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# The Impact of Teaching the Subject "Pressure" with STEM Approach on the Academic Achievements of the Secondary School 7th Grade Students and Their Attitudes Towards STEM

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## Abstract

The objective of this study is to determine the effect of a teaching module on the topic of pressure, developed with STEM approach, on the academic achievements of the students as well as on their attitudes towards STEM. The study employed the explanatory sequential design, as one of mixed method research designs. On the quantitative aspect of the study, a pre-test and post-test control group, quasi-experimental design was used, while phenomenological design was utilized for qualitative aspects. The sample group of the research comprises of 33 7th grade students studying in a village school located in a district of one of the metropolitan municipalities in Turkey for the Spring Semester of the 2017-2018 school year. A STEM education approach was used in the experimental group for teaching the subject of "Pressure" while utilizing the approach as stipulated in the curriculum for the control group. An academic achievement test, an attitude scale for STEM, semi-structured interviews, and the student diaries are the data collection tools used in the study. A significant difference was found between the experimental group and the control group, with the former showing increased academic achievement over the latter in the research. A significant difference was also found between the experimental group and the control group, with the former showing more positive attitudes towards STEM than were shown by the latter. The opinions of the students on STEM education were analyzed in order to study the results obtained from quantitative data. Five themes – feelings and opinions, positive aspects, skills gained, features and problems faced, and the learning process were obtained—as well as 26 codes—with the content analysis of semi-structured interviews and students' diaries. It was concluded that involving STEM-based implementations in teaching the subject "Pressure" increased the academic success rate and attitude scores of students while helping the students to develop positive perceptions of STEM education. In future studies, certain influences of STEM education implementations, such as self-confidence of students, the ability to present creative solutions, communication skills, for example, may be studied.

## Keywords

Academic achievement
Attitude
Pressure
Secondary school students
STEM education
STEM teaching module

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## Introduction

Science, with its structure based not only on observations, but also inferences, is a human activity facilitating human lives by researching the mysteries of the world, nature, and the universe, as well as directing scientists to question what they wonder about (Knorr-Cetina, 2013; Özcan, 2013). Science, with its structural openness to change, is modernized and developed in line with society's requirements. On this matter, technological tools are of great importance; in fact, computers, tablets, and smartphones have ultimately become essential elements of our lives in 21st century. The generation of the millennium age, popularly named "Generation Z", has grown in direct touch with these technological tools. This situation forms a basis for Generation Z to have a greater need for the environments enriched with technology than does Generation Y, the previous generation, thus making Generation Z more successful in respect to technological field. Despite these developments, adopting traditional methods in education negatively affects the interests and attitudes of Generation Z students to the lessons. In order to inspire students' interests in their lessons, as well as to encourage positive attitudes, their learning environments should be enriched with technology in their design and structure (Gu, Zhu, & Guo, 2013; Jones, Jo, & Martin, 2007; Prensky, 2012; Thompson, 2013). Research suggests that the students studying in these technically rich environments would gain such skills as productivity, entrepreneurial ability, innovativeness and critical thinking, which would in turn help the countries to achieve the economic and political objectives (Aydeniz, 2017; Bybee, 2010). The regulations to be applied to the educational policies for improving the national capacity for innovation have a material impact on educating the individuals in science literacy equipped with these abilities, and for these individuals to show interest in fields related to innovation (OECD, 2018). Considering these issues, many countries have started to focus on STEM education in order to achieve their targets.

In order to gain international recognition as one of the developed countries, to to succeed in the struggle in spite of today's competitive conditions, and to have a voice in the technological and innovative fields fields, each and every country must review its own system of education with an innovative approach. In recent years, the focal point of the regulations applied to educational policies has been in STEM education (science, technology, engineering, and mathematics), as have the studies carried out to improve this educational method (León, Núñez, & Liew, 2015; NRC, 2011; OECD, 2018). Since it was first recognized in the United States as part of efforts to making changes on the field of education in the late 1990s, STEM has awakened the interests of European countries and Asian countries with advanced economies like Korea, Japan, China, Taiwan, thus taking its place in the educational systems and governmental policies of these countries (Blackley & Howell, 2015).

STEM is a radical change movement applied to the educational field in the 21st century (Land, 2013). The generation that will constitute the labor force of the future is expected to have the skills of 21st century like reasonable thinking, problem solving, communicating, having a facility with teamwork, innovativeness and productivity, working systematically, as well as utilizing the technology on the highest level possible (Association for Career and Technical Education, National Association of State Directors of Career Technical Education Consortium and Partnership for 21st Century Skills, 2010; Bybee, 2010; Kertil & Gürel, 2016; Morrison, 2006; Omundsen, 2014; Wagner, 2008). It has been recognized by many countries to apply an interdisciplinary approach like STEM education, instead of traditional methods in order for these projected skills to be gained (Gonzalez & Kuenzi, 2012). STEM education is an interdisciplinary approach gathering science, technology, engineering and mathematics that are traditionally presented separately, as well as providing learning experiences for the students to adapt these disciplines into their lives (Vasquez, Comer, & Sneider, 2013). STEM education means organizing of the educational activities related to science, technology, engineering and mathematics disciplines as integrated (Gonzalez & Kuenzi, 2012). In other words, integrated STEM education is the teaching of the information and skills within the main discipline by being gathered together with the other STEM disciplines, after being shaped with the interest and lives of the students and teachers

(Çorlu, Capraro, & Capraro, 2014). Integrated STEM education ensured different points of view to be generated for STEM implementations. Roehrig, Moore, Wang, and Park (2012) discuss these points of view under two different models as the content integration and context integration. The content integration means the preparation of a teaching program that is structured or based on a flexible STEM, where more than one discipline is adapted; while context integration teaches a discipline by placing it on the center, without ignoring the unique characteristics, depth and difficulty of the main discipline, as well as deciding on the respective contexts from the other disciplines (Kertil & Gürel, 2016). Keeping the curriculums and examination systems within the Turkish Educational System under control constitutes a significant impediment for ensuring the flexibility required for content integration (Çorlu, 2013). Therefore, it would be a suitable approach to employ context integration for integrated STEM education studies that are planned for implementation in Turkey.

In recent years, the results of Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA), carried out internationally by Organisation for Economic Cooperation and Development (OECD), as well as the examinations carried out in our country by Student Selection and Placement Center (ÖSYM), show that the success levels of Turkish students in the fields of science and mathematics are below the expected levels (Aydeniz, 2017; Han, 2015; OECD, 2012). It can be said that the studies of the Turkish Educational System on compliance with the European Union standards began with the curriculums based on a constructive approach regulated in 2005 (Akgündüz, 2016; Gömleksiz & Bulut, 2007). Similarly, the updates carried out on the curriculums in 2013 and 2017 were discussed from the perspective of an approach based on research and questioning. Here, it was aimed at combining a discipline together with other disciplines in terms of subject and class level. Such studies taken together may be considered to be the steps that possess the characteristics to make up the infrastructure for STEM education.

Along with changes made in the educational system, STEM leads to changes in the industrial areas of the countries as well, and the Industry 4.0 movement may be cited for this subject matter. Industry 4.0 is a revolutionary movement aimed at equipping factories with the machinery and operators endowed with the ability to communicate directly with each other via the internet, thus ensuring the production of higher-quality products within a shorter period of time (Lasi, Fettke, Kemper, Feld, & Hoffmann, 2014). Industry 4.0 has the potential to enable the Turkish industrial sector to be carried to the top in terms of contribution to become a major contributor to the economy while serving to eliminate deficits with other countries in terms of the industrial sector (Industry 4.0, 2018).

The echoes of STEM education, having emerged in developed countries and progressed with various implementations in these countries, can be perceived across Turkey, as well. The most significant objective of STEM activities in Turkey, an objective that is projected to be achieved, is to prioritize national needs instead of directly adopting the implementations of developed countries. With this purpose in mind, helping students earn the skills of the 21st century by including the required implementations, by guiding them through the requirements of qualified science and mathematics education and by offering flexible curriculums, can all be counted within the objectives (Çorlu, 2017; Knezek, Christensen, Wood, & Periathiruvadi, 2013).

An examination of STEM education studies on the progress of STEM in Turkey shows a concentration on the development and adaptation of a scale towards achieving STEM, the organizational structure of STEM education, and the influences on the students of STEM education implementations. Several key areas fell within the scope of the experimental studies, including identifying the effects of STEM education implementations on the behaviors of students; determining students' interest in STEM career areas; and measuring comprehension of STEM, scientific process skills and success levels (Ayar, 2015; Baran, Canbazoğlu Bilici, Mesutoğlu, & Ocak, 2016; Gülhan & Şahin, 2016; Karahan, Canbazoğlu Bilici, & Ünal, 2015; Sümen & Çalışıcı, 2016; Yamak, Bulut, & Dündar, 2014;

Yıldırım & Altun, 2015). The studies on secondary school students are comprised of STEM education implementations, regulated for teaching different subjects in the Turkish Ministry of National Education (MoNE) Science Curriculum. Examining the studies carried out with secondary school students, there was no study in which STEM education implementations were applied for teaching the subject "Pressure" within MoNE Science Curriculum. Additionally, other reasons for the selection of the subject of "Pressure" for this study include the convenient and related structure of the subject with engineering, mathematics, and science disciplines as well as the challenges that students confront while trying to comprehend the gains from the subject of "Pressure" (Akgün, Tokur, & Özkara, 2013; Goszewski, Moyer, Bazan, & Wagner, 2013; Pathare & Pradhan, 2011; Muliyani & Kaniawati, 2015; Ünal, 2005; Wijaya & Muhardjito, 2016).

***The Importance and Objective of the Research***

It is of great importance for Turkey to be ranked among the competitive and powerful economies, making integrated STEM education as integral a part of Turkey's educational system as it is in other countries. Therefore, the way STEM is adapted into the educational system of our country, and how it would be implemented efficiently are two key areas of concentration. Examining the national literature within this context, it can be seen that studies on STEM education have centered on secondary school students, high school students, and teacher candidates over the last five years. STEM studies with secondary school students in Turkey have been mainly carried out with formal and informal learning environments and have been based on the curriculums. Reviewing the national studies methodologically reveals that the qualitative or quantitative research methods were frequently applied and that mixed method studies were rarely seen where these two methods were applied together. The mixed method studies where the qualitative and quantitative variables are analyzed together are of great importance in terms of providing more detailed information on the efficiency of STEM education. In this study, we attempted to present the impacts of STEM implementations on students in a detailed manner by using the mixed method in our research.

