The Effects of STEM-Based Alternative Energy Activities on STEM Teaching Intention and Attitude

Dr.Emrah Hiğde
Aydın Adnan Menderes University - Turkey
ORCID: 0000-0002-4692-5119
emrah.higde@adu.edu.tr

Abstract

The aim of this study was to determine the effects of STEM-based alternative energy activities on integrative STEM teaching intention and attitude of pre-service science teachers towards STEM. Some examples of daily life problems were given to participants to design STEM projects about the theme of alternative energy sources during the whole semester. Participants worked in groups of four while designing STEM products. In the research, one-group pre-test and post-test experimental design, which is one of the quantitative research methods, was utilized. The study group was composed of 29 female and 11 male pre-service science teachers studying at the science education department. Integrative STEM teaching intention questionnaire and attitude towards STEM scale were used to collect data. As a result of the research, integrative STEM teaching intention and attitude towards STEM have significantly increased compared to the pre-implementation. There were significant differences between the pre- and post-tests' participants scores of knowledge, value, attitude, perceived behavioral control and behavioral intention, subjective norm subscales of integrative STEM teaching intention. There were significant differences between the pre- and post-tests scores for science, mathematics, engineering and technology and 21th century skills sub-scales of attitude towards STEM. The effect size for all subscales of integrative STEM teaching intention was large except for subjective norm according to Cohen (1988). The effect size was large for science, was small for math, and was medium for engineering and technology and 21th century skills subscales of attitude towards STEM. The majority of pre-service science teachers made designs about alternative energy resources, such as hydroelectric energy, solar energy and wind energy, while a small number of preservice science teachers designed STEM products about biomass energy and energy generation by vibration (piezoelectric). Findings suggested that STEM-based alternative energy activities can be implemented to improve pre-service science teachers' integrative STEM teaching intention and attitude of pre-service science teachers towards STEM.

Keywords: *Alternative energy, Attitudes, STEM, Teaching intentions.*

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INTRODUCTION

During the recent years, rapid changes in technology, science and economy have led governments and societies to search for new education in terms of education and an educational approach that can raise people who can cover the needs and expectations of the 21st century. Countries did not want to be left behind in both scientific developments and technological advances and in the economic race (Aydeniz, 2017). Therefore, they have turned to interdisciplinary education by giving importance to science, mathematics, technology and engineering education. At this point, they came across STEM education (Science, Technology, Engineering and Mathematics), which presents science, mathematics, technology and engineering education together and whose abbreviated name consists of the initials of these disciplines (Bybee, 2013).

STEM education should be planned with a perspective that develops students' capacity to use technology, increases their engineering and design skills, and solves problems in daily life (Bybee, 2010). STEM-educated students are expected to have skills required by the current century, which are defined as 21st century skills in the literature, such as self-confidence, problem solving, innovation, logical thinking, communication, sociability, using technology at a high level, competitiveness, and critical thinking (Bybee, 2010; Morrison, 2006).

In order not to lose the competitive race in the technology, science and economy, countries are planning to develop their students and other stakeholders of the society with STEM-based education according to the standards in the 21st century. Such approaches, which aim to develop and change the whole society, can only be realized when they receive training from experts and trainers who are familiar with this approach. For this reason, to distribute STEM education approach, it was needed to make teachers STEM literate individuals and make them successful STEM education practitioners and instructors (Eroğlu & Bektaş, 2016). Teachers are trying to gain the skills that pre-service teachers need to have in order to overcome the difficulties they faced with in everyday life (Baran, Bilici, Mesutoglu, & Ocak, 2016). In addition, teachers are expected to train as persons who criticize, think scientifically, become creative, respect human rights, and be respectful and responsible towards their society, and to raise their students in this way. In this context, participants need to be acquainted about sufficient knowledge and qualifications in science, mathematics, technology and engineering education and apply these disciplines throughout their professional life (Stohlmann, Moore, & Roehrig, 2012).

Recently, the efforts have been made to decrease the carbon footprint around the world. The governments are focusing to decrease their carbon footprints on their lands. When alternative energy sources are compared with the energy produced by fossil fuels, the amount of carbon produced is very low (Kumbur, Özer, Özsoy, & Avcı, 2005). Therefore, alternative energy should be promoted to prevent global temperature rise, and alternative energy generation is expected to create more job opportunities in the future. It is important to educate today's youth with STEM skills to meet the workforce necessity of the future, and it is obvious that this will happen with STEM-based education (Subramanian, 2019). For this reason, there is a need to train teacher candidates who have important duties and responsibilities in raising future generations by considering alternative energy sources in STEM education (Karakul, 2016).

