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THE IMPACTS OF STEM SUPPORTED SCIENCE TEACHING ON 8TH GRADE STUDENTS' ELIMINATION OF MISCONCEPTIONS ABOUT "SOLID, FLUID AND GAS PRESSURE", AND THEIR ATTITUDES TOWARDS SCIENCE AND STEM

Resarch article

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Abstract

In the study, it was aimed to determine the misconceptions of 8th grade students about the concepts of "solid, fluid and gas pressure", to correct these misconceptions by using STEM supported Science activities, and to improve their attitudes towards Science and STEM. The study group consisted of 46 8th grade students at a public school in Ankara in the fall semester of the 2019-2020 school year. They were determined using the appropriate sampling method, one of the non-probabilistic sampling methods In the study, experimental method with pre-test-post-test single group model was used. The study was conducted with two experimental groups in order to increase the reliability of the research. The data were collected via the "Pressure Conceptual Understanding Test", “Attitude Scales towards Science and STEM”. The results revealed that the students had misconceptions about “Pressure" in the pre-test. It was also found out that STEM was useful to overcome the detected misconceptions, largely overcome the misconceptions existing in students, and the participant students' attitudes towards STEM developed at a positive level, whereas there was no change in their attitude towards Science.

Keywords: Science class, pressure, solid, liquid, gas, STEM, misconception

1. Introduction

The needs of individuals are in constant change depending on the changing conditions. Staying behind the developing and changing world and responding to the needs of the age is only possible by raising qualified individuals. Societies that want to raise qualified individuals have turned to rapid changes in the education process. STEM is a radical change movement realized in the field of education in the 21st century (Land, 2013). STEM; It is an educational approach that aims to provide 21st century skills. It provides to solve problems in the most appropriate way by using scientific research methods with interdisciplinary cooperation on engineering design-oriented teaching of knowledge, skills and ideas of Science, technology, engineering and mathematics. (Rogers, & Porstmore, 2004). STEM is an interdisciplinary approach that brings together Science, technology, engineering, and mathematics, traditionally presented separately, and provides learning experiences for students to adapt these disciplines to their lives (Vasquez, Comer, & Sneider, 2013). In the renewed 2018 Science course curriculum, students at national and international level; one of the eight basic competencies they will need in their personal, social, academic and business life is stated as "mathematical competence and basic competencies in Science / technology". The field-specific skills in the Science Program have also been updated as "scientific process skills", "life skills" and "engineering and design skills". In the Science curriculum, it is aimed that students will look at problems from an interdisciplinary perspective by integrating Science with mathematics, technology and engineering (MEB, 2018). STEM is one of the educational approaches that can give students an interdisciplinary perspective and make them the most active in the course. This research is important in terms of determining the misconceptions of 8th grade students about the concepts of "solid, fluid and gas pressure", correcting these misconceptions by using STEM-supported Science activities, and enabling them to develop their attitudes towards Science and STEM and 21st century skills. When the related literature is examined, it is seen that there are increasing numbers of studies on STEM studies (Özcan, & Koca, 2019; Gazibeyoğlu, 2018; Karcı, 2018; Dedetürk, 2018; Aygen, 2018; Doğanay, 2018; Yıldırım, & Selvi, 2017; Ceylan, & Özdilek, 2015; Barcelona, 2014). However, it is thought that this study will contribute to the literature due to the very limited number of studies using STEM activities to identify and eliminate misconceptions. In addition, the structure of the subject of pressure that can be easily associated with Science, technology, engineering and mathematics disciplines, the difficulties experienced by the students in learning the pressure subject have been effective in choosing the subject area of pressure in this study (Akgün, Tokur, & Özkara, 2013; Goszewski, Moyer, Bazan, & Wagner, 2013; Muliyani, & Kaniawati, 2015; Pathare, & Pradhan, 2011; Ünal, 2005; Wijaya, & Muhardjito, 2016). In this context, in this study, it is aimed to determine the misconceptions of 8th grade students about the concepts of "solid, fluid and gas pressure", to correct these misconceptions by using STEM supported Science activities, and to improve their attitudes towards Science and STEM.

According to the main purpose of the research, the problem statement whose answer is sought in the research is: ***What is the effect of STEM supported Science teaching on eighth grade students' misconceptions about "solid, fluid and gas pressure" concepts and their attitudes towards Science and STEM?***

The following sub-research questions were determined based on the main research question above.

1. What are the misconceptions of the students about the concepts of solid, fluid and gas pressure?
2. What is the effect of STEM supported through Science activities on overcoming misconceptions?
3. Is there a significant difference between the attitude of students towards Science pretest and posttest averages?
4. Is there a significant difference between the attitude of students towards STEM pretest and posttest averages?

2. Method

2.1. Research Model

In this study, the pretest-posttest single group model was used which is suitable for a quasi-experimental method. According to Arıkan, experimental method is measuring, weighing, counting, seeing, smelling, etc., without any processing of the material that is divided into groups or available in a single group to record the information provided by the means or to conduct trials by processing the same material (Arıkan, 2000: 69). The misconceptions of the students who participated in the study about solid, fluid and gas pressure within the scope of the "Pressure" unit, their attitudes towards Science and STEM were examined at the beginning and end of the learning process. Pre and post-test single group experimental design was used in the research. However, a study was conducted with two experimental groups in order to increase the reliability of the research. The pretest-posttest single group experimental design model used in the research is shown in Table 1.

Table1. *The pretest-posttest single group experimental design model used in the research*

Studying groups	Pre test	Method	Post test
E1	P1	X1	Po1
E2	P1	X1	Po1

E1: First experimental group
E2: Second experimental group
P1: Pre-test measurements of experimental groups
X1: Independent variable observed to have an effect on experimental groups
Po1: Post-test measurements of experimental groups

According to Table 1, the independent variable that has an effect on the learning outcomes of the students participating in the study in the experimental groups is STEM supported education.