The National Education System does not provide flexibility for teachers in terms of large-scale examinations and the time needed for covering the learning objectives. Besides, teachers in different disciplines lack some knowledge and skills. This may lead to some challenges in adapting the integrated STEM implementations into national curricula. Therefore, reorganization of topics in the science curricula based on an integrated STEM education concept may lend assistance to the teachers applying STEM within their lessons. Within this context, this study is based on teaching the subject "Pressure" within the curriculum of Science via STEM education. The objective of this study is to identify the impacts on students' academic achievements and their attitudes towards STEM of a teaching module, concerning the subject "Pressure," developed with the STEM approach. In line with this purpose, we searched for answers on the following research questions:

1. Is there a significant difference between the academic achievement points of the groups, where either STEM education or the approach as stipulated by the curriculum are applied for teaching the subject "Pressure"?
2. Is there a significant difference between the groups in terms of attitude points towards STEM, where either STEM education or the approach as stipulated by the curriculum is applied for teaching the subject "Pressure"?
3. What are the opinions of the group, where STEM education is utilized, concerning STEM education during the teaching process of the subject "Pressure"?

# Method

### *Research Design*

The mixed method of research is defined as the research in this study, where the qualitative data is collected, analyzed, and integrated via one or more than one data collection tool, using both qualitative and quantitative methods (Figure 1).

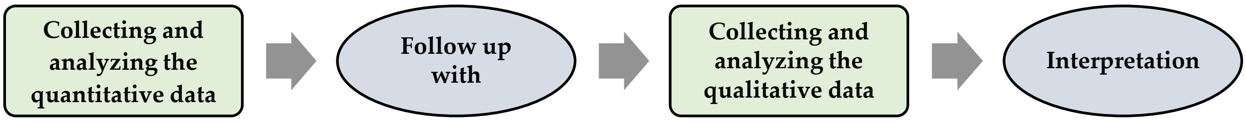



**Figure 1.** Explanatory Sequential Design (Creswell & Clark, 2017)

The most significant contribution of using the quantitative and qualitative methods together is to produce the opportunity to study and analyze the research problem at all points (Creswell & Clark, 2017; Niglas, 2010). In this study, explanatory sequential design was used as one of the mixed method research designs. This is a design where the quantitative data is collected and analyzed in the first phase, and where the qualitative data is collected and analyzed in order to provide explanations of the reasons for results obtained from the quantitative results. With this design, research is subjected to interpretation of the results obtained from data analysis of both quantitative and qualitative data together (Creswell & Clark, 2017; Niglas, 2010). Quantitative data collection tools were used to collect and analyze in this study, and then the second phase steps were initiated, where the qualitative data were collected and analyzed under the light of quantitative data. All of this data was interpreted as a whole as we produced the results of the study. The design was aimed at reaching at better explanations regarding the reasons for the data obtained from the quantitative data collection tools in the study, using explanatory sequential design.

The quantitative aspect of the research was designed with a pre-test, post-test control group semi-experimental design. In this design, the experimental and control groups are designated from the ready groups having similar structures with each other with regards to the input characteristics predicted from the pre-test. While the experimental group is subjected to the experimental process, the control group is maintained with routine implementations. It attempts to detect the impact of the experimental process by comparing the difference between the pre-test and post-test scores of both groups (Fraenkel, Wallen, & Hyun, 2012). The qualitative aspect of the research was designed in line with the phenomenological design. The phenomenological design considers the perceptions of individuals about a fact or incident based on their experiences while defining that fact or incident (Yin, 2016). In this study, our objective is to reveal the meanings ascribed to STEM education by the students, as well as their perceptions of their experiences with STEM education

### *Study Group and its Characteristics*

The study group was comprised of 33 7th grade students, studying in a village school located in a district in one of the metropolitan municipalities of Turkey in the spring semester of the 2017-2018 school year. The sampling of the study was determined with the convenient sampling method, as one of the probabilistic sampling methods. The convenient sampling method saves both time and effort for the implementers in terms of reaching the convenient sampling (Patton, 2002). Having a long-term implementation period, as well as a requirement for setting the technological tools and materials ready before the implementation process begins, can be counted as key reasons for choosing the convenient sampling method for this study.

The two intact seventh grade classes from the village school were selected as the experimental and control groups. For this reason, the experimental and control groups had different numbers of students. The study group was comprised of 33 students, while 20 students (n=20) made up the experimental group where the STEM education approach was applied, and 13 students (n=13) were included in the control group where the approach as stipulated by the respective curriculum was applied (Table 1), on teaching the subject "Pressure." The students within the experimental and control groups were between 11 and 12 years old. Moreover, the socioeconomic (level of income, educational background of the parent, status of the residential home, access level for social activities and technological tools, for example) and the academic achievement levels of the students comprising both groups possessed similar structure, according to the feedback received from the teachers. Before the implementation process began, the approvals of the students within the study group were obtained stating that they voluntarily participated in the study.

**Table 1.** Study Group

| Group Type | Male | Female | Total |
|---|---|---|---|
| Experimental Group | 10 | 10 | 20 |
| Control Group | 8 | 5 | 13 |
| Total | 18 | 15 | 33 |

Semi-structured interviews were performed in order to detail the opinions of students within the experimental group, where the STEM education approach was applied, on the educational process, as well as to obtain more data. While deciding on the students to be interviewed, the academic achievement test results were accepted as the sampling criterion. Thus, criteria related sampling, which is one of the purposeful sampling strategies, were used in selecting the study participants (Creswell & Clark, 2017; Yıldırım & Şimşek, 2016). Following the academic success test, the scores of the experimental group were ranked from the highest to the lowest for selecting four students from each of the high, middle, and low level groups. Since one of the experimental group members (comprising of 12 members) did not come to school on the day of the interview, the interview included 11 group members. Additionally, the student diaries, in which the students within the experimental group would convey their feelings and opinions concerning each lesson at the end of every lesson, were utilized as qualitative data resources.

***Data Collection Tools***

We sought to ensure data diversity in the study by providing support for the quantitative data collection tools with qualitative data collection tools. As shown in Table 2, the academic achievement test and the attitude towards STEM scale were utilized as quantitative data collection tools, while the semi-structured interview form and student diaries were utilized as qualitative data collection tools.

**Table 2**. Data Collection Tools

| | Before implementation | After implementation |
|---|---|---|
| Experimental Group | AAT, ATSS | AAT, ATSS, SSI, SD |
| Control Group | AAT, ATSS | AAT, ATSS |

Academic Achievement Test (AAT)
Attitude Towards STEM Scale (ATSS)
Semi-structured Interviews (SSI)
Student Diaries (SD)

*1. Academic Achievement Test:* This test comprises 20 questions in order to determine the academic achievement levels of the students on the subjects "Pressure" (Figure 2). While forming the AAT, the relationship between the acquisitions from the subject "Pressure" within the Science curriculum and from the questions in AAT were analyzed after being converted to a table of specifications. Thus, the distribution of questions and the number of acquisitions were regulated in compliance with each other, and the required steps were taken for ensuring the content validity. We were careful to select questions that are valid and reliable during the formation process. Within this context, the examination questions of previous years by MoNE on the subject "Pressure" (Secondary Education Exam, Public Boarding School Exam, Placement Test, Transition from Primary to Secondary

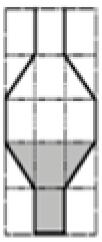
Education), and the questions that were deemed suitable as per the table of specifications were added into the pool of questions. Comprising 25 items, AAT were analyzed by 2 science educators and 2 science teachers in order to evaluate the test in terms of suitability and comprehensiveness for the students. After receiving the opinions of the experts, 5 items were removed from the test. A pilot version of the test comprising 20 items was carried out with the 20 8th grade students, who were provided with the lessons on the subject "Pressure." The data obtained from the pilot version was subjected to substance analysis, and the internal consistency coefficient of "KR-20" was calculated in order to settle the question of the reliability of the achievement test. The coefficient KR-20 obtained following the pilot version was calculated as .82, thus proving the test to be reliable. After applying the amendments on the test as deemed necessary, the final form of the test for the implementation process comprised of 20 items. The average difficulty level of the items within the test was calculated as .50, while the average discrimination indexes were .47, and KR-20 internal consistency coefficient was .83 (Table 3).

**Table 3.** Item Analysis Results of Academic Achievement Test

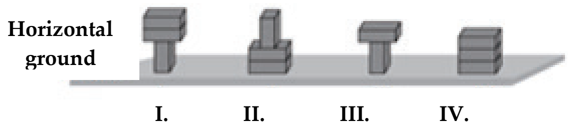
| **Item No** | Item Difficulty Index ($p_J$) | Item Discrimination Index ($r_{Jx}$) | **Item No** | Item Difficulty Index ($p_J$) | Item Discrimination Index ($r_{Jx}$) |
|---|---|---|---|---|---|
| **1** | .44 | .38 | **11** | .69 | .38 |
| **2** | .50 | .75 | **12** | .44 | .38 |
| **3** | .63 | .25 | **13** | .31 | .38 |
| **4** | .44 | .25 | **14** | .25 | .25 |
| **5** | .63 | .38 | **15** | .44 | .63 |
| **6** | .69 | .63 | **16** | .38 | .75 |
| **7** | .63 | .50 | **17** | .50 | .50 |
| **8** | .56 | .63 | **18** | .50 | .63 |
| **9** | .44 | .38 | **19** | .50 | .50 |
| **10** | .56 | .63 | **20** | .44 | .25 |

**16.** The liquid in the figure shows the amount of liquid in the container and the pressure is measured as 2P. **Two times** more liquid is added to the same liquid. In the last case how many P is the liquid pressure acting in the rough?

**A)** 3 **B)** 5 **C)** 6 **D)** 10



**17.** Identical bricks are placed on the horizontal surface as in the figure.




What two mechanisms should be chosen in order to prove that the pressure of the bricks on the ground depends on the **weight of the bricks and the surface area** that touches the floor?

| | Weight | Surface Area |
|---|---|---|
| **A)** | I. and III. | I. and II. |
| **B)** | II. and III. | I. and IV |
| **C)** | I. and II. | I. and III. |
| **D)** | I. and III. | II. and IV. |

**Figure 2.** Sample Questions for the Academic Success Test

When comparing academic achievement levels of the experimental and control groups, multiple-choice questions were used due to their ease of use and provision of an objective scoring opportunity. However, in STEM education, it is suggested to use process-oriented measurement tools, rather than the product-oriented ones. Therefore, the working sheets completed by the students in the experimental group during the lessons were scored in order to evaluate the process in the measurement and assessment section of the STEM-based Teaching Module. The use of student worksheets was aimed at determining how students find a solution to a given problem and observing which steps they follow when creating their products. Analyzing student worksheets was aimed at revealing the steps in which students have difficulty during the experiments, the steps in which they are successful, and the plans they make during the lesson activities. Students' worksheets were designed for each activity and consisted of two separate pages that were entitled as research worksheet and planning worksheet. In the meantime, Plickers and Kahoot implementations were used for ensuring instant feedback to the students during the process.