In the literature, there were studies on integration of STEM education and energy resources with pre-service teachers and undergraduate students. Gutierrez, Ringleb, Kidd, Ayala, Pazos and Kaipa (2020) provided the opportunity to work with engineering undergraduate and pre-service teachers in the Ed+gineering learning project. Ed+gineering learning project is an interdisciplinary partnership integrating engineering into elementary teacher preparation programs. Participants engaged in the pedagogy courses related to science, technology and engineering in both engineering design and teaching fields together, and they carried out planning and implementation studies for secondary school students in science and engineering. After this implementation, participants were willing and successful in planning and applying technology, engineering and science together. Engineering undergraduate students also had positive gains from group work and they were willing to plan and implement STEM lessons together with teacher candidates. In addition, researchers implemented a STEM application (called as second life) in a virtual lab environment for a recyclable energy project with Japanese pre-

service science teachers. In this application, participants have both learned to use the engineering design process in terms of STEM and designed a wind powered aircraft that can make maximum use of recyclable energy. In this study, participants designed original products, attempted to comply with planning process, used the engineering design process, and used the information they learned about alternative energy within the scope of the study (Barry et al., 2017). As a result of the STEM-based alternative energy sources studies applied to the students and teacher candidates, they could use the design process effectively. They develop critical thinking skills and 21st century skills (Sulaeman, 2020). Similarly, as a consequence of the STEM-based solar energy project carried out with 28 physics teacher candidates, the participants' knowledge of engineering, technology and mathematics developed, respectively, of which science was the most. Participants developed original projects, used the design process effectively, and increased their knowledge and awareness of alternative energy sources (Mayasari, Susilowati & Winarno, 2019).In the research, the subject of "alternative energy sources" is presented to pre-service science teachers in the science education department in an elective course with integrated STEM education. The subjects of the alternative energy sources course are generally seen as a complex subject by pre-service science teachers (Cebesoy & Karışan, 2017). In addition, these issues will contribute to participants' understanding of the transformation of energy that they were encountered frequently in their daily life and that they use in their homes. Participants gained an active and problem-based learning experience with STEM activities based on daily life problems. It would provide more opportunities for participants to produce scientific ideas and different ideas about alternative energy sources. In this way, participants were stimulated by activities including daily life problems and engineering designs on alternative energy sources to complete their designs.

In the studies on STEM in recent years, science and mathematics teachers only have teaching knowledge in the branch in which they are experts. Their teaching knowledge in their branch is not enough to raise the manpower and new generation profile that our country needs in the 21st century (Çorlu, Capraro, & Capraro, 2014). Teachers are expected to have developed professional competencies in STEM fields and how to integrate these fields, to encourage students to do scientific research and design, to provide training that improves students' analytical and design skills, and to be open to innovations. In addition, teachers are expected to have important skills such as adaptability, cooperation, critical thinking, leadership ability, problem solving, entrepreneurship, flexible thinking, accessing and using information, verbal and written communication, and creativity (Wagner, 2008). However, it is important to determine the knowledge, skills and attitudes of teachers about STEM before they gain these cognitive and psychomotor gains. Teachers are expected to apply STEM approach in which they develop an affective attitude and interest in their classrooms. Therefore, in this study, it was examined how the pre-service science teachers' attitudes towards STEM fields and their intentions towards STEM teaching changed as a result of the integrated STEM education. The aim of this study was to determine effect of STEM based alternative energy activities on STEM teaching intention and attitude of participants towards STEM. Research questions:

1) Is there a significant difference between pretest and posttest scores in the attitudes towards STEM of participants who took the STEM-based alternative energy sources activities?
2) Is there a significant difference between pretest and posttest scores in the integrative STEM teaching intentions of participants who took the STEM-based alternative energy sources activities?

METHOD

In this study, the one group pre-test and post-test weak experimental design was utilized (Fraenkel, Wallen & Hyun, 2012). Weak experimental design was used in the research, and the data were obtained with a single-group pre-test and post-test. With a single group pre-test-post-test with a weak experimental design, the effect of the experimental procedure is tested with a study on a single group. The measurements of the subjects regarding the dependent variable are obtained by using the same subjects and the same measurement tools as pre-test and post-test before the application (Karasar, 2013). In a single-group pre-test-post-test weak experimental design, an independent variable is applied

to a group; measurement is made before and after the experiment. After the measurement, the difference between the pre-test and post-test mean scores shows the effect of the independent variable on the dependent variable (Fraenkel, Wallen & Hyun, 2012). In this study, it was decided to use this design because it was aimed to examine the effect of design-based STEM activities.

The sample of study

The study group consisted of 29 female and 11 male pre-service science teachers. They were studying at the science education department. Participants worked in groups of four while designing STEM products. Participants participated in the study completely voluntarily and determined their own study groups. It has been observed that the ages of teacher candidates vary between 19-22 years. Participants in the sample were selected based on voluntariness, with the easily accessible sampling method. In this method, the most appropriate sample group in terms of time and cost is used to obtain rich data about a particular situation (Patton, 1990).

Data collection tools

In this section, general information about data collection tools and their sub-dimensions, validity and reliability information were given. Before and after STEM integrated alternative energy sources activities, Integrative STEM Teaching Intention Questionnaire and Attitude towards STEM Scale was used as pretest and posttest for undergraduate students to examine intention towards teaching STEM and attitude towards STEM.

1-Integrative STEM teaching intention questionnaire

The questionnaire was enhanced by Lin and Williams (2015). This questionnaire was translated and adapted to Turkish to decide teacher candidates' STEM intentions by Hacıömeroğlu and Bulut (2016). Five sub-scales were named as value, knowledge, attitude, perceived behavioral control and behavioral intention, and subjective norm. In this study, Cronbach Alpha coefficient was calculated as .92 for overall questionnaire. The questionnaire involved 31 items with a 7-point likert type. The questionnaire involved value (α=.82), knowledge (α=.71), attitude (α=.85), perceived behavioral control and behavioral intention (α=.89) and subjective norm (α=.83) sub-scales. For the data to be relevant for factor analysis the KMO value is expected to be more than .60 and Bartlett sphericity test should be significant (Field, 2013; Pallant, 2020). The result of the data analysis showed that the KMO value was .934 the Bartlett sphericity result was found to be statistically significant ($p < 0.001$). Based on the results, it can be said that the data are relevant for factor analysis.

