. https://doi.org/10.1080/0022027870190403

Newman Jr, W. J., Abell, S. K., Hubbard, P. D., McDonald, J., Otaala, J., & Martini, M. (2004). Dilemmas of teaching inquiry in science methods. *Journal of Science Teacher Educatio*n, 15(4), 257-279. doi: 10.1023/B:JSTE.0000048330.07586.d6

Palmer, D. (2006). Durability of changes in self-efficacy of preservice primary teachers. International Journal of Science Education, 28(6), 655-671. doi: 10.1080/09500690500404599

Park, S., & Oliver, J. S. (2008). Revisiting the conceptualisation of pedagogical content knowledge (PCK): PCK as a conceptual tool to understand teachers as professionals. Research in science Education, 38(3), 261-284. doi. 10.1007/s11165-007-9049-6

Patton, M., Q. (2002). *Qualitative research and evaluation Methods* (3rd.ed.). Thousand Oaks,CA; Sage.

Patton, M. Q. (2014). Qualitative research and evaluation methods, (Trans; Ed,. Butun and Demir). Ankara: PegemA Akademi.

Project 2061 [American Association for the Advancement of Science]. (1989). Science for all Americans: A Project 2061 Report on Literacy Goals in Science, Mathematics, and Technology (Vol. 89). Amer Assn for the Advancement of.

Posnanski, T. J. (2010). Developing understanding of the nature of science within a professional development program for in-service teachers: Project nature of science teaching. *Journal of Science Teacher Education*, 21(5), 589- 621.doi: 10.1007/s10972-009-9145-8

Renner, J.W; Abraham, M.R., Birnie, H.H. (1998).The necessity of each phase of the learning cycle in teaching high school physics'. *Journal of Research in Science Teaching*. 25(1), 39-58.doi: 10.1002/tea.3660250105

Robertson, B. (2006). Getting past 'inquiry versus content'. *Educational Leadership*, 65(4), 67-70. Retrieved from http://heartlandscience.pbworks.com/f/inquiry_article1.pdf.

Roth, K. & Garnier, H.(2007). What science teaching looks like: An international perspective, *Educational leadership,* 64(4). Retrieved from https://pdfs.semanticscholar.org/64c5/019fd2f8ecc9f94404dd8f42a4ae0912ab42.pdf

Rönnebeck, S., Bernholt, S. & Ropohl, M. (2016). Searching for a common ground–A literature review of empirical research on scientific inquiry activities. *Studies in Science Education*, 1-37. doi: 10.1080/03057267.2016.1206351.

Puntambekar, S., & Hubscher, R. (2005). Tools for scaffolding students in a complex learning environment: What have we gained and what have we missed?. *Educational psychologist*, 40(1), 1-12. https://doi.org/10.1207/s15326985ep4001_1

Rushton, G. T., Lotter, C. & Singer, J. (2011). Chemistry teachers' emerging expertise in inquiry teaching: the effect of a professional development model on beliefs and practice. *Journal of Science Teacher Ed*ucation, 22(1), 23-52. doi: 10.1007/s10972-010-9224.

Russell, C. B., & Weaver, G. C. (2011). A comparative study of traditional, inquiry-based and research-based laboratory curricula: impacts on understanding of the nature of science. *Chemistry Education Research and Practice*, 12(1), 57-67.doi: 10.1039/c1rp90008k

Salovaara, H,(2005). An exploration of students' strategy use in inquiry-based computer-supported collaborative learning. *Journal of Computer Assisted Learning* 21, 39–52. doi: 10.1111/j.1365-2729.2005.00112.

Schunk, D. H. (2014). *Learning Theories* (5th ed), Sahin (Eds.), pp. 140, Ankara Nobel Press..