2. *Attitude towards STEM Scale:* The attitude towards STEM scale, for which the adaptation studies are carried out by the researchers (Özcan & Koca, 2018), comprises of 37 items, 5-point Likert scale type (Figure 3). A pilot version of the form, which was adapted into Turkish, was applied on a sampling of 52 students studying in the 7th grade. During the pilot study, three items which students had difficulty understanding were revised. Following the material analysis after the pilot version, the respective regulations were performed on the Turkish form. The actual application of the regulated Turkish form was performed on a sampling of 1323 students studying in the 6th, 7th and 8th grades, then the obtained data was subjected to confirmatory factor analysis at first, followed by explanatory factor analysis. Based on the results of the obtained data, the Turkish form for the measurement took its final form. The highest possible score on the scale is 185, while the lowest score is 37. The scale comprises four sub-dimensions: mathematics, science, engineering & technology, and the skills of the 21st century. Examining Cronbach Alpha internal consistency cofactors of the scale and subdimensions, they were settled to be .91 for the entire scale, .90 for the subdimension of mathematics, .89 for science, .90 for the subdimension of engineering and technology, and .92 for the subdimension of century skills, and these values suggest that the scale is highly reliable.

| Put a cross (x) in the relevant boxes from 1 to 5. | Strongly Disagree → Strongly Agree | | | | |
|---|---|---|---|---|---|
| **Sample Item:** I like my school. | **1** | **2** | **3** | **4** | **5** |
| **MATH** | | | | | |
| **1.** Math has been my worst subject. | **1** | **2** | **3** | **4** | **5** |
| **2.** I would consider choosing a career that uses math. | **1** | **2** | **3** | **4** | **5** |
| **SCIENCE** | | | | | |
| **1.** I am sure of myself when I do science | **1** | **2** | **3** | **4** | **5** |
| **2.** I would consider a career in science. | **1** | **2** | **3** | **4** | **5** |
| **ENGINEERING AND TECHNOLOGY** | | | | | |
| **1.** I like to imagine creating new products | **1** | **2** | **3** | **4** | **5** |
| **2.** If I learn engineering, then I can improve things that people use every day. | **1** | **2** | **3** | **4** | **5** |
| **21ST CENTURY LEARNING** | | | | | |
| **1.** I am confident I can lead others to accomplish a goal. | **1** | **2** | **3** | **4** | **5** |
| **2.** I am confident I can encourage others to do their best. | **1** | **2** | **3** | **4** | **5** |

**Figure 3.** Sample Item Concerning the Attitude Scale towards STEM

3. *Semi-Structured Interview Form:* The semi-structured interviews were utilized shortly after the implementation process, as one of the qualitative data collection tools of the study (Figure 4). Semi-structured interviews comprise the questions regulated before the implementation process in line with the objective of the research. Besides, it provides the opportunity to use questions generated

extemporarily in addition to the existing questions, in order to obtain more detailed information during the interview (Fraenkel et al., 2012). Interview questions were prepared by two members of the faculty) who are experts in science. This interview forms were analyzed by the science teachers of the school where the study was carried out, and their opinions were collected. The pilot study was carried out with a class on the same level in a different school. The items that students had difficulty answering were revised, based on the views from the experts about the interview protocol, and were revised by alternative items. The interview form consists of seven open-ended questions. The eleven students were selected to represent the upper-middle-subgroup from the experimental group, taking into account the results of the quantitative data (Creswell & Clark, 2017; Yıldırım & Şimşek, 2016). The interviews were recorded with an audio recorder, while the obtained data was transcribed in written form, then being set for analysis. The content analysis method was used for analyzing the data. The themes and codes were formed in line with the answers received from the students during the interviews.

**1. What are your thoughts on STEM activities used in the courses? Explain with examples.**

**Probe:** Group work
When designing
Using technology (Smart board, Computer, Powtoon, Plickers, Animation)

**7. Do you think using the STEM activities in the course will benefit you? How? Explain with examples.**

**Alternative:** Which knowledge and skills do you think will improve the continuous use of STEM activities?

**Figure 4.** Sample Questions from the Semi-Structured Interview Form

*4. Student Diaries:* Another qualitative data collection tool of the study is made up of the diaries used in qualitative research methods. The diaries are the personal documents revealing the students' perspectives concerning their experiences, thus providing an opportunity to determine the meanings attributed to these experiences (Merriam & Tisdell, 2015). Apart from having the ability to be written freely, the diaries can also be kept in line with a pre-specified form (Halbach, 2000). The diaries in this study were used to learn the feelings and opinions of the students within the experimental group, to which the STEM education program was applied for teaching the STEM education subject "Pressure.". The students were asked to keep a diary comprising of their feelings and opinions on the respective forms, including the activities performed in the lesson, at the end of every lesson. A short training session was provided for the students in order to help them easily complete the diaries before the implementation process began.

***Preparing the Teaching Module based on STEM Education***

Determining the acquisitions from the subject "Pressure" within the Curriculum of Science, which underlies the study, the STEM Education Teaching Module was designed to be integrated with mathematics, technology, and engineering disciplines. In designing the teaching module, national and international studies regarding STEM education were analyzed in detail (Ayar, 2015; Baran et al. 2016; Biçer, Boedeker, Capraro, & Capraro, 2015; Ceylan & Özdilek, 2015; Cotabish, Dailey, Robinson, & Hughes, 2013; Erdoğan, Çorlu, & Capraro, 2013; Knezek et al., 2013; Gencer , 2015; Guzey, Moore, Harwell, & Moreno, 2016; Gülhan & Şahin, 2016; Karahan et al., 2015; Lamb, Akmal, & Petrie, 2015; Mutakinati, Anwari, & Kumano, 2018; Park, Park, & Bates, 2018; Toma & Greca, 2018; Siverling, Guzey, & Moore, 2017; Thananuwong, 2015; Yamak et al., 2014; Yıldırım & Selvi, 2017). Following the analyses performed on these studies, the STEM Cycline was utilized for the integration of STEM (Figure 5). STEM Cycline is presented as a scientific process and social product describing the mutual activities between the student and the teacher within the class. The teacher activities are to be structured in accordance with the 5E model (Engage, Explore, Explain, Extend, Evaluate) and in a manner ensuring the flexibility required for the implementation, as determined during the pre-lesson planning (Çorlu, 2017).

The lesson plans that comprise the STEM Education-based Teaching Module were prepared based on the 5E-model, and the required flexibility was provided (See Appendix 1).

In the next step, the lesson plans that were implemented in the control group were prepared (See Appendix 2). The lesson plans were prepared in accordance with the research-question based teaching structure as stipulated by the respective curriculum, taking into account the acquisitions of the subject "Pressure." The experiments on the subject "Pressure" that were included in the 7th-grade textbook of MoNE were included in these lesson plans (Tuncel, 2017).

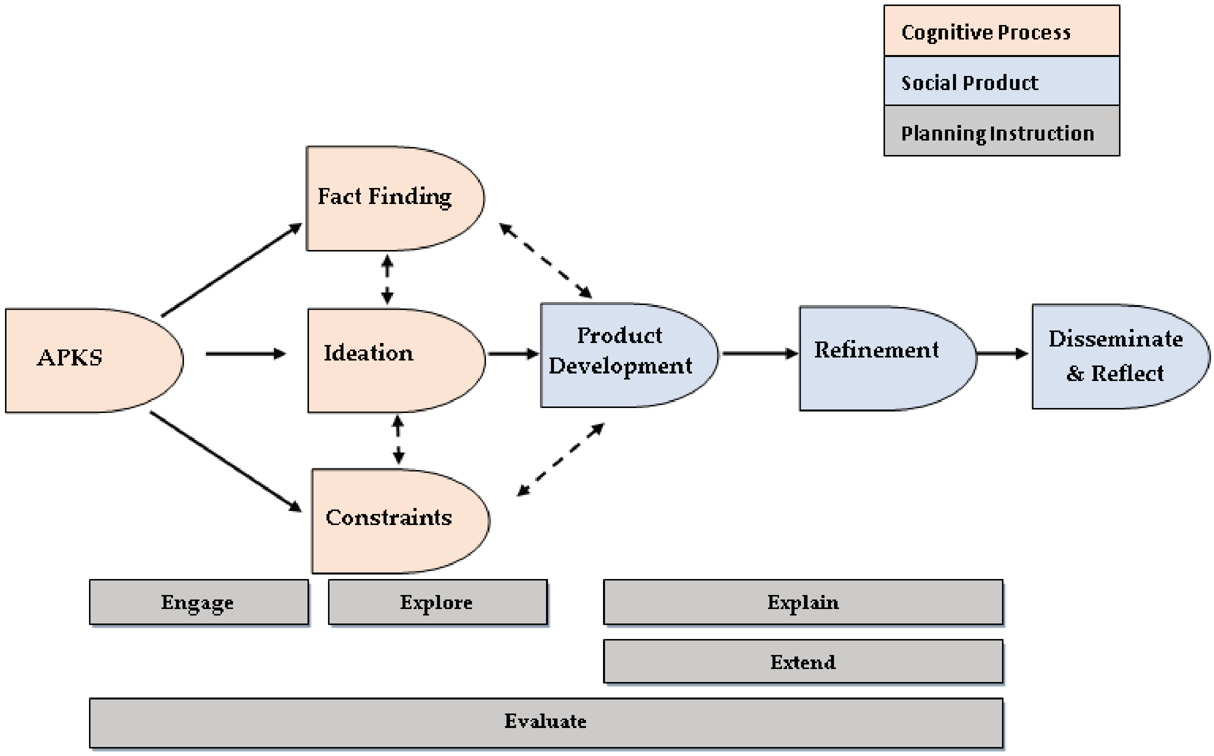



**Figure 5.** STEM Çemgisi (Çorlu, 2017, s. 4)

*Implementation Process*

The pre-test was administered to the students before the implementation to see whether there were any significant differences between the experimental and control groups in terms of achievement and attitudes. The data obtained after the pre-test were transmitted into the SPSS 22.0 package program in order to perform independent sample t-tests, and no significant difference was detected between the two groups.

Following the plan, the implementation lasted for 12 lesson hours. During the teaching of the concept of pressure, the STEM education approach was used in the experimental group, while the regular curriculum suggested by the Ministry of National Education was used in the control group. Implementations for both groups were carried out by the researcher. To prevent implementation bias, the process- and product-oriented measurement and assessment tools were analyzed without any personal interpretations, and the opinions of the experts were followed when analyzing the qualitative data.