2-Attitude towards STEM scale

The original form of the scale was improved by The Friday Institute for Educational Innovation (2012). This scale was translated and adapted to Turkish to decide students' attitudes towards STEM by Özcan and Koca (2018). The adapted version of the scale included of 37 items with 5-point likert type. Four sub-scales of adapted version of the scale were science, mathematics, technology and engineering and 21th-century skills. Cronbach Alpha coefficients for the overall scale (α=.92) and science (α=.72), mathematics (α=.90), technology and engineering (α=.86), and 21th-century skills (α=.91) were calculated. The result of the data analysis showed that the KMO value was .88 the Bartlett sphericity result was found to be statistically significant ($p < 0.001$). Based on the results, it can be said that the data are relevant for factor analysis.

Data analysis

Quantitative data was analyzed with Wilcoxon test and paired sample t-test. Integrative STEM teaching intentions questionnaire and attitude towards STEM scale was used at the end and beginning of the 14-week implementation period. The normality test was performed as Kolmogorov-Smirnov test to determine whether the obtained scores were in accordance with the normal distribution (Büyüköztürk, 2009). Normality test results proved that while the data show normal distribution for subjective norm sub-scale, the data do not show normal distribution for knowledge, attitude, value, perceived behavioral control and behavioral intention for subscales of Integrative STEM teaching intention (Table 1).

Table 1. *Normality test results for subscales of Integrative STEM teaching intention*

	Statistics	df	*p*
Post-knowledge	.910	40	.004
Pre-knowledge	.910	40	.004
Post-value	.932	40	.019
Pre-value	.932	40	.019
Post-attitude	.880	40	.001
Pre-attitude	.880	40	.001
Post-norm	.973	40	.450
Pre-norm	.973	40	.450
Post-intention	.935	40	.023
Pre-intention	.935	40	.023

Normality test results proved that while the data show normal distribution for mathematics, technology and engineering, and 21th-century skills sub-scales, the data do not show normal distribution for science sub-scales for subscales of Attitude towards STEM scale (Table 2).

Table 2. *Normality test results for subscales of Attitude towards STEM scale*

	Statistics	df	*p*
Post-math	.984	40	.826
Pre-math	.984	40	.826
Post-science	.942	40	.042
Pre-science	.942	40	.042
Post-technology and engineering	.970	40	.373
Pre-technology and engineering	.970	40	.373
Post-21th century skills	.945	40	.051
Pre-21th century skills	.945	40	.051

The homogeneity of variances was performed as Levene's test to determine whether the obtained scores were in accordance with the equality of variances (Büyüköztürk, 2009). Levene's test results proved that while the data show equal variance for all subscales of Integrative STEM teaching intention and Attitude towards STEM scale (Table 3).

Table 3. *Levene's test results for subscales of Integrative STEM teaching intention and Attitude towards STEM scale*

	Levene Statistic	df1	df2	Sig.
Post-knowledge	.366	1	38	.549
Pre-knowledge	.366	1	38	.549
Post-value	.441	1	38	.511
Pre-value	.441	1	38	.511
Post-attitude	.129	1	38	.722
Pre-attitude	.129	1	38	.722
Post-norm	.768	1	38	.386
Pre-norm	.768	1	38	.386
Post-intention	.323	1	38	.573
Pre-intention	.323	1	38	.573
Post-math	.329	1	38	.569
Pre-math	.329	1	38	.569
Post-science	2.948	1	38	.094
Pre-science	2.948	1	38	.094
Post-technology and engineering	.494	1	38	.487
Pre-technology and engineering	.494	1	38	.487
Post-21th century skills	.075	1	38	.786
Pre-21th century skills	.075	1	38	.786

Instructional design

The application process covered the whole of a one-term undergraduate course. It was ensured that all students who participated in the implementation process had previously participated in STEM education theoretically in one of the professional field courses of teaching. Also, they were informed about STEM approach at the beginning of this period in a public university. This information process aimed to check whether there are deficiencies in the previous education of the teachers and to correct any misconceptions about STEM education. After this informative study, the presentations were made by the researcher about alternative energy sources and renewable energy sources, which are the content

of the course and activities, and how they are used throughout first seven weeks. Presentations about water (hydroelectric sources), wind, solar energy, plant materials (biomass), heat of the earth (geothermal), waves, ocean currents and energy of tides was made to improve students' knowledge about the alternative energy sources. After these presentations, some examples of daily life problems were given to participants to design STEM projects. They would make STEM projects about the theme of alternative energy sources throughout five weeks. In addition, participants were aimed to design STEM projects based on alternative energy sources, which they could find themselves. They worked as a group inside or outside the classroom. At the end of the five-week process of designing STEM projects with the theme of alternative energy sources, all groups made promotional videos for their products and tried to present and evaluate their products in front of the class throughout two weeks. Firstly, researcher evaluated the projects and then participants made comments about the presented projects.