Scholer, A. & Hatton, M. (2008). An evaluation of the efficacy of a laboratory exercise on cellular respiration. *Journal of College Science Teaching*. 38(1) 40-45.Retrieved from https://search.proquest.com/docview/200326141?pq-origsite=gscholar
Schwab, J. (1962). *The teaching of science as enquiry*. In J. J. Schwab, & P. F. Brandwein, (Eds.), the teaching of science (pp. 1-103). New York: Simon and Schuster.
Smith, A., & Hall, E. H. (1902). *The teaching of chemistry and physics in the secondary school*. Longmans, Green, and Company.
Smith, K.J. and Metz, P.A. (1996). Evaluating student Understanding of Solution Chemistry Through Microscopic Representations. *Journal of Chemical Education.* 73(3), 233-235. doi:10.1021/ed073p233
Stake, R. E. (1995). *The art of case study research.* Thousand Oaks, CA: Sage Publications.
Strauss, A., & Corbin, J. (1998). Basics of qualitative research: Techniques and procedures for developing grounded theory. Thousand Oaks, CA: Sage
Songer, N.B., Lee, H. & Kam, R. (2002). Technology-rich inquiry science in urban classrooms: what are the barriers to inquiry pedagogy? *Journal of research in science teaching, 2*(39), 128-150. https://doi.org/10.1002/tea.10013
Soy, S. (1997).The case study as a research method uses & users of information– LIS391.D1-Spring. pp. 2. Retrived from https://www.ischool.utexas.edu/~ssoy/usesusers/l391d1b.htm on 5 July 2015.
Sun, D., Looi, C. K., & Xie, W. (2017). Learning with collaborative inquiry: a science learning environment for secondary students. *Technology, Pedagogy and Education*, 26(3), 241-263. doi: 10.1080/1475939X.2016.1205509
Thomas, G. & Meldrum, A. (2018) "Students' perceptions of changes to the learning environments of undergraduate physics laboratories: An empirical study", Interactive Technology and Smart Education, Vol. 15 Issue: 2, pp.165-180, https://doi.org/10.1108/ITSE-10-2017-0045
Thomas, J. A., & Pedersen, J. E. (2003). Reforming science teacher preparation: What about extant teaching beliefs?. *School Science and Mathematics*, *103*(7), 319-330.doi: 10.1111/j.1949-8594.2003.tb18209.x
Tobin, K. (1990). Research on science laboratory activities: In pursuit of better questions and answers to improve learning. *School science and Mathematics*, *90*(5), 403-418. https://doi.org/10.1111/j.1949-8594.1990.tb17229.x
Trowbridge, L., Bybee, R., & Powell, J. (2004).*Teaching secondary school science: Strategies for developing scientific literacy.* Upper Saddle River, NJ: Merrill/Prentice Hall.
Tournaki, N., & Podell, D. M. (2005). The impact of student characteristics and teacher efficacy on teachers'predictions of student success. Teaching and Teacher Education, 21, 299–314. doi. https://doi.org/10.1016/j.tate.2005.01.003
Van Aalderen-Smeets, S. I., Walma van der Molen, J. H. & Asma, L. J. (2012). Primary teachers' attitudes toward science: A new theoretical framework. *Science Education*, *96*(1), 158-182. doi: 10.1002/sce.20467
Wallace, C.S. & Kang, N. (2003).An investigation of experienced secondary science teachers' beliefs about inquiry: an examination of competing belief sets, *Journal of Research In Science Teaching*, 41 (9), 936-960. doi: 10.1002/tea.20032
Wee, B., Shepardson, D., Fast, J., & Harbor, J. (2007). Teaching and learning about inquiry: Insights and challenges in professional development. *Journal of Science Teacher Education*, 18(1), 63-89. doi: 10.1007/s10972-006-9031-6
Wenglinsky, H. (2000). *How teaching matters: Bringing the classroom back into discussions of teacher quality.* Princeton, NJ: Educational Testing Service, Policy Information Center. Retrieved from http://files.eric.ed.gov/fulltext/ED447128.pdf.
Wilke, R. R. & Straits W. J. (2005). Practical advice for teaching inquiry-based science process skills in the biological sciences. *The American Biology Teacher*, 67 (9), 534- 540. doi: 10.1662/0002
Wheeler, L., & Bell, R. (2012). Open-ended inquiry. *The Science Teacher*, *79*(6), 32
White, B. Y., & Frederiksen, J. R. (1998). Inquiry, modeling, and metacognition: Making science accessible to all students. *Cognition and instruction*, 16(1), 3-118.
Whitworth, B. A., Maeng, J. L., & Bell, R. L. (2013). Differentiating inquiry. Science Scope, 37(2), 10.
Wolf, S. J., & Fraser, B. J. (2008). Learning environment, attitudes and achievement among middle-school science students using inquiry-based laboratory activities. *Research in science education*, 38(3), 321-341. https://doi.org/10.1007/s11165-007-9052-y
Wu, H. K., & Hsieh, C. E. (2006). Developing sixth graders' inquiry skills to construct explanations in Inquiry-based learning environments. *International Journal of Science Education*, 28(11), 1289-1313. https://doi.org/10.1080/09500690600621035