2.2. Studying group

The study group of the research was determined using the appropriate sampling method, one of the non-probabilistic sampling methods. In the appropriate sampling, the researchers select the participants among individuals who are easy to reach, suitable for research, and volunteers (Gravetter, & Forzano, 2012). The study group of the research consisted of 46 students studying in the 8th grade in the central province of Ankara in the fall semester of the 2018-2019 academic years. The students participating in the study consist of twenty-two girls and twenty-four boys. The descriptive statistics results regarding the students in the study group are included in Table 2.

Table 2. *Descriptive statistics results regarding the students in the study group*

	Gender					
Group	**Male**		**Female**		**TOTAL**	
	N	%	N	%	N	%
Experimental 1	10	45,4	12	54,6	22	52,3
Experimental 2	12	50	12	50	24	47,7
TOTAL	22	47,8	24	52,2	46	100

When Table 2 is examined, the students participating in the study are 47,8 % female and 52,2 % male students.

2.3. Data Collection Tools

The data of the study were obtained by three separate data collection tools. These are: "Pressure Conceptual Understanding Test", "Attitude Scale towards Science" and "Attitude Scale towards STEM".

2.3.1. Pressure Conceptual Understanding Test

The "Pressure Conceptual Understanding Test" consisting of ten open-ended questions was used in order to determine students' misconceptions about the concepts of "solid, fluid and gas pressure". This test was developed by the researcher by examining the 2013 Science course curriculum, textbooks and related literature. The "Pressure Conceptual Understanding Test" has a two-stage structure consisting of multiple choice and explanatory sections. Therefore, in the first stage, students were asked to answer the multiple choice question. In the second stage, students were expected to make a statement about their answers. Their answers to the multiple choice test were evaluated together with the explanations of the question. The opinions of two experts in the field of Science education were taken for the content validity of the test. For the reliability studies, a pilot application was carried out before the actual implementation. The pilot application was carried out with 106 students who were continuing their education in the 8th grade. The data of the pilot study were coded by two researchers and the consistency coefficient was found to be ,87. According to the coding control, which gives internal consistency, the consensus between coders is expected to be at least 80% (Miles and Huberman, 1994; Patton, 2002). Therefore, it can be said that the test is reliable. The conceptual understanding test consists of ten open-ended questions and is organized with enough space for explanations under each question.

2.3.2. Attitude Scale towards Science

Attitude Scale towards Science was used to measure students' attitudes towards Science. The scale indicates a total of 30 judgments with 17 negative and 13 positive statements in five-point Likert type. Each judgment is numbered from 1 to 5, from the negative attitude to their positive attitude of the students towards Science. The applied attitude scale was evaluated 150 points. The Attitude Scale towards Science was developed by Benli (2010). The internal consistency coefficient of the scale was also determined in the study. The reliability coefficient was found as $\alpha = .91$. Considering the reliability coefficient, it was decided that the measuring tool had sufficient reliability since this value was well over .70 and it was used to collect data (Büyüköztürk, 2011).

2.3.3. Attitude Scale towards STEM

In order to measure students' attitudes towards STEM was applied "Attitude Scale towards STEM" developed by Lin and Williams in 2016 and adapted into Turkish by Hacıömeroğlu and Bulut. The scale consists of a five-point Likert-type Science, Mathematics, Engineering and 21st Century Skills departments with 4 negative and 33 positive statements and a total of 37 items. (Hacıömeroğlu, & Bulut, 2016). The internal consistency coefficient of the scale was also determined in the study. The reliability coefficient was found as $\alpha = .89$.

2.4. Data Collection Process

The study was conducted with 46 students studying in the eighth grade in a state secondary school in the central district of Ankara in the Fall Semester of the 2018-2019 Academic Year. In order to increase the reliability of the study, it was studied with two experimental groups. In the study, the working group was determined by using the appropriate sampling method, one of the non-probabilistic sampling methods. In order to increase the reliability of the study, it was studied with two experimental groups. The study group of the research was determined using the appropriate sampling method, one of the non-probabilistic sampling methods.

Information on the learning process is specified in Table 3.

Table 3. Learning process

Groups	Pre test	Learning process	Time	Post test
Experimental Group 1	"Pressure" Conceptual Understanding Test, Attitude Scale towards Science and Attitude Scale towards STEM	STEM Supported Science Teaching Activities: • My footprint • The tipper of my toy truck • Basketball hoop according to my height • Climbing the mountain • Pressure cooker	10 Course Hours	"Pressure" Conceptual Understanding Test, Attitude Scale towards Science and Attitude Scale towards STEM
Experimental Group 2	"Pressure" Conceptual Understanding Test, Attitude Scale towards Science and Attitude Scale towards STEM	STEM Supported Science Teaching Activities: • My footprint • The tipper of my toy truck • Basketball hoop according to my height • Climbing the mountain • Pressure cooker	10 Course Hours	"Pressure" Conceptual Understanding Test, Attitude Scale towards Science and Attitude Scale towards STEM

Before the learning process, Pressure Conceptual Understanding Test "," Attitude Scale towards Science" and "Attitude Scale towards STEM" were applied as pre-tests to the students of both experimental groups. Subsequently, the subject was completed in 10 lesson hours with STEM supported teaching activities. After the learning process, "Pressure Conceptual Understanding Test", "Attitude Scale towards Science" and "Attitude Scale towards STEM" were applied again as a post test.