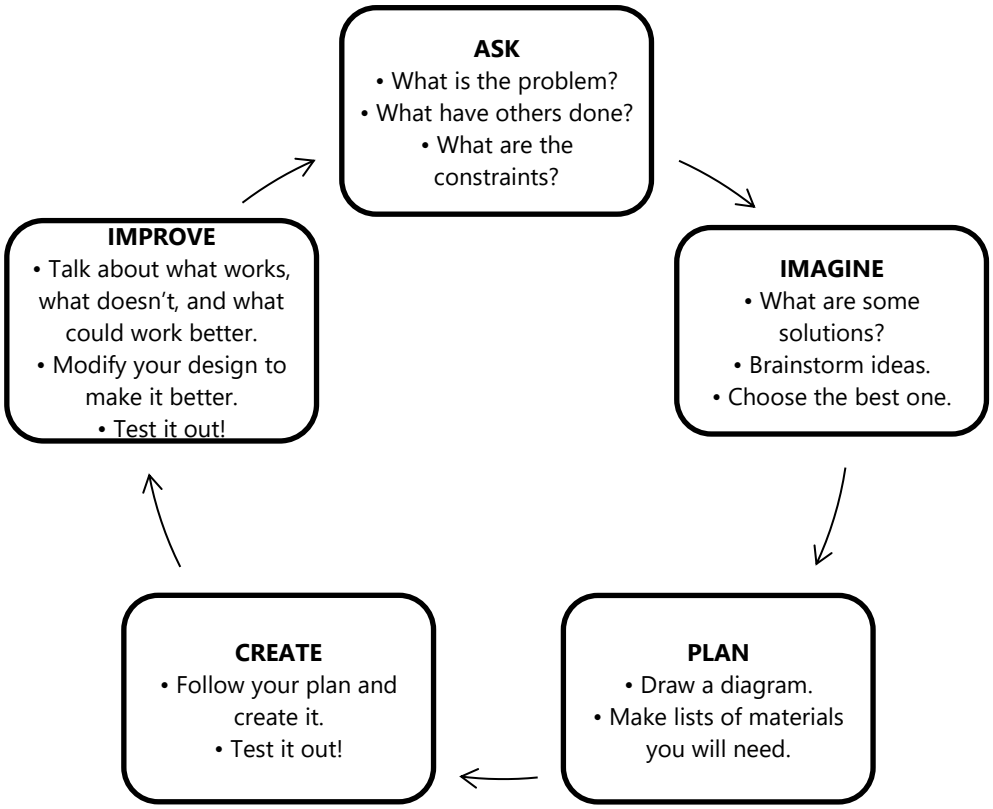

Figure 1. *The engineering design process (Cunningham & Hester, 2007)*

The participants, who started their presentations by explaining the problems they set out and the context of daily life, then presented STEM products in detail on the basis of the design process cycle, in order of how they acquired the knowledge, how they developed their ideas, how they built the first prototype of their products, whether they tested and modified. The activities were based on the engineering design process (Figure 1). One of the sample figures of designs of participants were given below.

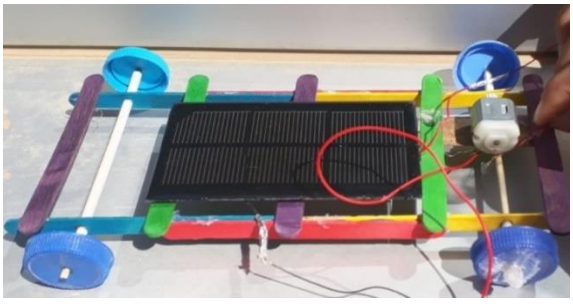

Figure 2. *Solar Car*

Figure 2 illustrated solar car design of participants to make their own solar cars by using alternative items and waste materials from their environment. The purpose of the activity was to make a solar car by using alternative items. They used small solar energy materials, toy car motors, bottle-caps, pipets, toothpick, ice cream stick, wire. In Table 4 below, a complete list of STEM activities and the relationship of STEM disciplines were provided.

Table 4. *Overview of STEM activities and relationships of STEM disciplines*

Activity	Science	Technology	Engineering	Mathematics
Recycled Car	Using waste materials and frictional force	Using waste materials, designing of wheels and vehicle	Designing of recycled car	Measurement and calculations of fricitional force of air and motion
Solar Powered Street Lamp Model	Understanding of electrical energy	Using solar panel	Designing a street lamp model using LED lamp and solar panels	Involving Ohm's Laws
Solar Car	Electrical and mechanical energies	Using of solar panel and toy motor engine	Designing a solar car	Measurement of motion and energy
Solar Oven	Solar energy and heat energy	Understanding of space technology	Designing a heat-efficient solar oven	Calculating relationship between temperature and solar eenergy
Zero-Energy House model (wind energy)	Understanding of importance of wind energy	Designing sustainable zero-energy house model in terms of electrical energy	Designing a house model illuminated by wind energy	Comparing zero-energy house model using wind energy and daily electric power demand for a home
Water Tribune Model	Conversion of water energy to electrical energy	Comprehending the function of the water tribune	Designing an energy-efficient water turbine	Calculating the flow rate of water and energy
Hydroelectric Energy Activity	Understanding of effect of water pressure and gravity	Understanding the advantages and limitations of the hydroelectric power plants	Designing a hydroelectric power plant model	Calculating rate of water pressure and energy
Geothermal energy activity	Understanding of effect of vapor pressure and electricity	Understanding the advantages and limitations of the power plants	Designing a geothermal power plant model that will operate using steam energy	Measurement of rate of vapor pressure and energy
Wind turbine activity	Understanding of importance of wind energy and the effect of wind turbine on endangered livings	Understanding of advantages and limitations of the wind tribune and other technological solutions for endangered livings(birds)	Designing a product to save livings such as birds from wings of wind tribune	Calculations of wings of wind turbine and living area of endangered livings.
Biomass energy activity	Understanding the biomass energy	Understanding the advantages and limitations of biomass power plant	Designing a biomass in which they will find out what materials the biomass should consist of that will release the most biogas	Measurement of rate of biogas and biomass energy