**Table 4.** Implementation Study Plan

| Duration | Fulfilled Processes | |
|---|---|---|
| | **Experimental Group** | **Control Group** |
| 12 Course Hours | Pre-test implementations | Pre-test implementations |
| | Lesson plan and teaching implementations based on STEM education concerning the Solid Pressure | Teaching implementations stipulated in the Curriculum of Science concerning the Solid Pressure |
| | Lesson plan and teaching implementations based on STEM education concerning the Solid Pressure<br><br>Lesson plan and teaching implementations based on STEM education concerning the Liquid Pressure<br>*KBLP: The lesson plan related to liquid pressure and teaching implementations.*<br>*A watch company performed a liquid imperviousness test for a new wristwatch. The produced wristwatch was tested in water at a depth of 50 m and was found to be waterproof at a depth of 50 m. In addition to water, the watch company will also produce a commercial film in liquid A and liquid B, to show that the watch is also liquidproof. In this commercial, find how many meters deep were the two liquids, and can you shoot this commercial film?* | Teaching implementations stipulated in the Curriculum of Science concerning the Liquid Pressure |
| | Lesson plan and teaching implementations based on STEM education concerning the Liquid and Gas Pressures | Teaching implementations stipulated in the Curriculum of Science concerning the Gas Pressure |
| | Lesson plan and teaching implementations based on STEM education concerning the implementations for Pressure in Daily Life and Technology<br>*KBLP: An international project competition called "The use of liquid pressure in daily life" is being organized. Middle school students from many countries can participate in the competition. The aim of the project is to design a project that exemplifies the use of liquid pressure in daily life through pre-determined tools and materials. Our country will also participate in the project competition. The Ministry of National Education manifests this project to the schools and asks them to join this competition. Suppose that your school also joined this competition. If you were asked to design a simple hydraulic lift system, how would you design it?* | Teaching implementations stipulated in the Curriculum of Science concerning the Implementations for Pressure in Daily Life and Technology |
| | Post-test implementations | Post-test implementations |
| **200 Minutes** | Semi-structured interviews | |

Before implementing the STEM Education-based Teaching Module, the class was divided into heterogeneous groups, involving 4-5 students, and the required equipment, including the tools, instruments, and materials to be used for the respective activities, were made ready. The groups were formed by bringing together students with different levels of academic achievement and social skills, with the help of their teachers. Following each lesson, the study papers completed by the groups during activities were collected for analysis. Meanwhile, at the same time, each student was asked to fill his/her diary after every activity, and these diaries were collected at the next lesson. The product design and testing phases of the groups during activities were not logged based on the individual, but rather on the event itself, in line with the permissions of the students (Figure 6). The lessons were routinely taught in the control group in accordance with the respective lesson plans.

After teaching the subject "Pressure" AAT and ATSS post-tests were applied in the experimental and control groups. Shortly after completion of the implementation process, the semi-structured interviews were performed with 11 students from the experimental group, taking the results of the quantitative data into consideration.

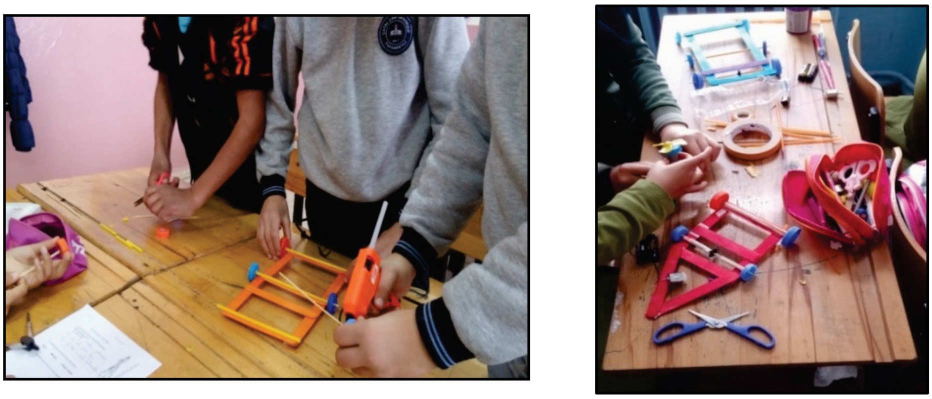


**Figure 6.** Images from the Implementation Process

***Data Analysis***

The quantitative data of the research was transmitted to the SPSS 22.0 package program and analyzed accordingly. Descriptive statistics were determined and the distribution characteristics of the data were examined. The normality of the AAT pre-test and post-test results and the ATSS pre-test and post-test results were checked through the Shapiro-Wilk test. The test results showed that AAT pre-test and post-test results were not normally distributed ($x^2$=.193, sd=33, p= .003<.05; $x^2$=.185, sd=33, p=.006<.05). Accordingly, to determine whether there is any significant difference between the experimental and control groups in terms of pre-test and post-test achievement, the Mann Whitney U test was conducted. The Wilcoxon signed ranks test was used in order to determine whether the average score differences of the academic achievement pre-test and post-test between the experimental and control groups were significant or not. In order to find out whether the average differences of approach in pre-test and post-test results between the experimental and control groups were significant, the t-test was used for independent groups, focusing on the research questions. To determine whether there is any significant difference between the pre-test and post-test mean achievement of experimental and control group students, a paired samples t test was conducted. Cohen's values were used in independent groups, while $d_{ppc2}$ (Morris, 2008) value was used in dependent groups in order to calculate the effect size of the interventions, as well. The following classification was taken into consideration as set forth by Cohen (1992) for interpreting the size of effect: a small effect can be mentioned between .20 - .50; medium effect between .50 – 80; and large effect over .80.

The qualitative data collected via semi-structured interviews and student diaries were subjected to category analysis, which is one form of content analysis. The category analysis was carried out by accessing the concepts that best describe the collected data and by detecting the themes related to these concepts. (Robson & McCartan, 2016; Yıldırım & Şimşek, 2016). Opinions of three experts, specialized in the respective fields, were obtained with regard to formation of codes and themes following the content analysis. The settlement percentage within the encoders was calculated to be 82%, based on the expert opinion. Having a settlement percentage that is over 70% shows that the codes and themes are reliable (Miles & Huberman, 1994). The formed themes were supported with direct references.

## Results

***The Impacts of STEM Education-based Curriculum Approach onn the Academic Achievement, over the Teaching Process of the Subject "Pressure"***

The significance of the difference between the experimental and control groups after applying a pre-test before the implementation process was analyzed with the Mann Whitney U test. A difference was found between the pre-test mean scores of the experimental ($\bar{X} = 29.2500$) and control ($\bar{X} = 27.3077$) groups. As can be seen in Table 5, this difference between the pre-test score averages was determined to be insignificant according to the Mann Whitney U test. [U (31) =113.500, p>.05].

**Table 5.** Mann Whitney U Test Results of Pre-Test Scores received from AATs for Experimental and Control Groups

| Group | N | Mean Rank | Sum of Ranks | U | P |
|---|---|---|---|---|---|
| Experimental | 20 | 17.83 | 356.50 | 113.500 | .537 |
| Control | 13 | 15.73 | 204.50 | | |

The significance of the difference between the experimental and control groups with regards to their post-test score averages for the teaching process of the subject "Pressure," where the STEM education approach and the approach as stipulated by the curriculum were applied, was analyzed with the Mann Whitney U test. A significant difference was found on behalf of the experimental group between the post-test mean scores of the experimental ($\bar{X} = 60$) and control ($\bar{X} = 41.5385$) groups. As can be seen in Table 6, this difference was found to be significant according to Mann Whitney U test [U (31) =48.500, p<.05]. Additionally, finding an effect size over .80 shows a large effect of the procedure, carried out on the experimental group.

**Table 6.** Mann Whitney U Test Results for Post-Test Scores of Experimental and Control Groups from AATs

| Group | N | Mean Rank | Sum of Ranks | U | P | d |
|---|---|---|---|---|---|---|
| Experimental | 20 | 21.08 | 421.50 | 48.500 | .002 | 1.226 |
| Control | 13 | 10.73 | 139.50 | | | |

The significance of the change in the post-test scores, taking into consideration the pre-test scores of the experimental and control groups, was evaluated with the Wilcoxon signed ranks test. As Table 7 shows, there is an important difference in favor of the experimental group concerning the change between the pre-test and post-test scores of the experimental and control groups. This difference was confirmed to be significant based on the result of the Wilcoxon signed ranks test, as shown on Table 7 [W (32) =152.500, p<.05]. Additionally, finding an effect size over .80 shows a large effect of the implementation carried out on the experimental group. Therefore, these results show that STEM Education Based Teaching Module had a significant contribution on the academic achievement of students (See Figure 7).

**Table 7.** Wilcoxon Signed Ranks Test Results for the Difference Between Pre-Test and Post-Test Scores received from AATs for Experimental and Control Groups

| Group | Tests | | n | Mean Rank | Sum of Ranks | z | p | $d_{ppc2}$ |
|---|---|---|---|---|---|---|---|---|
| Experimental | Post-test - Pre-test | Negative Ranks | 0 | - | - | 3.943 | .000 | 1.36 |
| | | Positive Ranks | 20 | 10.50 | 210 | | | |
| | | Ties | 0 | - | - | | | |
| Control | Post-test - Pre-test | Negative Ranks | 3 | 3.17 | 9.50 | 2.320 | .020 | |
| | | Positive Ranks | 9 | 7.61 | 68.50 | | | |
| | | Ties | 1 | - | - | | | |

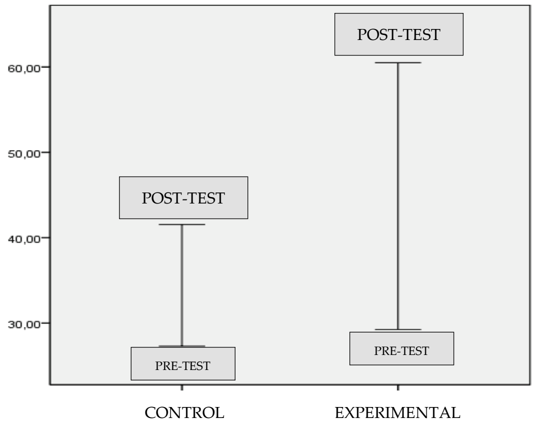



**Figure. 7.** Changes in AAT Scores of the Groups

The impact of STEM education on academic achievement was also examined through the student worksheets used in the experimental group as well as through the AAT. The findings from the worksheets used during STEM activities showed that the students gave correct answers to the questions about pressure, could to a large extent plan their methods to make their designs, and they revealed that participants experienced some difficulties in drawing their designs.

***The Impacts of STEM Education-based Curriculum Approach on the Approach Scores of the Groups in STEM Field, compared with the Teaching Process of the Subject "Pressure"***

The significance of the differences between the experimental and control groups was analyzed with a t-test for independent groups, by performing a pre-test between these two groups before the implementation process. As Table 8 illustrates, there is no significant difference between the pre-test mean scores of the experimental and control groups [t (31) =.116, p>.05].