Figure 1. Images from the implementation process

2.5. Data Analysis

The data of the "Attitude Scale towards Science" used to measure the students' attitudes towards Science and the "Attitude Scale towards STEM" used to measure their attitudes towards STEM were obtained by Statistical Package for the Social Sciences (SPSS) statistical package program. Dependent groups' t-test analysis was performed in order to compare the pre-test and post-test scores of the study group from the attitude scale. "Pressure Conceptual Understanding Test", which is used to determine students' misconceptions about "Solid, Fluid and Gas Pressure" concepts, has a two-stage structure consisting of multiple choice and explanatory sections. Therefore, in the first stage, pre and post test scores of the conceptual achievement test were analyzed using the SPSS statistical package program. In the second stage, the answers given by the students to the multiple choice test were evaluated together with the explanations of the question. In this part, the method of classification according to the level of understanding is used. In the relevant literature, in the analysis of open-ended questions, it is seen that the answers given are divided into four classes as "Full Comprehension (FC), Partial Comprehension (PC), Misconception / Alternative Thinking (AT) and Not Understanding / Missing (M)" (Marek, 1986; Ayas, 1995; Akdeniz, Bektaş, & Yiğit, 2000; Ürek, & Tarhan, 2005). In this study, the comprehension level of each answer was determined by combining the answers given to the multiple choice questions with the explanations of the students. The comprehension levels of the students' answers are given in Table 4 below.

Table 4. *Understanding levels of students related to their conceptual achievement test answers*

Comprehension Levels	Answer Given to a Multiple Choice Question	Open-Ended Explanation of the Problem
Full Comprehension (FC)	True	Answers that provide the intended purpose of achievement using most or all of the available information.
Partial Comprehension (PC)	True	Answers that are at an acceptable level but do not fully meet the purpose of the question.
Misconception / Alternative Thinking (AT)	False	Answers that are scientifically incorrect those provide an alternative to scientific knowledge.
Unanswered / Blank (B)	False/ Unanswered	Answers like don't leave blank, don't know.

The frequency and percentage values of students' comprehension levels and sample student expressions are given in the data analysis section.

3. Findings

In the study, three sub-research questions were investigated that: Misconceptions about the concepts of "Solid, Fluid and Gas Pressure", the effect of STEM-supported Science teaching on their attitude levels towards Science and STEM of middle school 8th grade students.

3.1. Findings and Comments on Misconceptions

In the first sub-problem of the study, the misconceptions of middle school eighth grade students about the concepts of "Solid, Fluid and Gas Pressure"; in the second sub-problem, the effect of STEM-supported Science teaching on overcoming misconceptions was examined. Findings and comments on both sub-research questions are presented together.

3.1.1. Findings and Comments on "Solid, Fluid and Gas Pressure" Concepts

The results of the t-test analysis for the related samples made to determine whether there is a significant difference regarding the answers given by the students to the questions about the concepts of "Solid, Fluid and Gas Pressure" before and after the application are given in Table 5.

Table 5. Dependent samples t-test results of the students' mean of "Solid, Fluid and Gas Pressure" concepts pretest-posttest mean scores

Pressure	**N**	$\overline{X}$	**SD**	**df**	**t**	**p**	η^2
Pre test	46	4,37	1,35	45	-11,03	,00	,72
Post test	46	7,70	1,99				

When Table 5 is examined, it is seen that there is a significant difference in favor of the posttest between the students' concepts of "Solid, Fluid and Gas Pressure" pre-test and post-test mean scores ($t_{45} = -11,03$, $p = 0.00 < 0.05$). The students' posttest average score ($\overline{X} = 7,70$) is higher than the pretest average score ($\overline{X} = 4,37$). The students showed a significant improvement after the application. The effect size of STEM supported Science education is wide in the posttest mean scores of the students' concepts of "Solid, Fluid and Gas Pressure" ($\eta^2 = ,72$). It is possible to say that STEM supported Science teaching has a great effect on the formation of this significant difference among students. Eta square (η^2) size value, on the basis of Cohen (1988: 44) classification, eta square cut-off values are classified as 0.01 small effect, 0.06 medium effect and 0.14 large effect (Cohen, 1988).

3.1.2. Findings and Comments on the Concept of "Pressure"

The distribution of the students' answers to the questions about the concept of "Pressure" before and after the application is given in Table 6.

Table 6. Pre-test-post-test frequency table according to students' level of understanding regarding the concept of "pressure"

Key Concept		***Full Comprehension***		***Partial Comprehension***		***Misconception***		***Unanswered / Blank***	
		f	*%*	*f*	*%*	*f*	*%*	*f*	*%*
Pressure (S.1)	***Pretest***	*3*	*6,52*	*4*	*8,69*	*31*	*67,39*	*9*	*19,56*
	Posttest	*32*	*69,56*	*7*	*15,21*	*6*	*13,04*	*1*	*2,17*
Pressure (S.2)	***Pretest***	*3*	*6,52*	*5*	*10,86*	*26*	*56,52*	*12*	*26,0*
	Posttest	*35*	*76,08*	*5*	*10,86*	*4*	*8,69*	*2*	*4,34*

When Table 6 is examined, it is seen that there is a very high rate of “misconception” in the pre-tests in the first and second questions directed to the students about the definition of pressure. After the experimental learning process, there is a significant decrease in the level of "misconception" compared to the pretest. However, alternative concepts (misconception) could not be corrected in all students. In the pre-test, students generally stated that the power obtained when the pressure is hit, the sound, violence, pressure, etc. sees as.

The misconceptions that students have about pressure:

- Pressure and power are the same concepts.
- Pressure is the sound an object makes when it falls to the ground.
- Pressure is the pressure that objects apply to the ground.

- Pressure occurs on hard surfaces as a result of printing.

The quotations of the students who have alternative concepts in the pretest before and after the learning can be expressed as follows:

S2-Pretest: I think I have heard the concept of pressure before. It is the sound made due to the pressure when hit a place.

S2-Posttest: Pressure is the perpendicular force acting on a surface.

S41-Pretest: The stronger we are, the more pressure we apply.

S41-Posttest: The size of the pressure is determined by the force applied and the area of the surface.

3.1.3. Findings and Comments on the Concept of "Solid Pressure"

The distribution of the students' answers to the questions about the concept of "Solid Pressure" before and after the application is given in Table 7.