FINDINGS

1. *The Effect of STEM Integrated Alternative Energy Sources Activities on Integrative STEM teaching intention*

To decide the effect of the STEM integrated alternative energy sources activities, Wilcoxon test was used to analyze whether there were significant differences in the value, knowledge, science, perceived behavioral control and behavioral intention, and attitude scores of participants between the pre- and post-tests. There were significant differences between the pre- and post-tests participants' scores of knowledge (z = -5.532, $p \leq 0.05$, r = .618), value (z = -5.527, $p \leq 0.05$, r = .618), attitude (z = -5.548, $p \leq 0.05$, r = .620), perceived behavioral control and behavioral intention (z = -5.531, $p \leq 0.05$, r

= .618) favoring the positive rank (Table 5). The effect size for knowledge, value, attitude and perceived behavioral control and behavioral intention was large using Cohen (1988) criteria of .1 = small effect, .3 = medium effect, .5 = large effect.

Table 5. *Wilcoxon test results*

Sub-scales		N	Mean Rank	Sum of Ranks	*z*	*p*	*r*
Knowledge	Negative ranks	0	.00	.00	-5.532	.000	.618
	Positive ranks	40	20.50	820.00			
	Ties	0					
	Total	40					
Value	Negative ranks	0	.00	.00	-5.527	.000	.618
	Positive ranks	40	20.50	820.00			
	Ties	0					
	Total	40					
Attitude	Negative ranks	0	.00	.00	-5.548	.000	.620
	Positive ranks	40	20.50	820.00			
	Ties	0					
	Total	40					
Intention	Negative ranks	0	.00	.00	-5.531	.000	.618
	Positive ranks	40	20.50	820.00			
	Ties	0					
	Total	40					

Table 6 illustrated the paired sample t-test results of pre- and post-tests' subjective norm scores. There were significant differences between the pre- and post-tests scores for subjective norm (t = -5.788, $p \leq 0.05$, d = .300). The effect size for subjective norm was small using to Cohen (1988) criteria of .2 = small effect, .5 = medium effect, .8 = large effect.

Table 6. *Paired sample t-test results*

	N	X̄	SD	DF	t	*p*	*d*
Pretest - subjective norm	40	2.4200	.63375	39	-5.788	.000	.300
Posttest - subjective norm	40	3.5800	.63375				

2. *The Effect of STEM Integrated Alternative Energy Sources Activities on Attitude towards STEM*

To decide the effect of the STEM integrated alternative energy sources activities, Wilcoxon test was used to analyze whether there were significant differences in the science attitude scores of participants between the pre- and post-tests. There were significant differences between the pre- and post-tests participants' scores of science (z = -5.499, p ≤ 0.05, r = .615) favoring the positive rank (Table 7). The effect size for science was large according to Cohen (1988).

Table 7. *Wilcoxon test results*

Sub-scale		N	Mean Rank	Sum of Ranks	*z*	*p*	*r*
Science	Negative ranks	0	.00	.00	-5.499	.000	.615
	Positive ranks	39	20.00	780.00			
	Ties	1					
	Total	40					

Table 8 illustrated the paired sample t-test results of pre- and post-tests' mathematics, engineering and technology, and 21th-century skills scores. There were significant differences between the pre- and post-tests scores for mathematics (t = -4.079, $p \leq 0.05$, d = .176), engineering and technology (t = -9.060, $p \leq 0.05$, d = .513) and 21th century skills (t = -13.109, $p \leq 0.05$, d = .688). The effect size for mathematics was small and the effect size for engineering and technology and 21th century skills were medium according to Cohen (1988).

Table 8. *Paired sample t-test results*

	N	X̄	SD	DF	t	*p*	*d*
Pretest - math	40	2.5000	.77522	39	-4.079	.000	.176
Posttest - math	40	3.5000	.77522				
Pretest - technology and engineering	40	2.1750	.57592	39	-9.060	.000	.513
Posttest - technology and engineering	40	3.8250	.57592				
Pretest - 21th century skills	40	1.9750	.49451	39	-13.109	.000	.688
Posttest - 21th century skills	40	4.0250	.49451				

CONCLUSION, DISCUSSION AND SUGGESTIONS

STEM integrated alternative energy sources activities significantly improved integrative STEM teaching intention and attitudes towards STEM disciplines of participants. The results are parallel to results of the other studies reported in related literature (Capraro & Jones, 2013; Çepni & Ormancı, 2018). As a result of the study implemented with pre-service science teachers within the context of renewable energy, integrative STEM teaching intention of pre-service science teachers was positively affected. The implementation of integrative STEM education enabled them to use their knowledge interdisciplinary, improve their intentions and skills to design and develop STEM products, and they also developed a positive attitude about alternative energy and renewable energy (Aygen, 2018). Similarly, pre-service science teachers attended in the STEM integrated Science, Technology, Society and Environment course. The STEM integrated course was provided the pre-service science teachers with the opportunity to learn STEM related to alternative and renewable energy in this course. As a consequence of this study, the attitudes of the pre-service science teachers about alternative and renewable energy increased compared to the pre-study and control group (Yıldırım & Selvi, 2016).