**Table 8.** T-Test Results for the Independent Groups concerning ATSS Pre-Test Scores of Experimental and Control Groups

| Group | N | $\bar{X}$ | SS | sd | t | p |
|---|---|---|---|---|---|---|
| Experimental | 20 | 138.6000 | 4.21551 | 31 | .116 | .743 |
| Control | 13 | 139.3846 | 5.29579 | | | |

The difference between the post-test scores of the STEM Education based instruction group and the traditional instruction group regarding the pressure concept was examined via independent samples t-test. The test results showed that there is a significant difference between the experimental ($\bar{X}$ = 148.6) and control groups ($\bar{X}$ = 142.3077) in terms of post-test scores. As can be seen on Table 9, there is a significant difference in favor of the experimental group between the post-test score average of the experimental ($\bar{X}$ = 148.6) and control ($\bar{X}$ = 142.3077) groups. This difference is significant for the independent groups as per the t-test result, as can be seen on Table 9 [t (31) =.966, p<.005]. However, finding an effect size of .35 shows a small effect of the procedure, as carried out on the experimental group.

**Table 9.** T-Test Results for Independent Groups concerning ATSS Post-Test Scores of the Experimental and Control Groups

| Group | N | $\bar{X}$ | SS | sd | t | p | d |
|---|---|---|---|---|---|---|---|
| Experimental | 20 | 148.6000 | 12.75849 | 31 | .966 | .004 | .35 |
| Control | 13 | 142.3077 | 24.61837 | | | | |

The significance of the change in the ATSS pre-test and post-test scores of the experimental and control groups was analyzed with the t-test for the dependent groups. As can be seen in Table 10, the post- test scores of the experimental group ($\bar{X}$ = 148.6) changed compared to the pre-test scores ($\bar{X}$ = 138.6). The significance of this difference was tested with a paired samples t-test, and it was found to be significant [t (19) = 2.229, p<.05]. As can be seen in Table 10, the post-test scores of the control group ($\bar{X}$ = 142.3077) are different compared to their pre-test scores ($\bar{X}$ = 139.7692). The significance of this difference was tested with a t-test for independent groups, and it was not found to be significant [t(12) =.259, p>.05]. Additionally, finding an effect size over .80 shows a large effect of the procedure, carried out on the experimental group. Results suggest that STEM education based teaching modüle helped students improve their attitudes towards STEM (See Figure8).

**Table 10.** T Test Results for Dependent Groups concerning the Difference between Pre-test and Post-test Scores of Experimental and Control Groups

| Group | Tests | n | $\bar{X}$ | sd | t | p | $d_{ppc2}$ |
|---|---|---|---|---|---|---|---|
| Experimental | Pre. Test | 20 | 138.6000 | 19 | 2.229 | .03 | 1.586 |
| | Fin. Test | 20 | 148.6000 | | | | |
| Control | Pre. Test | 13 | 139.7692 | 12 | .259 | .80 | |
| | Fin. Test | 13 | 142.3077 | | | | |

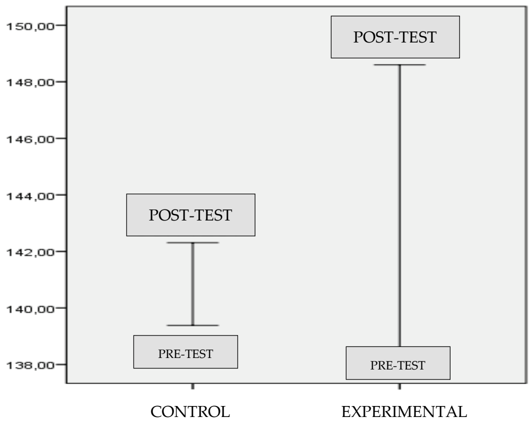



**Figure 8.** Changes in ATSS Scores of the Groups

***The Opinions of the Experimental Group on STEM Education, taken during the Process of teaching the subject "Pressure"***

In order to provide a better description of the information obtained by analyzing the quantitative data obtained with AAT and ATSS, the qualitative data obtained via SSI and SD were subjected to content analysis. The codes and themes given in Figure 9 were generated after analyzing the data obtained from SSI and SD.

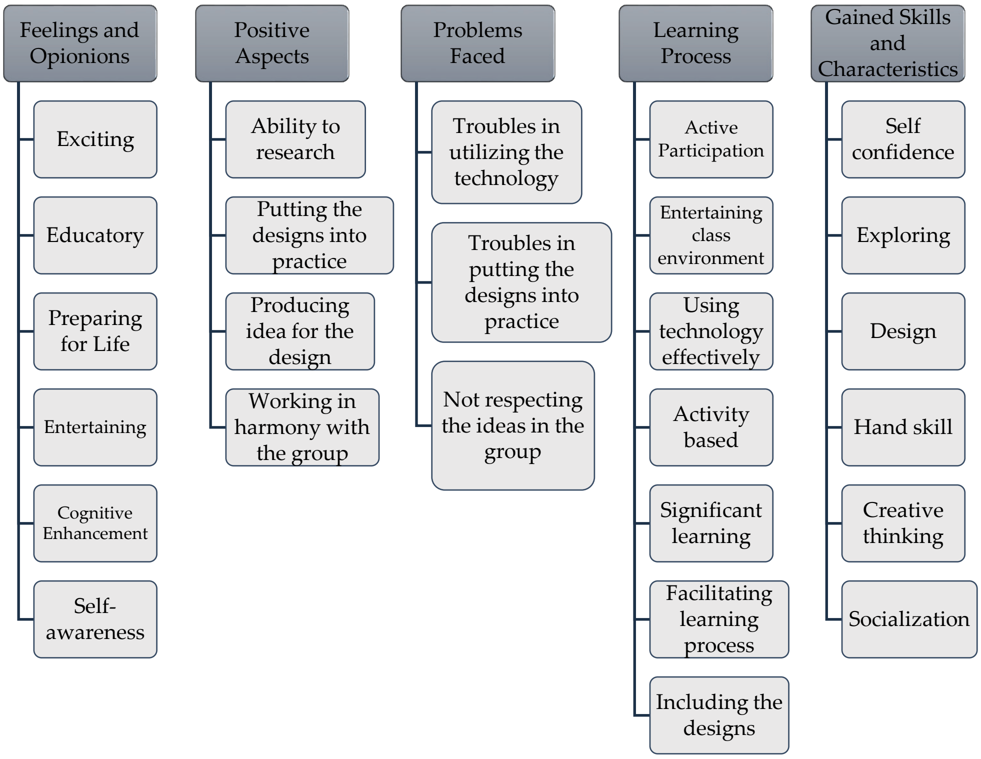



**Figure 9.** The Themes and Codes Reached Via Data Obtained from Qualitative Data Collection Tools

Examining the codes and themes, which can be seen in Figure 4, the students think that STEM education is exciting, educatory, and useful in terms of preparing for life, entertaining, encouraging cognitive enhancement, as well as having the characteristics to ensure them to realize the skills that they are gifted. Some of the statements by the students, taken from the SSIs and SDs, concerning this matter are as follows:

> *S3: "I was very happy during the lessons. I realized that I have the ability to create things that make my life easier. Performing activities and using technological tools in the lessons enable me to learn the subjects easier."*
>
> *S4: "It was quite entertaining. I felt very good for learning new things. Using the technology in the lesson made it more entertaining. I think I learn more and better thanks to this method."*
>
> *S9: "We designed some beautiful things. The lessons were quite entertaining. I realized my skills during the designing process, which I was not aware of before."*
>
> *S1: "We used a number of tools in the lesson. The smart board and the Plickers activity were quite entertaining to me. Apart from that, it was also quite entertaining and educational to create a product by using various materials. We both had fun and learned something" (Student Diary).*

The aspects of STEM education, including the ability to research, putting the designs into implementation, producing ideas for designs, working in harmony with the group, all made the students feel more successful. On the other hand, the students facing problems with the usage of technology, putting the design into implementation, and respecting the ideas of group members caused them to feel less successful, compared to other students. Some of the statements by the students, which are obtained from SSIs and SDs, supporting this matter, are as follows:

> *S5: "I was more successful in the design process for having better ideas. We faced some problems while trying to work in harmony in the group. Because I saw that the group members do not respect the ideas of each other. This lack of harmony led certain minor troubles in the design process."*
>
> *S7: "I was exceedingly in harmony with the group while studying. Working in collaboration with the group made me feel more successful about myself. I was kind of falling behind in producing ideas in the design process compared to my friends."*

*S8: "I was more successful in designing compared to my friends. I was more skillful and knowledgeable. We had some minor problems during the designing process, which led us to lose a bit of time. And we also faced with minor problems in using the technology while making research, yet we finally completed the research."*

*S2: "My friend "A" was a huge help in the designing process, unlike my friends "B" and "C," who could not contribute much, due to facing problems in using technology while making research" (Student Diary).*

The students emphasized the facts that they played a much more active role, that the class environment became more entertaining, that the technology is utilized effectively, that the activities and designs were frequently included, that the information provided became permanent, and that the learning process was easier with regards to learning with STEM education. Additionally, they also stated that their skills and characteristics with regards to self-confidence, discovering, designing, hand-skills, creative thinking and socialization would be improved in time thanks to STEM education. Some of the statements by the students on this matter, which are in the SSIs and SDs, are as follows:

*S3: "We carry out many activities and designs in STEM lessons, on that sense, it is different from other science lessons. I think STEM should be used in other subjects, as well, particularly in a mathematics lesson. We can learn the challenging subjects more easily, and the information we gain from these lessons would be lasting. This kind of lessons allows us to improve our ability in design, hand-skills, as well as ensuring us to socialize via groups."*

*S11: "This approach makes the lessons more understandable. Thanks to it, I learn more easily and feel stronger about myself. Continuous utilization of such activities allows us to gain self-confidence while motivating us more for the lessons. The lessons taught under this approach allow me to improve my skills in designing, handcraft, as well as the ability to discover new things."*

*S5: "We normally do not perform many activities in regular science lessons, but we were included much more the activities and designs for these lessons. Since we studied harder, the lessons were more entertaining. I would like this approach to be applied on other lessons and subjects, as well. My knowledge on Mathematics would improve while improving hand skills and knowledge store. My self-confidence would be in a better position, so I would produce creative ideas."*

## Discussion, Conclusion and Suggestions

In this study, we aimed to determine the impact of a teaching module developed with the STEM approach about the pressure concept on students' academic achievement and on their attitudes towards STEM. During the teaching process of the Pressure concept, it was ascertained that the differences between the post-test mean scores concerning the academic achievement of these two groups, where the STEM education approach and the approach as stipulated by the respective curriculum were applied, were significant in favor of the experimental group. Additionally, the differences between the pre-test and post-test scores of these two groups were significant in favor of the experimental group; there is no significant difference between the control group pre-test and post-test (Figure 8). The reasons of the differences between two groups in terms of academic success are thought to be in the individuals' capacities to access the information by themselves, as well as in having the opportunity to put them into implementation by correlating the information with engineering and technological disciplines.