Table 7. Pre-test-post-test frequency table according to students' level of understanding regarding the concept of "solid pressure"

Key Concept		**Full Comprehension**		**Partial Comprehension**		**Misconception**		**Unanswered/ Blank**	
		f	%	f	%	f	%	f	%
Solid Pressure -Weight Relationship	**Pretest**	5	10,86	17	36,95	16	34,78	8	17,39
	Posttest	39	84,7	4	8,69	2	4,34	1	2,17
Solid Pressure - Surface Area Relationship	**Pretest**	2	4,34	5	10,86	25	54,34	14	30,43
	Posttest	36	78,26	7	15,21	2	4,34	1	2,17

When Table 7 is examined, it draws attention that 47,81 % of the students were able to establish the solid pressure-weight relationship in pretests. When the explanations of the students are examined, it is seen that they can explain that the object with more weight will sink more. However, it is revealed that 54,34 % of the students have misconceptions in the relationship between solid pressure - surface area. Misconceptions students have about solid pressure:

- The pressure of solids is only related to weight.
- The pressure of solids depends on their shape, the bigger the shape, the bigger the pressure.
- The pressure of solids, regardless of weight, is inversely proportional to the floor area touching the ground
- The pressure of solids is least when the weight is high and the base area is small.
- The pressure of solids decreases when both weight and floor area is large.
- Pressure increases as the surface area in contact with the ground increases in solids.
- In solids, the number of surfaces in contact with the ground is equal to the pressure.

After STEM-supported Science teaching, students' misconceptions were greatly reduced, and they correctly expressed the reasons for the questions. The quotations of the students who have alternative concepts in the pretest before and after the learning can be expressed as follows:

S21-Pretest: The weights of solid objects determine the pressure they will apply.

S21-Posttest: The pressures of solid bodies depend on the force they apply, namely their weight and surface area.

S33-Pretest: If the areas where the solids touch the ground are large, the pressure is also high.

S33-Posttest: Pressure of solids is proportional to their weight and surface area.

3.1.4. Findings and Comments on the Concept of "Fluid Pressure"

The distribution of the students' answers to the questions about the concept of "Fluid Pressure" before and after the application is given in Table 8.

Table 8. Pre-test-post-test frequency table according to students' level of understanding regarding the concept of "fluid pressure"

Key Concept		***Full Comprehension***		***Partial Comprehension***		***Misconception***		***Unanswered / Blank***	
		f	*%*	*f*	*%*	*f*	*%*	*f*	*%*
Fluid Pressure - Density Relationship	***Pretest***	*0*	*0*	*5*	*10,86*	*35*	*76,08*	*6*	*13,04*
	Posttest	*30*	*65,21*	*3*	*3,48*	*9*	*19,56*	*3*	*6,52*
Fluid Pressure - Depth Relationship	***Pretest***	*1*	*2,17*	*9*	*19,56*	*25*	*54,34*	*11*	*23,91*
	Posttest	*36*	*78,26*	*6*	*13,04*	*3*	*3,48*	*2*	*4,34*
Fluid Pressure - Container Shape Relationship	***Pretest***	*1*	*2,17*	*4*	*8,69*	*36*	*78,26*	*5*	*10,86*
	Posttest	*39*	*84,78*	*3*	*3,48*	*3*	*3,48*	*1*	*2,17*

When Table 8 is examined, it is attention that the students had high levels of misconceptions about fluid pressure before learning. When the explanations of the students are examined, it is seen that they cannot establish a relationship between fluid pressure and density and depth. They generally associated the pressure of liquids with the amount of fluid and the shape of the container in which they were placed. Misconceptions students have about fluid pressure:

- The pressure of fluids depends on their rapid flow.
- The fluid pressure does not depend on the type of fluid; it is the amount that matters.
- The pressure of fluids depends on the amount of fluid.
- The pressure of the fluids depends on the shape of the container in which they are placed.
- Pressure of fluids is proportional to floor area.

After STEM-supported Science education, it is seen that most of the students' misconceptions about the concept of fluid pressure are replaced by full understanding. However, it was noticed that 19.56% of the students had misconceptions in the fluid pressure-density relationship after the application. The quotations of the students who have alternative concepts in the pretest before and after the application can be expressed as follows:

S5-Pretest: The pressure to be applied by the liquid with a high amount is also high.

S5-Posttest: The amount of liquid does not determine the pressure. This is just to mislead us ...

S45-Pretest: The pressure of the liquid placed in a large container is also high.

S45-Posttest: Liquid pressure does not depend on the shape of the container. But we have to look at the density and depth of the liquid.

3.1.5. Findings and Comments on the Concept of "Gas Pressure"

The distribution of the students' answers to the questions about the concept of "Gas Pressure" before and after the application is given in Table 9.

Table 9. *Pre-test-post-test frequency table according to students' level of understanding regarding the concept of "gas pressure"*

Key Concept		***Full Comprehension***		***Partial Comprehension***		***Misconception***		***Unanswered / Blank***	
		f	***%***	***f***	***%***	***f***	***%***	***f***	***%***
Gas Pressure - Volume Relationship	***Pretest***	*1*	*2,17*	*4*	*8,69*	*30*	*65,21*	*11*	*23,91*
	Posttest	*37*	*80,43*	*3*	*6,52*	*4*	*8,69*	*2*	*4,34*
Gas Pressure - Temperature Relationship	***Pretest***	*2*	*4,34*	*8*	*17,39*	*26*	*56,52*	*10*	*21,73*
	Posttest	*36*	*78,26*	*6*	*13,04*	*2*	*4,34*	*2*	*4,34*
Open Air Pressure	***Pretest***	*3*	*6,52*	*4*	*8,69*	*33*	*71,73*	*6*	*78,26*
	Posttest	*38*	*82,60*	*3*	*6,52*	*4*	*6,52*	*1*	*2,17*

When Table 9 is examined, it is noteworthy that the students had a high rate of misconceptions about gas pressure before the application. When the explanations of the students are examined, it is seen that generally there is no gas pressure and they cannot establish a relationship between "gas pressure" and "volume and temperature". The misconceptions students have about gas pressure:

- Gases do not exert pressure because they do not stay in place.
- There is no pressure in closed containers.
- If a substance is put into the container, it will start to pressure.
- Open air pressure increases as the weight of the air increases as you climb higher.
- Air does not apply pressure.
- Cold air pressure is higher than warm air. (If the air temperature increases, the open air pressure decreases.)
- As the wind, the pressure of the air increases.