Generally, similar results were obtained in integrated STEM education studies conducted with science teachers and pre-service science teachers on the theme of alternative and renewable energy. A project-based STEM education in science teacher training program was implemented with science teachers to build a model of a solar house by using a limited budget and design criteria (Felix & Harris, 2010). Science teachers improved their STEM content knowledge, cooperative learning in science or math, science concept knowledge end of the study. Another project-based STEM education about designing a livable city plan, different energy sources, a hydroelectric power station, a solar-powered car positively influenced on STEM attitudes, competence perceptions about 21st-century skills and intentions towards STEM teaching of science teachers candidates (Deniş Çeliker, 2020). Similarly, STEM implementations positively influenced on science teachers' STEM implementation orientations. As a consequence of this research, the significant difference was noted between before and after implementation scores of subjective norm, attitude and knowledge sub-dimensions. However, statistically significant difference was not noted between before and after implementation scores of behavioral intention, perceived behavioral control and value (Timur & Belek, 2020). In the current study, the influence of STEM based implementation about alternative energy sources on participants' integrated STEM teaching intentions indicated significant improvement.

The second finding is that attitudes towards STEM of participants have significantly improved. The attitudes towards science, technology and engineering, mathematics and 21st century skills have also risen significantly. Because of teachers' negative views toward STEM, less time is spent teaching mathematics and science, and less emphasis is placed on engagement of students in sophisticated inquiry-based practices (Appleton & Kindt, 2002). STEM attitudes of teachers are linked to STEM instruction methods (Thibaut et al., 2018). As a result, it is critical to identify and improve the attitudes of pre-service science teachers. Students' attitude toward STEM are positively influenced by STEM activities in a problem-based learning environment (Sarı, Alıcı & Şen 2018). These findings were in line with previous research. STEM-based applications have also boosted science teacher candidates' STEM attitudes (Wahono & Chang, 2018). The majority of instructors who took part in STEM education programs had affirmative views (Affouneh et al., 2020). Science teacher candidates' active participation in steps of engineering design process might have caused favorable shift in their views. Alternative energy sources activities can be extremely helpful in changing teachers' attitudes and intetions about STEM. Teachers who establish good attitudes about STEM are expected to integrate STEM into their class (Adams et al., 2014). The project-based teaching approaches increased STEM attitudes of freshman in technology institute (Tseng et al., 2013).

The findings of studies in the literature were similar with findings of current study. Preservice science teachers' integrative STEM teaching intentions were improved. This result was supported by studies on the same subject (Barry et al., 2017; Gutierrez et al. 2020; Mayasari, Susilowati & Winarno, 2019; Sulaeman, 2020) in the literature. Barry, Kanematsu, Lawson, Nakahira and Ogawa (2017) implemented a virtual lab environment for a recyclable energy project with Japanese pre-service science

teachers. Participants have both learned to use the engineering design process and used the information they learned about alternative energy. Gutierrez et al. (2020) provided the opportunity to work with engineering undergraduate and teacher candidates in the Ed+gineering learning project. End of the study, participants were willing and successful in planning and applying technology, engineering and science together. Engineering undergraduate students also had positive gains from group work and they were willing to plan and implement STEM lessons together with teacher candidates. Mayasari et al., (2019) revelaed STEM-based solar energy project improved pre-service physics teachers' knowledge of science, engineering, technology and mathematics and abilty to use design process. Sulaeman (2020) carried out a study about STEM-based alternative energy sources with Japanese high school students and Indonesian physics teacher candidates. The students saw wind energy and the teacher candidates considered solar energy more as alternative energy. In the light of the results of this study and literature, STEM integrated alternative energy sources activities improved the attitudes towards STEM education and integrative STEM teaching intention of pre-service science teachers.

One of the most significant challenges on implementation of STEM education was that students will confront STEM related issues such as energy efficiency, alternative energy sources, global climate change and social topics as citizens. Addressing this problem needs integrated curricular approach, firstly global issues were focused and then STEM disciplines were used to address and understand the issue as context-based science education (Bybee, 2010). The current study affirmed the effect of integrative STEM based education about alternative energy sources to improve STEM teaching intention and attitudes towards STEM disciplines of participants.

In the light of the results of this study, the STEM integrated alternative energy sources activities are effective in the development of pre-service teachers' attitudes towards STEM education and integrative STEM teaching intention. STEM integration about alternative energy sources was needed to improve pre-service science teachers' attitudes and intentions. Alternative and renewable energy courses might be conducted in an interdisciplinary sense in order to maximize pre-service science teachers' attitude, intentions for teaching STEM and their ability to offer creative products about energy education. One of the limitations of this study is that it is a single group experimental design. In order to overcome this limitation, it is recommended to conduct studies with control groups. Elective courses related to alternative energy sources or renewable energy sources in current curricula are offered to pre-service science teachers. It is recommended that the content of this course be integrated with approaches such as STEM-based, project or problem-based and presenting a course content where all teacher candidates can prepare projects, practice within the scope of the course, and increase their awareness.