Examining the literature, we can find certain studies showing that STEM education has a positive impact on the academic achievement, which is consistent with the results of this study (Ceylan & Özdilek, 2015; Cotabish et al., 2013; Çevik, 2018; León et al., 2015; Owen & Çapan, 2017; Toma & Greca, 2018; Yıldırım & Selvi, 2017). Han, Capraro, and Capraro (2015) indicated that project-based STEM education, carried out within the scope of mathematics, led to a greater success for students with low performance levels, compared to those having medium or high-performance levels. Kakarndee, Kudthalang, and Jansawang (2018) reached the conclusion that the academic achievements and creative thinking skills of high school students improved in another study, where the impact of STEM education on students was researched. The results of these studies, as in the current study, show that STEM education is efficient in terms of improving the academic success levels of students towards the respective subject. On the other hand, it was found in another study carried out in Turkey by Öner and

Capraro (2016) that there is no significant difference between the success levels in science and mathematics of the students studying in schools that apply STEM education approaches and the students that study in schools in which the teaching approach is stipulated by the respective curriculum. However, the researchers explained that insignificant differences between these two types of schools could be due to the fact that the current structure of the schools using STEM education does not meet the requirements for STEM education and that there is no proper mechanism for auditing the success levels of these schools.

In the teaching of the Pressure concept, a significant difference was also found between the post-test attitude mean scores of the STEM education supplied group and the traditional curriculum supplied group. Additionally, the difference between the pre-test and post-test attitude mean scores of these two groups was found to be significant in favor of the experimental group (Figure 9). The reasons for this difference between the two groups in terms of attitude scores towards STEM are thought to be that the participants have a better opportunity to observe their personal skills within the scope of STEM areas during the STEM education implementation; that they are provided with the opportunity to display these skills; that technological tools and software, used during STEM education implementation, increase the interest of students towards STEM areas; and that they can create a product in line with the information obtained from STEM implementations. Having a positive attitude toward STEM plays a significant role in students' career plans in the field of STEM, as well as increasing their interest in such fields.

The idea that the implementation of STEM education provides a positive impact on the attitudes of the students within the respective fields, is supported by many studies (Aydın, Saka, & Guzey, 2017; Baran et al., 2016; Chonkaew, Sukhummek, & Faikhamta, 2016; Guzey et al., 2016; Gülhan & Şahin, 2016; Karakaya & Avgın, 2016; Karahan et al., 2015; Yamak et al., 2014; Toma & Greca, 2018; Yerdelen, Kahraman, & Taş, 2016). In a study where the attitudes towards STEM, including the relationships between these approaches and STEM career fields, were researched, it was suggested that the students having positive attitudes toward STEM are more prone to building careers in such fields (Yerdelen et al., 2016). Since the career groups of the future are thought to be in STEM areas, the students are expected to tend to have career opportunities in these areas. It is thought that students in teaching and learning environments of STEM education develop a positive attitude towards these areas, thus planning their careers in these areas, as well. The results of another study carried out by Toma and Greca (2018) shows that the students develop a positive attitude for STEM education, while also suggesting that the teachers are unwilling to utilize STEM education in their lessons, and they need detailed directives during the implementation process. On the other hand, certain studies also suggest that the STEM activities do not cause any statistically significant difference between the experimental and control groups (Yıldırım & Selvi, 2017).

Five themes – feelings and opinions, positive aspects, skills and features gained, problems faced in the learning process-, as well as 26 codes, were obtained with the content analysis of semi-structured interviews and students' diaries. The opinions of the experimental group reveal the reasons for differences between the two groups in terms of academic achievement and attitude. Regarding their learning processes with STEM education, the students commented on the fact that they played a much more active role in learning, that the class environment became more entertaining, that the technology was utilized effectively, that the activities and designs were frequently included, that the information provided became permanent, and that the learning process was easier. They also emphasized the fact that that the knowledge they gained is much more lasting, and that the learning process is easier. The students expressed feeling that STEM education is exciting, educatory, useful in terms of preparing for life, entertaining, encouraging cognitive enhancement, as well as having the characteristics to ensure them to realize the skills with which they are gifted, and together this supports the idea that students developed a positive attitude for STEM. Moreover, the students stated that their skills and characteristics with regards to self-confidence, discovering, designing, hand-skills, creative thinking, and socialization would be improved in time thanks to STEM education, statements which not only support the idea of developing a positive attitude, but which are also signs of a sense of achievement. The qualitative findings of the research further support the idea that many skills aimed for the individual achievement in the 21st century can be gained with STEM education. When considered from this point of view, in many studies within the literature emphasize that STEM education is the most suitable approach for improving the skills of the 21st century (Bybee, 2010; Ejiwale, 2012; Ostler, 2012). Students need a number of skills during STEM education, including researching, using technology, working in groups, creating products, and making presentations. In STEM environments, students are offered opportunities to develop these skills.

During the implementation process for STEM educational activities, it is necessary to organize the learning environment in advance, to prepare the required technological equipment and infrastructure as well as the layout plans of the groups and the materials. Such preparations will prevent possible time loss for lessons and will encourage the planned teaching process to be carried out as required.

Future studies may focus on research planned in accordance with STEM education in different grades and in different subjects of the curriculum. In this way, adapting many subjects in the curriculum with STEM education will be a guide for those preparing the curriculum and for the teachers. Researchers who plan to carry out studies on STEM education might develop course contents with clear and detailed directives to be used by teachers with the limited knowledge, and this will promote the use of STEM approaches in the courses. Additionally, certain influences of STEM education implementations such as the self-confidence of students, the ability to present creative solutions, and communication skills may be studied in upcoming research.

In this study, the group in which STEM education was implemented consisted of 20 students. Teachers who would like to carry out STEM training implementations in crowded classrooms are advised to select equipment that is within reach and economical, to determine the number of students in the groups based on the availability of technological equipment, and to provide detailed information about how to implement STEM education implementations before the implementation occurs. This study was limited to a 12-hour period. Nevertheless, in this short period of time, the STEM education approach improved students' achievement, attitude, and 21st century skills. STEM training activities can be incorporated into the classroom more frequently in order for students to gain 21st century skills completely.

When STEM education implementations were examined, it was observed that the activities were mostly carried out in a laboratory environment. However, since there were no laboratories in the selected schools, STEM activities were conducted in a classroom environment. It became compulsory to allocate specific time before the lessons, due to the fact that the tools and equipment to be used in the course of the activities in the classroom need to be prepared in advance and the proper location and infrastructure need to be provided in order to use the technological equipment. The laboratory environment is thought to be more advantageous for STEM education as it provides the equipment to be used by the students, provides regularity in using the technological equipment, and makes it available to use large and practical tables where students can work comfortably.

## References


Akgün, A., Tokur, F., & Özkara, D. (2013). TGA stratejisinin basınç konusunun öğretimine olan etkisinin incelenmesi. *Amasya Üniversitesi Eğitim Fakültesi Dergisi*, *2*(2), 348-369.

Akgündüz, D. (2016). A research about the placement of the top thousand students in stem fields in Turkey between 2000 and 2014. *Eurasia Journal of Mathematics, Science & Technology Education*, *12*(5), 1365-1377.

Association for Career and Technical Education, National Association of State Directors of Career Technical Education Consortium and Partnership for 21st Century Skills. (2010). *Up to the challenge: The role of career and technical education and 21st century skills in college and career readiness.* Retrieved from http://www.p21.org/storage/documents/CTE_Oct2010.pdf.

Ayar, M. C. (2015). First-hand experience with engineering design and career interest in engineering: An informal STEM education case study. *Educational Sciences: Theory ve Practice*, 15(6), 1655-1675.

Aydeniz, M. (2017). *Our education system and vision for the 21st century: A STEM-oriented economic roadmap for Turkey as moving toward 2045 goals*. Knoxville: University of Tennessee.

Aydın, G., Saka, M., & Guzey, S. (2017). Science, technology, engineering, mathematic (STEM) attitude levels in grades 4th-8th. *Mersin University Journal of the Faculty of Education*, *13*(2), 787-802.

Baran, E., Canbazoğlu Bilici, S., Mesutoglu, C., & Ocak, C. (2016). Moving STEM beyond schools: Students' perceptions about an out-of-school STEM education program. *International Journal of Education in Mathematics, Science and Technology*, *4*(1), 9-19.

Bicer, A., Boedeker, P., Capraro, R. M., & Capraro, M. M. (2015). The Effects of STEM PBL on Students' Mathematical and Scientific Vocabulary Knowledge. *Online Submission*, 2(2), 69-75.

Blackley, S., & Howell, J. (2015). A STEM narrative: 15 years in the making. *Australian Journal of Teacher Education*, *40*(7), 102-112.

Bybee, R. W. (2010). Advancing STEM education: A 2020 vision. *Technology and Engineering Teacher*, *70*, 30-35.

Ceylan, S., & Özdilek, Z. (2015). Improving a sample lesson plan for secondary science courses within the STEM education. *Procedia-Social and Behavioral Sciences*, *177*, 223-228.

Chonkaew, P., Sukhummek, B., & Faikhamta, C. (2016). Development of analytical thinking ability and attitudes towards science learning of grade-11 students through science technology engineering and mathematics (STEM education) in the study of stoichiometry. *Chemistry Education Research and Practice*, *17*(4), 842-861.

Cohen, J. (1992). A power primer. *Psychological bulletin*, *112*(1), 155.

Cotabish, A., Dailey, D., Robinson, A., & Hughes, G. (2013). The effects of a STEM intervention on elementary students' science knowledge and skills. *School Science and Mathematics*, *113*(5), 215-226.

Creswell, J. W., & Plano Clark, V. L. (2017). *Designing and conducting mixed methods research* (3th ed.). Los Angeles: SAGE.

Çevik, M. (2018). Impacts of the project based (PBL) science, technology, engineering and mathematics (STEM) education on academic achievement and career interests of vocational high school students. *Pegem Journal of Education and Instruction, 8*(2), 281-306.

Çorlu, M. S. (2013). Insights into STEM education praxis: An assessment scheme for course syllabi. *Educational Sciences: Theory and Practice*, *13*(4), 2477-2485.

Çorlu, M. S., Capraro, R. M., & Capraro, M. M. (2014). Introducing STEM education: Implications for educating our teachers for the age of innovation. *Education and Science*, *39*(171), 74-85.

Çorlu, S. M. (2017). STEM: Integrated teaching framework. In S. M. Çorlu & E. Çallı (Eds.), *STEM theories and applications, science, technology, engineering and mathematics education* (pp. 1-10). İstanbul: Pusula Publishing.

Ejiwale, J. A. (2012). Facilitating teaching and learning across STEM fields. *Journal of STEM Education: Innovations and Research*, *13*(3), 87.

Endüstri 4.0. (2018). Hakkımızda. Retrieved from http://www.endustri40.com/hakkimizda.