After STEM-supported Science education, it is seen that the misconceptions of most of the students about the concept of gas pressure are replaced by full or partial understanding. The quotations of the students, who have an alternative concept in the pretest, before and after learning, can be expressed as follows:

S9-Pretest: Gas substances do not have pressure, even if it does, we cannot see it.

S9-Posttest: Gases have a pressure just like solids and liquids.

S27-Pretest: Cold air hits our face very hard, because it makes too much pressure.

S27-Posttest: Whether the air is hot or cold is not related to the pressure applied.

3.2. Findings and Comments on Attitude towards Science

In the third sub-problem of the study, it was examined whether the pre-test and post-test averages of middle school 8th grade students' attitude towards Science differed. In Table 10, related samples t-test results regarding the attitude towards Science are given and these results are interpreted.

Table 10. Dependent samples t-test results according to the mean of students' attitude levels towards Science

Group	N	$\bar{\chi}$	SD	df	t	p
Pretest	46	122,15	9,73	8,19	-,55	,58
Posttest	46	122,83	11,12			

When Table 10 is examined, there is no significant difference between the attitudes towards Science of the students in the study group, pre-test and post-test scores ($t_{(46)}$ = -, 55, p > 0.05). The students' posttest scores ($\bar{\chi}$ = 122,83) are approximately the same as their pretest scores $\bar{\chi}$ (= 122,15). STEM-supported Science education has no effect on students' attitudes towards Science. Considering the pre-test scores of the students in the study group, it is seen that their attitude level towards Science is quite positive. It is noteworthy that these students with high attitude levels continued their positive attitude towards Science after the application.

3.3. Findings and Comments Regarding the Attitude towards STEM

In the fourth sub-problem of the study, it was examined whether the average of middle school 8th grade students' attitude pre-test towards STEM and post-test mean difference. In Table 11, related samples t-test results regarding attitude levels towards STEM are given and these results are interpreted.

Table 11. *Dependent samples t-test results according to the mean of students' attitude levels* towards STEM

Group	N	$\bar{X}$	SD	df	t	p	η^2
Pre test	46	74,24	10,78	7,98	-16,28	,00	,85
Post test	46	100,13		10,48			

When Table 11 is examined, the attitudes towards STEM of the students in the study group difference significantly in their pre-test and post-test scores (t (46) = -16.28, $p < 0.05$, η2 = 0.92). Post-test scores of the students ($\bar{X}$ = 100,13) are higher than their pre-test scores ($\bar{X}$ = 74,24). On the other hand, in order to determine the effect size of STEM supported

Science teaching on attitude towards STEM, eta square (η2) value was examined. The eta-square value calculated for the STEM attitude was found to be 85. Although the eta-square value shows that 85% of the students' attitudes towards STEM change due to STEM supported Science teaching, the teaching method has a high effect on the attitude towards STEM. It is possible to say that STEM supported Science teaching has a great effect on the formation of this significant difference among students. Eta square (η2) size value, on the basis of Cohen (1988: 44) classification, eta square cut-off values are classified as 0.01 small effect, 0.06 medium effect and 0.14 large effect (Cohen, 1988).

4. Discussion and Conclusion

It has been determined that secondary school 8th grade students have misconceptions about "Solid, Liquid and Gas Pressure" and these misconceptions are generally caused by their use in daily life. It has been revealed that the STEM supported Science activities, which are used to overcome the detected misconceptions, largely overcome the misconceptions existing in students and can transfer them to daily life correctly. In the study conducted by Yaman (2016), it was observed that 8^{th} grade students had misconceptions about pressure and that rigid pressure misconceptions were more easily eliminated especially after the teaching process. In addition, Schnittka, & Bell (2011) observed in their study that engineering design classroom activities were effective on middle school students' conceptual understanding of heat conversion and thermal energy.

In the first stage of the conceptual understanding test applied to measure students' misconceptions about the concepts of "Solid, Liquid and Gas Pressure", it was observed that there was a significant difference in favor of the posttest between the pre-test and post-test mean scores of the students. The subject of "Pressure" was taught with STEM supported Science activities for 10 class hours. It was revealed in the posttest that the students achieved a significant level of success after the application. The calculated Eta squared (η2) size value also showed that STEM supported Science teaching had a great effect on the formation of this significant difference in students.

When the answers given by the students before learning about the concept of "Pressure" were analyzed, it was found that 67,39 % in the first question and 56,52 % in the second question had misconceptions. The misconceptions that students have about "Pressure" before learning are as follows: "Pressure and power are the same concepts.", "Pressure is the sound of an object when it falls to the ground.", "Pressure is the pressure that objects apply to the ground." pressure builds up on surfaces. “After the learning process was completed with STEM supported Science activities, it was observed that students' misconceptions about the concept of "Pressure" decreased significantly. While this ratio decreased to 13,04 % in the first question, it was 8,69 % in the second question.

Students' misconceptions about the concept of "Solid Pressure" were examined in two separate questions as "Solid Pressure - Weight Relationship" and "Solid Pressure - Surface Area Relations". When the answers given before the learning were analyzed, it was noticed that 47,81 % of the students could establish the "Solid Pressure - Weight" relationship in the pretests. Although 36,95 % of these students could not make a full explanation, they stated that the heavier objects could apply more pressure. However, the students reached this inference by comparing weight regardless of surface area. It has been revealed that 54,34 % of the students have misconceptions in the "Solid Pressure - Surface Area" relationship. It is noteworthy that they focus on the size of objects rather than surface area. The misconceptions that students have about solid pressure are as follows: "The pressure of solids is only related to weight." It is inversely proportional.", "Pressure of solids decreases when weight is high and base area is small","Pressure of solids decreases when both weight and floor area are large." "The number of surfaces in contact with the ground in solids is equal to the pressure." After completing the application process with STEM supported Science activities, it was revealed that the students were able to establish "Solid Pressure - Weight" and "Solid Pressure - Surface Area" relations correctly and only 4,34 % of them had misconceptions. When the related literature is examined, Gazibeyoğlu (2018), Karcı (2018), Dedetürk, (2018), Aygen, (2018), Doğanay, (2018), Yıldırım, & Selvi (2017), Ceylan, & Özdilek (2015), Barcelona (2014) revealed that the academic achievement of the experimental group students in which STEM-supported courses were taught improved positively.