REFERENCES

Adams, A. E., Miller, B. G., Saul, M., & Pegg, J. (2014). Supporting elementary pre-service teachers to teach stem through place-based teaching and learning experiences. *Electronic Journal of Science Education, 18*(5), 1-22.

Affouneh, S., Salha, S., Burgos, D., Khlaif, Z. N., Saifi, A. G., Mater, N., & Odeh, A. (2020). Factors that foster and deter STEM professional development among teachers. *Science Education, 104*(5), 857-872. https://doi.org/10.1002/sce.21591

Appleton, K., & Kindt, I. (2002). Beginning elementary teachers' development as teachers of science. *Journal of Science Teacher Education, 13(*1), 43-61. https://doi.org/10.1023/A:10151 81809961

Aydeniz, M. (2017). Eğitim sistemimiz ve 21. yüzyıl hayalimiz: 2045 hedeflerine ilerlerken, Türkiye için STEM odaklı ekonomik bir yol haritası [Our education system and our 21st century dream: A STEM-oriented economic roadmap for Turkey as we move towards 2045 goals]. *University of Tennessee, Knoxville*.

Aygen, M. B. (2018). *Fen bilgisi öğretmen adaylarının bütünleşik öğretmenlik bilgilerinin desteklenmesine yönelik STEM uygulamaları. [STEM applications for supporting integrated teacher knowledge of science teacher candidates]* (Unpublished master's thesis). Fırat University, Institute of Educational Sciences, Elazığ.

Baran, E., Bilici, S. C., 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. DOI:10.18404/ijemst.71338

Barry, D. M., Kanematsu, H., Lawson, M., Nakahira, K., & Ogawa, N. (2017). Virtual STEM activity for renewable energy. *Procedia computer science*, *112*, 946-955. https://doi.org/10.1016/j.procs.2017.08.130

Bozkurt Altan, E. B., & Ercan, S. (2016). STEM education program for science teachers: perceptions and competencies. *Journal of Turkish Science Education*, *13*(special), 103-117. doi: 10.12973/tused.10174a

Büyüköztürk, Ş. (2009). *Manual of data analysis for social sciences.* Ankara: Pegem Academy.

Bybee, R. W. (2010). Advancing STEM education: A 2020 vision. *Technology and engineering teacher, 70*(1), 30.

Bybee, R. W. (2013). *The case for STEM education: Challenges and opportunities*. NSTA press.

Capraro, M. M., & Jones, M. (2013). *Interdisciplinary STEM project-based learning in STEM Project-Based Learning, Rotterdam* (pp. 51-58). The Netherlands: Sense Publishers. https://doi.org/10.1007/978-94-6209-143-6_6

Cebesoy, Ü, B., & Karışan, D. (2017). Investigation of Pre-service Science Teachers' Knowledge, Teaching Efficacy Perceptions and Attitude towards Renewable Energy Sources. *YYU Journal of Education Faculty, 14*(1), 1377-1415.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences.* NJ: Erlbaum.

Cunningham, C. M., & Hester, K. (2007). *Engineering is elementary: An engineering and technology curriculum for children.* In American Society for Engineering Education Annual Conference & Exposition, Honolulu, HI.

Çepni, S., & Ormancı, Ü. (2018). *The world of the future.* In Ç. Salih (Ed.), *From Theory to Practice in Stem Education* (pp. 1-37). Ankara: Pegem Academy.

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

Deniş Çeliker, H. (2020). The Effects of Scenario-Based STEM Project Design Process with Pre-Service Science Teachers: 21st Century Skills and Competencies, Integrative STEM Teaching Intentions and STEM Attitudes. *Journal of Educational Issues, 6*(2), 451-477. https://doi.org/10.5296/jei.v6i2.17993

Eroğlu, S., & Bektaş, O. (2016). Ideas of Science Teachers took STEM Education about STEM based Activities. *Journal of Qualitative Research in Education, 4*(3), 43-67. DOI: 10.14689/issn.2148-2624.1.4c3s3m

Felix, A., & Harris, J. (2010). A project-based, STEM-integrated alternative energy team challenge for teachers. *Technology and Engineering Teacher*, *69*(5), 29.

Field, A. (2013). *Discovering statistics using IBM SPSS statistics*. SAGE.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. (2012). *How to design and evaluate research in education* (8th ed.). New York: McGrawHill.

Friday Institute for Educational Innovation (2012). *Middle and High School STEM-Student Survey.* Raleigh, NC: Author.

Gutierrez, K., Ringleb, S. I., Kidd, J. J., Ayala, O. M., Pazos, P., & Kaipa, K. (2020). *Partnering Undergraduate Engineering Students with Pre-service Teachers to Design and Teach an Elementary Engineering Lesson through Ed+gineering*. 2020 ASEE Virtual Annual Conference Content Access, June 22-26, 2020.

Hacıömeroğlu, G., & Bulut, A. S. (2016). Integrative STEM teaching intention questionnaire: A validity and reliability study of the Turkish form. *Journal of Theory and Practice in Education, 12*(3), 654-669.

Karakul, A. K. (2016). Educating labour force for a green economy and renewable energy jobs in Turkey: A quantitave approach. *Renewable and Sustainable Energy Reviews, 63*, 568-578.