Erdoğan, N., Çorlu, M. S., & Capraro, R. M. (2013). Defining innovation literacy: do robotics programs help students develop innovation literacy skills?. *International Online Journal of Educational Sciences*, *5*(1), 1-9.

Fraenkel, J., Wallen, N., & Hyun, H. H. (2012). *How to design and evaluate research in education* (8th ed.). San Francisco: McGraw Hill.

Gencer, A. S. (2015). Scientific and engineering practices in science education: twirly activity, *Journal of Inquiry Based Activities*, *5*(1), 1-19.

Gömleksiz, M. N., & Bulut, İ. (2007). An assessment of the implementation of new science and technology curriculum. *Hacettepe University Journal of Education*, *32*(32), 76-88.

Gonzalez, H. B., & Kuenzi, J. J. (2012). *Science, technology, engineering, and mathematics (STEM) education: A primer*. Congressional Research Service, Library of Congress.

Goszewski, M., Moyer, A., Bazan, Z., & Wagner, D. J. (2013). Exploring student difficulties with pressure in a fluid. *AIP Conference Proceedings, 1513*(1), 154-157.

Gu, X., Zhu,Y., & Guo, X. (2013). Innovative technologies for the seamless integration of formal and informal learning. *Journal of Educational Technology & Society*, *16*(1), 392-402.

Guzey, S. S., Moore, T. J., Harwell, M., & Moreno, M. (2016). STEM integration in middle school life science: Student learning and attitudes. *Journal of Science Education and Technology*, *25*(4), 550-560.

Gülhan, F., & Şahin, F. (2016). The effects of science-technology-engineering-math (STEM) integration on 5th grade students' perceptions and attitudes towards these areas. *Journal of Human Sciences*, *13*(1), 602-620.

Halbach, A. (2000). Finding out about students' learning strategies by looking at their diaries: A case study. *System*, *28*(1), 85-96.

Han, S., Capraro, R., & Capraro, M. M. (2015). How science, technology, engineering, and mathematics (STEM) project-based learning (PBL) affects high, middle, and low achievers differently: The impact of student factors on achievement. *International Journal of Science and Mathematics Education*, *13*(5), 1089-1113.

Han, S. W. (2015). Curriculum standardization, stratification, and students' STEM-related occupational expectations: Evidence from PISA 2006. *International Journal of Educational Research*, *72*, 103-115.

Jones, V., Jo, J. ve Martin, P. (2007). Future schools and how technology can be used to support millennial and generation-z students. In *1st International Conference of Ubiquitous Information Technology and Applications* (pp. 886-891). Dubai.

Kakarndee, N., Kudthalang, N., & Jansawang, N. (2018). The integrated learning management using the STEM education for improve learning achievement and creativity in the topic of force and motion at the 9th grade level. *AIP Conference Proceedings,* 1923(1), 030024.

Karahan, E., Canbazoğlu Bilici, S., & Unal, A. (2015). Integration of media design processes in science, technology, engineering, and mathematics (STEM) education. *Eurasian Journal of Educational Research, 15*(60), 221-240.

Karakaya, F., & Avgın, S. S. (2016). Effect of demographic features to middle school students' attitude towards FeTeMM (STEM). *Journal of Human Sciences*, *13*(3), 4188-4198.

Kertil, M., & Gürel, C. (2016). Mathematical modeling: A bridge to STEM education. *International Journal of Education in Mathematics, Science and Technology*, *4*(1), 44-55.

Knezek, G., Christensen, R., Tyler-Wood, T., & Periathiruvadi, S. (2013). Impact of environmental power monitoring activities on middle school student perceptions of STEM. *Science Education International*, *24*(1), 98-123.

Knorr-Cetina, K. D. (2013). *The manufacture of knowledge: An essay on the constructivist and contextual nature of science*. Elsevier.

Lamb, R., Akmal, T., & Petrie, K. (2015). Development of a cognition-priming model describing learning in a STEM classroom. *Journal of Research in Science Teaching*, *52*(3), 410-437.

Land, M. H. (2013). Full STEAM ahead: The benefits of integrating the arts into STEM. *Procedia Computer Science*, *20*, 547-552.

Lasi, H., Fettke, P., Kemper, H. G., Feld, T., & Hoffmann, M. (2014). Industry 4.0. *Business & Information Systems Engineering*, *6*, 239-242.

León, J., Núñez, J. L., & Liew, J. (2015). Self-determination and STEM education: Effects of autonomy, motivation, and self-regulated learning on high school math achievement. *Learning and Individual Differences*, *43*, 156-163.

Merriam, S. B., & Tisdell, E. J. (2015). *Qualitative research: A guide to design and implementation*. San Francisco: Jossey-Bass.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. London: SAGE.

Morris, S. B. (2008). Estimating effect sizes from pretest-posttest-control group designs. *Organizational research methods*, *11*(2), 364-386.

Morrison, J. (2006). *Attributes of STEM education: The student, the school, the classroom*. Baltimore: TIES.

Muliyani, R., & Kaniawati, I. (2015). Identification of quantity student's misconception on hydrostatic pressure with three tier-test. *International Conference on Global Trends in Academic Research (GTAR)*, *Vol. 2*. (pp. 716-721).

Mutakinati, L., Anwari, I., & Kumano, Y. (2018). Analysis of students' critical thinking skill of middle school through stem education project-based learning. *Jurnal Pendidikan IPA Indonesia*, *7*(1), 54-65.

Niglas, K. (2010). The multidimensional model of research methodology: An integrated set of continua. In A. Tashakkori & C. Teddlie (Eds.) *Handbook of mixed methods in social and behavioral research* (pp. 215-236). London: SAGE.

NRC. (2011). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: National Academies.

OECD. (2012). *Education at a glance 2012: OECD indicators.* Retrieved from https://www.oecd-ilibrary.org/education/education-at-a-glance-2012_eag-2012-en.

OECD. (2018). *Strengthening education for innovation*. Retrieved from https://www.oecd.org/sti/outlook/e-outlook/stipolicyprofiles/humanresources/strengthening educationforinnovation.htm.

Omundsen, J. (2014). Cardboard boat building in math class. *Middle School Journal*, *46*(2), 3-9.

Ostler, E. (2012). 21st century STEM education: A tactical model for long-range success. *International Journal of Applied Science and Technology*, *2*(1), 28-33.

Owen, F. K., & Çapan, B. E. (2017). Fen, teknoloji, matematik ve mühendislik alanlarını seçmeyi planlama: meslek seçimine ilişkin inançlar. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, *33*(4), 915-933. doi: 10.16986/HUJE.2017032884.

Öner, A. T., & Capraro R. M. (2016). Is STEM Academy designation synonymous with higher student achievement? *Education and Science, 41*(185), 1-17.

Özcan, H. (2013). *Development of pre-service science teachers' pedagogical content knowledge for nature of science embedded into science content* (Unpublished doctoral dissertation). Gazi University, Educational Science Institute, Ankara.

Özcan, H., & Koca, E. (2018). Turkish adaptation of the attitude towards STEM scale: A validity and reliability study. *Hacettepe University Journal of Education*. Advance online publication. doi: 10.16986/HUJE.2018045061

Park, D. Y., Park, M. H., & Bates, A. B. (2018). Exploring young children's understanding about the concept of volume through engineering design in a STEM activity: A case study, *International Journal of Science and Mathematics Education*, *16*(2), 275-294.

Pathare, S., & Pradhan, H. C. (2011). Students' alternative conceptions in pressure, heat and temperature. *Physics Education*, *21*(3-4), 213-218.

Patton, M. (2002). *Qualitative evaluation and research methods*. Beverly Hills, CA: SAGE.

Prensky, M. (2012). *From digital natives to digital wisdom: Hopeful essays for 21st century learning*. Thousand Oaks, CA: Corwin Press.

Robson, C., & McCartan, K. (2016). *Real world research* (4th ed.) UK: John Wiley & Sons.

Roehrig, G. H., Moore, T. J., Wang, H. H., & Park, M. S. (2012). Is adding the E enough? Investigating the impact of K-12 engineering standards on the implementation of STEM integration. *School Science and Mathematics*, *112*(1), 31-44.

Siverling, E. A., Guzey, S. S., & Moore, T. J. (2017). Students' science talk during engineering design in life science-focused STEM integration units. In *2017 IEEE Frontiers in Education Conference (FIE)* (pp. 1-9). San Jose.

Sümen, Ö. Ö., & Çalisici, H. (2016). Pre-Service Teachers' Mind Maps and Opinions on STEM Education Implemented in an Environmental Literacy Course. *Educational sciences: Theory and practice*, *16*(2), 459-476.

Thananuwong, R. (2015). Learning science from toys: A pathway to successful integrated STEM teaching and learning in Thai middle school, *K-12 STEM Education*, *1*(2), 75-84.

Thompson, P. (2013). The digital natives as learners: Technology use patterns and approaches to learning. *Computers & Education*, *65*, 12-33.

Toma, R. B., & Greca, I. M. (2018). The effect of integrative STEM instruction on elementary students' attitudes toward science. *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(4), 1383-1395.

Tuncel, E. (2017). *7th grade science textbook*. Ankara: Mevsim Publishing.

Ünal, G. (2005). *Deep learning in science teaching: Modelling for "pressure"* (Unpublished master's thesis). Dokuz Eylül University, Educational Science Institute, İzmir.

Vasquez, J. A., Comer, M., & Sneider, C. (2013). *STEM lesson essentials, grades 3-8: Integrating science, technology, engineering, and mathematics* (1st ed.). Portsmouth, NH: Heinemann.

Wagner, T. (2008). Rigor redefined. *Educational Leadership, 66(2), 20-24.*

Wijaya, C. P., & Muhardjito, M. (2016). The diagnosis of senior high school class x mia b students misconceptions about hydrostatic pressure concept using three-tier. *Jurnal Pendidikan IPA Indonesia*, *5*(1), 13-21.

Yamak, H., Bulut, N., & Dündar, S. (2014). The impact of stem activities on 5th grade students' scientific process skills and their attitudes towards. *Gazi University Journal of Gazi Educational Faculty*, *34*(2), 249-265.

Yerdelen, S., Kahraman, N., & Taş, Y. (2016). Low socioeconomic status students' STEM career interest in relation to gender, grade level, and STEM attitude. *Journal of Turkish Science Education*, *13* (Special Issue), 59-74.

Yıldırım, B., & Altun, Y. (2015). Investigating the effect of stem education and engineering applications on science laboratory lectures, *El-Cezerî Journal of Science and Engineering*, *2*(2), 28-40.

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

Yıldırım, B., & Selvi, M. (2017). An experimental research on effects of STEM applications and mastery learning, *Journal of Theory and Practice in Education*, *13*(2), 183-210.

Yin, R. K. (2016). *Qualitative research from start to finish* (2nd ed.). NY: Guilford Publications.