The misconceptions that students have about the concept of "Fluid Pressure" were examined in three separate questions as "Fluid Pressure-Density Relationship", "Fluid Pressure-Depth Relationship" and "Fluid Pressure - Cup Shape Relationship". When the answers given before the learning were analyzed, it was noted that the students could not establish the "Fluid Pressure-Density Relationship" and that 76,08 % had misconceptions about it. They often associated the pressure of liquids with the amount of liquid and the shape of the container in which it was placed. They stated that as the amount of liquid increases, the pressure it will apply will also increase. The misconceptions that students have about fluid pressure are as follows: "The pressure of liquids depends on their rapid flow", "The fluid pressure does not depend on the type of the fluid, and it is the amount that matters.", "The pressure of liquids depends on the amount of fluid." depends on the shape of the container in which they are placed. "," The pressure of liquids is proportional to the floor area. "It is seen that after the implementation process with STEM supported Science activities is completed, most of the students leave their misconceptions to fully understand. However, it was pointed out that 19,56 % of the students had misconceptions in the fluid pressure-density relationship after learning.

The misconceptions that students have about the concept of "Gas Pressure" were examined in three separate questions as "Gas Pressure-Volume Relationship", "Gas Pressure-Temperature Relationship" and "Open Air Pressure". When the answers given before the application were analyzed, it was seen that most of the students did not have gas pressure, had misconceptions in the relationship between "gas pressure" and "volume and temperature" or left the question unanswered. The misconceptions that students have about gas pressure in closed containers are as follows: "There is no pressure in closed containers.", "If a substance is put in the container, it starts to pressurize.", "Gases do not apply pressure because they do not stay in place." The misconceptions that students have about open air pressure are as follows: "As the weight of the air increases, the open air pressure increases.", "Air does not apply pressure.", "The pressure of cold air is higher than that of hot air. (If the air temperature increases, the open air pressure decreases.)", "As the wind increases, the pressure of the air increases. "After STEM-supported Science education, it is seen that the misconceptions of most of the students about the concept of gas pressure have been replaced by full or partial understanding.

Another striking result of the study is that there was no significant difference between the students' attitude levels towards Science and their pre-test and post-test scores. STEM-supported Science education has no effect on students' attitudes towards Science. When the scores of the students are examined, the students' posttest scores ($\overline{X}$ = 122,83) are approximately the same as their pretest scores ($\overline{X}$ = 122,15). It was noticed that the students whose attitude levels towards Science were high before the application continued their positive attitude towards Science after the application. When the relevant literature was examined, in the study conducted by Karcı (2018), STEM-supported Science education had no effect on students' attitudes towards Science. In another study, Wendell, & Rogers (2013) stated in their study that engineering design-based activities revealed a low level difference between students' pretest - posttest Science attitude scores.

When the attitude levels of students towards STEM are examined, their pre-test and post-test scores differ significantly. Students' post-test scores ($\overline{X}$ = 100,13) are higher than their pre-test scores ($\overline{X}$ = 74,24). The eta square (η^2) value calculated to determine the effect size of STEM supported Science teaching on the attitude towards STEM also revealed that this method has a wide effect. When the relevant literature was examined, it was seen in the studies conducted by Pekbay (2017), Gülhan, & Şahin (2016) that STEM supported Science education provided a positive improvement in the attitudes of students towards STEM.

5. Suggestions

The following suggestions can be made considering the results obtained in the research conducted in order to prevent and eliminate misconceptions about the concepts of "Solid, Liquid and Gas Pressure" in STEM supported Science education:

Courses should be supported with multiple learning environments in a way that students can improve their STEM skills and appeal to more skills. Especially in difficult to reach, abstract and complex subjects, educators should ensure that the subject is taught with STEM supported Science activities. This research was conducted with 8th grade students using STEM supported activities. In this context, it can be suggested to create different learning environments at various grade levels, with different units, considering that it will contribute to the literature to eliminate misconceptions.

References

Akdeniz, A.R., Bektaş, U., & Yiğit, N. (2000). İlköğretim 8. sınıf öğrencilerinin temel fizik kavramlarını anlama düzeyi. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 19,* 5-14.

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

Ayas, A. (1995). *Lise I kimya öğrencilerinin maddenin tanecikli yapısı kavramını anlama seviyelerine ilişkin bir çalışma.* II. Ulusal Fen Bilimleri Eğitimi Sempozyumu, ODTÜ, Ankara.

Aygen, M., B. (2018). *Fen bilgisi öğretmen adaylarının bütünleşik öğretmenlik bilgilerinin desteklenmesine yönelik Stem uygulamaları.* Yayınlanmamış Yüksek Lisans Tezi, Fırat Üniversitesi, Eğitim Bilimleri Enstitüsü, Elazığ.

Barcelona, K. (2014). 21st century curriculum change initiative: A focus on STEM education as an ıntegrated approach to teaching and learning. *American Journal of Educational Research, 2* (10), 862-875.

Benli, E. (2010). *Probleme dayalı öğrenmenin fen bilgisi öğretmen adaylarının akademik başarılarına, bilgilerin kalıcılığına ve fene karşı tutumlarına etkilerinin araştırılması.* Yayınlanmamış Yüksek Lisans Tezi, Gazi Üniversitesi, Eğitim Bilimleri Enstitüsü, Ankara.