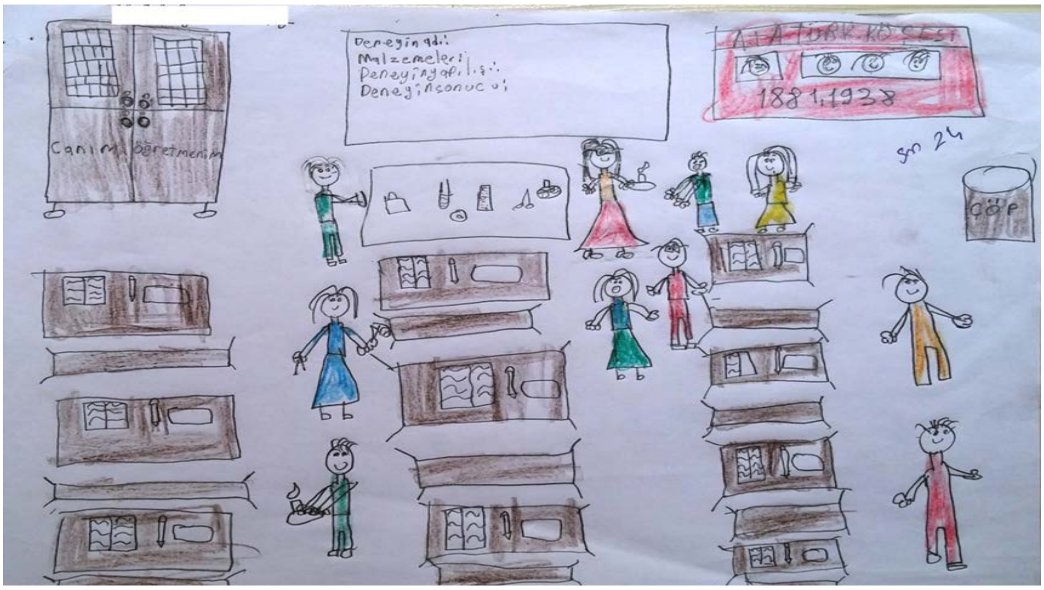
Yıldırım, A., Simsek,H. (2014). *Qualitative Methods in Social Sciences*, Seckin Press, Ankara.
Yıldız, E., Aydoğdu, B., Akpınar, E., & Ergin, Ö. (2006). The attitude of science teachers to science experiments. *Boğaziçi Üniversity Journal of Education.* 24(2), 71-86. Retrieved from https://dergipark.org.tr/en/download/article-file/43756
Yin, R. K. (2009). *Case study research: Design and methods* (4th ed.). pp. 18. In United States: Library of congress cataloguing-in-publication data.
Yang, W-T.,Yu-Ren Lin, Y-R., Hsiao-Ching She, H-C & Huang, K-Y., (2015).The effects of prior-knowledge and online learning approaches on students' inquiry and argumentation abilities, *International Journal of Science Education,* 37:10, 1564- 1589, doi:10.1080/09500693.2015.1045957
Zuckerman, G. A., Chudinova, E. V., & Khavkin, E. E. (1998). Inquiry as a pivotal element of knowledge acquisition within the Vygotskian paradigm: Building a science curriculum for the. *Cognition and Instruction*, 16 (2), pp. 202. doi: 10.1207/s1532690xci1602_3

Appendix 1. *Lecture plan*

Lecture Name	Science and Technology
Name of Unit	Matter
Concepts	Sinking, floating
Duration	2 lecture hours
Learning Strategies, Methods and Techniques	Guided Inquiry Based Learning, Experiment, 5 E Learning Model
Experiment materials, tools and references	For each group: 1 big basin, 3 stone, paper clips, tissue, crown caps, ping-pong balls, paper of different thicknesses, water, 1 plastic bag, 2 or more metal coins, textbook, articles
5E Learning Model	**Engage:** Students are asked to guess whether the given materials (stone, soda lids, paper clips etc.) would sink or float in water. After they wrote their hypothesis in their notebooks the students were asked to try each material in the basin there were given, and were expected to compare their results with their hypothesis. **Explore**: Each of the groups is asked to make a ship from the paper given to them and to write their observations in their notebook. **Explain:** Each group explains the results of their experiments. The teacher asks the students to define the concepts of floating and sinking. If there are misconceptions then the teacher explains them by asking questions and all class discussions are completed. **Elaborate:** The teacher asks the students how they will make the sinking ships float and how they will sink the floating ships. The intention is to find the importance of surface area and weight of objects for floating and sinking. **Evaluation:** The presentations and experiment reports are used for evaluation.
Evaluation	During the presentations the students had some difficulties in speaking such as a lack of lack of fluency and not completing sentences. But they produced different materials other than given materials to explore whether they are sinking or floating. Also students realized the reasons for their erroneous hypotheses. When they were doing experiments they were very happy and asked many questions about the surface area of floating objects and raw material of the paper.

Appendix 2: *The students' drawings of the learning environment before the implementation*

Appendix 3. *The students' drawing of the learning environment after the implementation*



Appendix 4. *The photograph of students engaged in the GIBL implementation*