## Appendix 1. 7. A Sample Lesson Plan by STEM Teaching Module on the Subject "Pressure" in 7th Grade

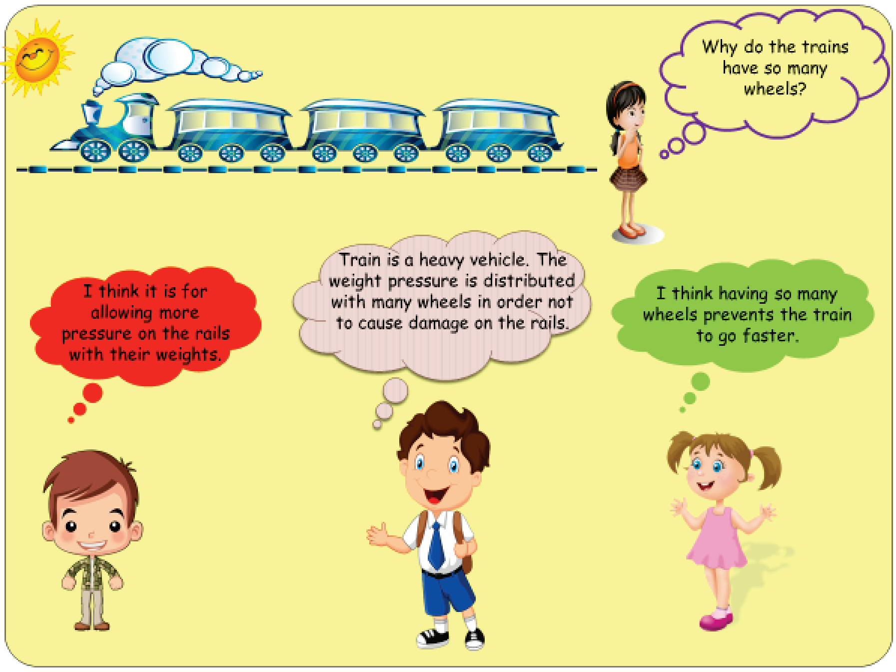
| **Section 1: General Information on the Lesson** | | |
|---|---|---|
| **Lesson** | Science | |
| **Grade** | 7th grade | |
| **Suggested time** | 80 minutes | |
| **Unit** | Strength and Energy | |
| **Subject** | The relation between Strength – Solid Pressure | |
| **Acquisitions** | **a) Acquisitions from Science** | |
| | 7.2.2.1. Discovers the variables affecting the solid pressure by testing and analyzes the relation between these variables. | |
| | **b) Acquisitions from Mathematics** | |
| | M.5.1.2.9. Finds the element members that are not known in the operation, by comprehending the relation between multiplication and division (multiplier, quotient or dividend).<br>M.5.2.4.1. Calculates the area of the rectangle uses square centimeter and square meter.<br>M.5.2.5.3. Solves the problems requiring the calculation of the surface area of the rectangular prism.<br>M.6.1.6.3. Designates the ratio of two quantities within the same or different elements to each other. | |
| | **c) Acquisitions from Engineering** | |
| | ○ Defines a problem clearly in order to solve it.<br>○ Plans the steps to be taken in order to solve a problem.<br>○ Creates a unique design to provide solution for a problem.<br>○ Controls whether the designed tool provides a solution to the respective problem, by testing it. | |
| | **d) Technological Acquisitions** | |
| | ○ Uses the information-communication tools for finding a solution to a problem and conducts research. | |
| **Focal Concepts** | Pressure, Surface Area, Pressure Force | |
| **Training Technologies** | Smart Board, Powtoon, Plickers | |
| **Tools, Instruments and Materials** | ○ Plastic bottle cap<br>○ Skewer<br>○ Electric motor<br>○ Switch<br>○ Battery holder<br>○ Modeling clay<br>○ Binding agent | ○ Sticky tape<br>○ Scissors<br>○ Craft knife<br>○ Pen<br>○ Paper<br>○ Schoolbook |
| **Section 2: Information concerning the Learning Process** | | |
| **a) Knowledge-Based Life Problem (KBLP)** | | |
| The company "Hayat Textile" uses always the same method for distributing its products. The products to be distributed are carried with the companies own vehicles. The track distortions cannot be eliminated despite the fact that the roadworks are carried out annually on a regular basis. The municipal employees decide to designate the reason for distortions on this road. With the researches carried out on this matter, it was found that the reason for distortions on the road is caused by smaller vehicles carrying relatively heavy goods. The municipal employees contact with Hayat Tekstil and explain the situation. Then the company "Hayat Tekstil" decides to consult to an engineering firm for a healthy transportation on this route. You are working on these engineering company and you are expected to design a vehicle that protects the road against distortions while carrying the products of Hayat Tekstil. | | |
| **b) Limitations** | | |
| ○ You can only use the tools-instruments provided for you.<br>○ You need to draw the designed vehicle first.<br>○ The design must be unique.<br>○ You must complete the design of the vehicle within 30 minutes. | | |

***c)* Planning the lesson as per 5E-method**

1. *Engage*

Before starting the lesson, the students are divided into heterogeneous groups comprising of 4-5 persons. It is ensured that the students within the same group remain together.

The students are provided with the following conceptual caricature drawn concerning the respective subject before sharing the KBLP. A short discussion may be made among the students on the conceptual caricature. A short presentation is made to the students, which is prepared in the Powtoon in order to present the KBLP problem corporally to the students. This presentation will help the students to come up with ideas in order to solve the problem.




2. *Explore*

KBLP presentation and limitations are presented each group in written form. Additionally, each group is provided with two study sheets as a research notebook and planning notebook.

The following research questions were included in the first chapter of the Research Notebook:

- What should be observed during road repair?
- What are the variables that change the pressure of a vehicle?
- What should be done in order to reduce the pressure of a vehicle on the surface?
- How is the electric motor used?

The students are given 10 minutes for answering the questions on the second chapter of the research notebook, researching online and in the 7th-grade textbook, and entering the data into their notebooks. The obtained information is discussed by the groups for 5 minutes, making the evaluations and additions as required. After answering the research questions, the task distribution is made within the groups (designer, recorder, engineer, researcher). Each group is asked to start designing its own vehicle. The materials to be used are left on the table of each group. First, they are asked to answer the questions within the planning notebook in brief and to design the vehicle within 30-35 minutes. The students are reminded that each of them has responsibility for designing the vehicle and that the designed vehicles will be tested. The tables of the groups are monitored during the design process, and students are asked directive questions, if required. Once the design time is completed, the vehicles designed by the groups are collected, and each group is asked for making a presentation on their own vehicle. Finally, 100g of weight are loaded on the designed vehicles, and each vehicle is tested in terms of the arrival time within a certain distance.

3. *Explain*

A short presentation is made on the subject “What are the variables in the solid pressure?” The presentation comprises of sample questions, as well as information and animation on cases.

4. *Extend*

For making a comparison between the pressure levels of the objects applying force on the surface and those with different surface areas, detailed information is provided in mathematical formulas and elements. The students are provided with sample question solutions in order to let them learn the subject permanently.

5. *Evaluate*

- The product design and design process are evaluated with scale scoring key.
- The answers on the research notebook and planning notebook are evaluated after the lesson.
- After the teaching process, the questions prepared on the solid pressure are evaluated using Plickers.

# Appendix 2. Control Group Sample Course Plan

| **Section 1: General Information on the Lesson** | |
|---|---|
| **Lesson** | Science |
| **Grade** | 7th |
| **Suggested time** | 80 minutes |
| **Unit** | Force and Energy |
| **Subject** | Force – Solid Pressure relationship |
| **Gains** | F.7.2.2.1. The variables are tested and discovered that effect the solid pressure, thus analyzing the relation between these variables. |
| **Focal terms** | Pressure, Surface Area, Pressure Force |
| **Educational Technologies** | Smart Board |
| **Teaching Strategies, Methods, and Techniques** | Teaching, brain storm, discussion, Q&A based on research - questioning |
| **Tools, Instruments, and Materials** | 2 bricks, washbowl, sand, notepad, ruler |

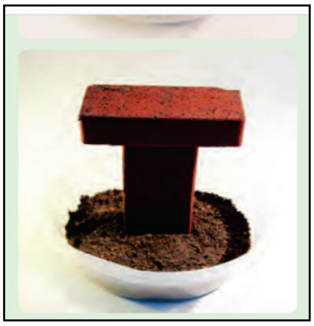
**Section 2: Information on the Teaching Process**

Before starting the lesson, students are divided into separate groups of 3 – 4. The following question is reflected on the smart board in order to arouse the attention of students.

Think of a day with heavy snowfall. Which of the above options would you choose to walk over the snow without letting your feet down into the snow? Why?

After the question is answered, the students are asked to discuss it within their groups. It is ensured that ideas are exchanged between the groups. No direct explanation is made by the teacher, but rather, he/she asks questions that direct the students into discussion.

**1. Defining the problem**



The above figure is reflected on the smart board, and the following question is directed to the students: "When the bricks, which are placed one on the top of the other within a container full of sand as can be seen in the figure, turned upside down, how would the state of sinking into the sand change?" Thus the problem will have been defined.

**2. Suggesting the predictions and hypothesis**

During this phase, the students brainstorm within their groups in order to present their predictions on the solution of the problem. A hypothesis is constituted for solving the problem based on these predictions.

**3. Testing the hypothesis**

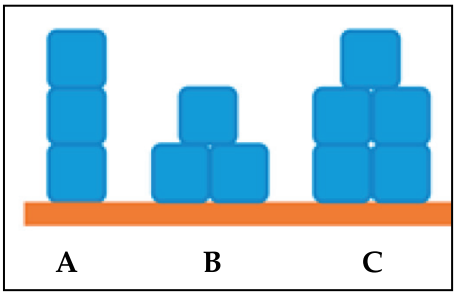
During this phase, the students are asked to describe the method to be followed for testing their hypothesis.

(*The groups expressed their intention to test the hypothesis by carrying out an experiment for having the respective tools, instruments, and materials in the class.*)

**4. Implementation**
During this phase, each group performs the experiment to approve their hypothesis.

**5. Evaluating and sharing the results**
During this phase, each group shares the hypothesis and the information that they reached following the experiment. After the respective results are shared, a general explanation is made by the teacher for solving the problem, thus constituting a correlation with the pressure, including the concepts affecting the pressure.

**6. Evaluation**
During this phase, the questions prepared concerning the solid pressure are presented to the students by means of a smart board, thus evaluating the gains.
***Sample question:***




A, B, and C materials comprise of identical cubes. Fill in the following blanks concerning the pressure exerted by these three materials on the floor.
1. The pressure exerted by object A is …………………… than the pressure exerted by object B.
2. The pressure exerted by object C is …………………… than the pressure exerted by object B.

3. The highest pressure exerted on the floor is from the material …………………..