Büyüköztürk, Ş. (2011). Deneysel desenler (3. baskı). Ankara: Pegem Akademi.

Ceylan, S., & Özdilek, Z. (2015). Improving a samplelesson plan forsecondary Science courseswithin the STEM Education. *Procedia-Socialand Behavioral Sciences, 177,* 223-228.

Cohen, J. (1988). *Statistical power analysis for the behavioral Sciences.* Hillsdale, NJ: Erlbaum.

Dedetürk, A. (2018). *6. sınıf ses konusunda FeTeMM yaklaşımı ile öğretim etkinliklerinin geliştirilmesi, uygulanması ve başarıya etkisinin araştırılması.* Yayınlanmamış Yüksek Lisans Tezi, Erciyes Üniversitesi, Eğitim Bilimleri Enstitüsü, Kayseri.

Doğanay, K. (2018). *Probleme dayalı STEM etkinlikleriyle gerçekleştirilen bilim fuarının ortaokul öğrencilerinin fen bilimleri dersi akademik başarılarına ve fen tutumlarına etkisi.* Yayınlanmamış Yüksek Lisans Tezi, Kastomonu Üniversitesi, Eğitim Bilimleri Enstitüsü, Kastamonu.

Gazibeyoğlu, T. (2018). *STEM uygulamalarının 7. sınıf öğrencilerinin kuvvet ve enerji ünitesindeki başarılarına ve fen bilimleri dersine karşı tutumlarına etkisinin incelenmesi.* Yayınlanmamış Yüksek Lisans Tezi, Kastomonu Üniversitesi, Eğitim Bilimleri Enstitüsü, Kastamonu.

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.

Gravetter, F. J., & Forzano, L. B. (2012). *Research Methods for the Behavioral Sciences* (4th ed.). Belmont, CA: Wadsworth.

Gülhan, F., & Şahin, F. (2016). Fen-teknoloji-mühendislik-matematik entegrasyonunun (STEM) 5. sınıf öğrencilerinin bu alanlarla ilgili algı ve tutumlarına etkisi. *International Journal of Human Science, 13*(1), 602- 620.

Hacıömeroğlu, G., & Bulut, A.S. (2016). Integrative Stem Teaching Intentıon Questionnaire: A Validity And Relaibility Study of the Turkish Form. *Journal of Theory and Practice in Education, 12*(3), 654-669.

Karcı, M. (2018). *STEM etkinliklerine dayalı senaryo tabanlı öğrenme yaklaşımının (STÖY) öğrencilerin akademik başarıları, meslek seçimleri ve motivasyonları üzerine etkisinin incelenmesi.* Yayınlanmamış Yüksek Lisans Tezi, Çukurova Üniversitesi, Eğitim Bilimleri Enstitüsü, Adana.

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

Marek, E. A. (1986). They misunderstand, but they'll pass. *The Science Teacher*. 32-35.

MEB (2018). *Fen bilimleri dersi öğretim programı (İlkokul ve ortaokul 3, 4, 5, 6, 7 ve 8. sınıflar).* Ankara: Milli Eğitim Bakanlığı.

Miles, M. B., & Huberman, A. M. (1994). *An expanded sourcebook qualitative data analysis.* Thousand Oaks, California: Sage Publications.

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), 2,* 716-721.

Özcan, H., & Koca, E. (2019). STEM yaklaşımı ile basınç konusu öğretiminin ortaokul 7. sınıf öğrencilerinin akademik başarılarına ve STEM'e yönelik tutumlarına etkisi. *Eğitim ve Bilim, 198* (44), 201-227.

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

Patton, M. Q. (2002). *Qualitative research and evaluation methods.* Sage Publications: Thousand Oaks.

Pekbay, C. (2017). *Fen, teknoloji, mühendislik ve matematik etkinliklerinin ortaokul öğrencileri üzerindeki etkileri.* Yayınlanmamış Yüksek Lisans Tezi, Hacettepe Üniversitesi, Eğitim Bilimleri Enstitüsü, Ankara.

Rogers, C., & Portsmore, M. (2004). Bringing engineering to elementary school. *Journal of STEM Education, 5*(3), 17-28.

Schnittka, C., & Bell, R. (2011). Engineering design and conceptual change in Science: Add ressing thermal energy andheat transfer in eighth grade. *International Journal of Science Education, 33*(13), 1861-1887.

Ünal, G. (2005). *Fen öğretiminde derinliğine öğrenme: Basınç konusunda modelleme.* Yayınlanmamış Yüksek Lisans Tezi, Dokuz Eylül Üniversitesi, Eğitim Bilimleri Enstitüsü, İzmir.

Ürek, R. Ö., & Tarhan, L. (2005). Kovalent bağlar konusundaki kavram yanılgılarının giderilmesinde yapılandırmacılığa dayalı bir aktif öğrenme uygulaması. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 28,* 168-177.

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

Yaman, E. G. (2016). *Ortaokul 8.sınıf öğrencilerinin basınç konusunda kavramsal anlamalarının incelenmesi.* Yayınlanmamış Yüksek Lisans Tezi, Balıkesir Üniversitesi, Eğitim Bilimleri Enstitüsü, Balıkesir.

Yıldırım, B., & Selvi, M. (2017). STEM uygulamaları ve tam öğrenmenin etkileri üzerine deneysel bir çalışma. *Eğitimde Kuram ve Uygulama, 13*(2), 183-210.

Wendell, K. B., & Rogers, C. (2013). Engineering design-based Science, Science content performance, and Science attitudes in elementary school. *Journal of Engineering Education*, *102*(4), 513-540.

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.

APPENDICES

Appendix 1: *The Learning Outcomes of 8th Grade about "Pressure Unit" in the Field Science, Technology, Engineering and Mathematics*

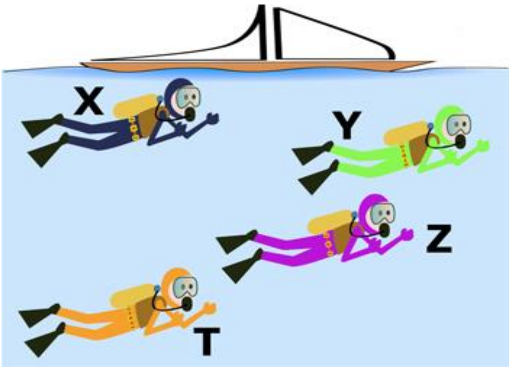
DISCIPLINES	LEARNING OUTCOMES
SCİENCE	F.8.3.1.1. Discover the variables that affect the solid pressure by experimenting. Pascal is given as the unit of pressure. Mathematical relations are not entered. F.8.3.1.2. Predicts variables that affect fluid pressure and tests predictions. a. Gases are stated to exert pressure similarly to liquids. Open air pressure is exemplified. b. Mathematical relations are not entered. c. Variables affecting gas pressure are not entered. F.8.3.1.3. It gives examples of the applications of pressure properties of solids, liquids and gases in daily life and technology. a. Examples of applications of Pascal's principle related to fluid pressure are given. b. Emphasis is placed on principles and principles as a type of scientific knowledge.
TECHNOLOGY	TT. 7. B. 1. 1. Tells that the design process is a process of defining a problem and proposing a solution. TT. 7. B. 1. 2. Expresses a problem, need or dream that can be realized in daily life as a "design problem". TT. 8. C. 3. 1. Express the relationship between engineering and design. TT. 8. C. 3. 4. Designs a product using the engineering design process.
ENGINEERING	K1.Detects the processes involved in an engineering project: explains the stages such as planning, design, prototyping, execution, quality control and reporting. K2.The student sees himself / herself as a team member in different roles in the project work and successfully completes the work required for that role. K3. He explains his thoughts on the solution proposal by writing and drawing. K4. Takes into account the opinions of others about the solution proposal.
MATH	M.7.1.4.3. Decides whether the two multiples are proportional by examining real life situations. M.7.1.4.4. Expresses the relationship between two directly proportional multiplicities. M.7.1.4.5. Determines and interprets the proportion constant of two directly proportional multiplicities. M.7.1.4.6. Decides whether the two multiples are inversely proportional by examining real life situations. M.7.1.4.7. Solves problems related to direct and inverse proportion.

Appendix 2: *Activity: Basketball hoop according to my height*

A Sample Lesson Plan by STEM Teaching Module on the Subject "Pressure" in 8th Grade

Lesson	Science
Grade	8th
Suggested time	40+40 minutes
Unit	Pressure
Subject	Liquid Pressure
Science	➢ **Learning Outcomes from Science** F.8.3.1.3. It gives examples of the applications of pressure properties of solids, liquids and gases in daily life and technology. a. Examples of applications of Pascal's principle related to fluid pressure are given.
Technology	➢ **Learning Outcomes from Technology** TT. 7. B. 1. 1. Tells that the design process is a process of defining a problem and proposing a solution. TT. 7. B. 1. 2. Expresses a problem, need or dream that can be realized in daily life as a "design problem".
Engineering	➢ **Learning Outcomes from Engineering** K1.Detects the processes involved in an engineering project: explains the stages such as planning, design, prototyping, execution, quality control and reporting. K2.The student sees himself / herself as a team member in different roles in the project work and successfully completes the work required for that role.
Math	➢ **Learning Outcomes from Math** M.7.1.4.3. Decides whether the two multiples are proportional by examining real life situations.
Concepts	Pressure, Liquid Pressure
Training Technologies	Smart Board, Animation
Tools, Instruments and Materials	Syringe, plastic tube, wood, cardboard, utility knife, ruler, glue, cardboard cup.
Learning Process	
Knowledge-Based Life Problem (KBLP)	**Problem:** Ahmet who is 1st grade student in the primary school. He and his friends went to the field in the park next to their house. They wanted to play basketball together. But they saw that the basketball hoop was too long and they were upset. Ahmet says, "I wish this basketball hoop was for our height." His friend Mehmet objected, saying "then adults could not play". How can you find a solution to this problem of Ahmet and Mehmet?

Appendix 3: *Sample questions from "Pressure Conceptual Understanding Test"*



1. X, Y, Z and T divers set out to dive. Since each dives at a different depth, which of the following is the relationship between the fluid pressures acting on X, Y, Z and T divers?

A) X = Y = Z = T

B) T > Z > Y > X

C) X > Y > Z > T

D) T > Z > Y = X

Explain the reason for your answer.

2. What happens if one of the two tractors working in the field is fitted with a thin iron wheel, like a horse cart, and a thick wheel on the second?

A) Slim wheel tractor runs faster.

B) Thick wheeled tractor runs faster.

C) The thin wheeled tractor is buried in the ground.

D) There is no change in tractors.

Explain the reason for your answer.

Appendix 4: *Sample questions from "Attitude Scales towards Science"*

Attitude towards Science	***Strongly Agree***	***Agree***	***indecisive***	***Disagree***	***Strongly Disagree***
1. I like Science subjects.					
9. Science is not required to explain natural events.					
16. I learn the subjects I am curious about with Science studies.					
27. Everything related to Science attracts my attention.					
30. Studying Science increases my creativity.					

Appendix 5: *Sample questions from "Attitude Scales towards STEM"*

	Attitude towards STEM	***Strongly Agree***	***Agree***	***indecisive***	***Disagree***	***Strongly Disagree***
MATH	1. Mathematics is my worst subject.					
	8. I am good at math.					
SCİENCE	2. I can think of a career in Science.					
	9. I am sure that I can do advanced studies in Science.					
ENGİNEERİNG	6. I am curious about how electronic devices work.					
	7. I would like to use creativity and innovation in their future work.					
21ST CENTURY SKILLS	7. I'm sure I can make changes when things don't go as planned.					
	10. When I have tasks to do, I can choose which ones should be done first.					