Karasar, N. (2015). *Bilimsel Araştırma Yöntemleri [Scientific Research Methods]*. (28. Baskı). Ankara: Nobel Akademik Yayıncılık.

Kumbur, H., Özer, Z., Özsoy, H. D., & Avcı, E. D. (2005). Türkiye'de geleneksel ve yenilenebilir enerji kaynaklarının potansiyeli ve çevresel etkilerinin karşılaştırılması [Comparison of the potential and environmental impacts of traditional and renewable energy sources in Turkey]. *Yeksem 2005, III. Yenilenebilir Enerji Kaynakları Sempozyumu ve Sergisi,* 19-21.

Lin, K. Y., & Williams, P. J. (2016). Taiwanese pre-service teachers' science, technology, engineering, and mathematics teaching intention. *International Journal of Science and Mathematics Education, 14*(6), 1021-1036. DOI 10.1007/s10763-015-9645-2

Mayasari, T., Susilowati, E., & Winarno, N. (2019, November). Practicing integrated STEM in renewable energy projects: solar power. In *Journal of Physics: Conference Series* (Vol. 1280, No. 5, p. 052033). IOP Publishing.

Morrison, J. (2006). Attributes of STEM education: The student, the school, the classroom. *TIES (Teaching Institute for Excellence in STEM), 20*, 2-7.

National Research Council. (2011). *Successful K-12 STEM education: Identifying effective approaches in science, technology, engineering, and mathematics.* National Academies Press.

Özcan, H., & Koca, E. (2019). Turkish adaptation of the attitude towards STEM scale: A validity and reliability study. *Hacettepe University Journal of Education, 34*(2), 387-401. doi:10.16986/HUJE.2018045061

Pallant, J. (2020). *SPSS survival manual: A step by step guide to data analysis using IBM SPSS*. Routledge.

Patton, M. Q. (1990). *Qualitative evaluation and research methods.* Beverly Hills, CA: Sage Publications.

Sarı, U., Alıcı, M., & Şen, Ö. F. (2018). The effect of STEM instruction on attitude, career perception and career interest in a problem-based learning environment and student opinions. *The Electronic Journal for Research in Science & Mathematics Education*, *22*(1).

Stohlmann, M., Moore, T. J., & Roehrig, G. H. (2012). Considerations for teaching integrated STEM education. *Journal of Pre-College Engineering Education Research (J-PEER), 2*(1), 4.

Subramanian, R. (2019, November). STEM Education and Renewable Energy Jobs. *In 2019 Fall Mid Atlantic States Conference.*

Sulaeman, N. F. (2020). *A Study of STEM Education to Develop Solutions toward Issues in Renewable Energy in the Context of Japan and Indonesia*. Doctoral dissertation, Shizuoka University, Japan.

Thibaut, L., Ceuppens, S., De Loof, H., De Meester, J., Goovaerts, L., Struyf, A., & Depaepe, F. (2018). Integrated STEM education: A systematic review of instructional practices in secondary education. *European Journal of STEM Education, 3*(1), 02-12. https://doi.org/ 10.20897/ejsteme/85525

Timur, B., & Belek, F. (2020). Investigation of the effects of STEM activities on pre-service teachers' self-efficacy beliefs and STEM education orientations. *Pamukkale University Journal of Education, 50*, 315-332. doi: 10.9779/pauefd.465824

Tseng, K. H., Chang, C. C., Lou, S. J., & Chen, W. P. (2013). Attitudes towards science, technology, engineering and mathematics (STEM) in a project-based learning (PjBL) environment. *International Journal of Technology and Design Education, 23*(1), 87-102. https://doi.org/10.1007/s10798-011-9160-x

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

Wahono, B., & Chang, C. Y. (2018). *Examining the relationship between science teachers' knowledge, attitude, and application of stem education.* Proceedings of the 2018 International Conference of East-Asia Association for Science Education (EASE), Hualien.

Yıldırım, B., & Selvi, M. (2016). Examination of the effects of STEM education integrated as a part of science, technology, society and environment courses. *Journal of Human Sciences, 13*(3), 3684-3695. doi:10.14687/jhs.v13i3.3876.

STEM Temelli Alternatif Enerji Kaynakları Etkinliklerinin STEM Öğretim Niyetine ve Tutumuna Etkisi

Dr. Emrah Hiğde
Aydın Adnan Menderes Üniversitesi - Türkiye
ORCID: 0000-0002-4692-5119
emrah.higde@adu.edu.tr

Özet:

Bu çalışmanın amacı, STEM temelli alternatif enerji kaynakları etkinliklerinin, fen bilgisi öğretmen adaylarının bütünleştirici STEM öğretimi niyetine ve tutumlarına etkisini belirlemektir. Araştırmada nicel araştırma yöntemlerinden biri olan tek grup ön test-son test deneysel desen kullanılmıştır. Çalışma grubunu fen bilgisi öğretmenliği bölümünde öğrenim gören 29 kadın ve 11 erkek fen bilgisi öğretmen adayı oluşturmuştur. Veri toplamak için bütünleştirici STEM öğretme niyeti anketi ve STEM'e yönelik tutum ölçeği kullanılmıştır. Araştırma sonucunda, bütünleştirici STEM öğretimi niyeti ve STEM'e yönelik tutum, ön uygulama ile karşılaştırıldığında önemli ölçüde artmıştır. Bütünleştirici STEM öğretim niyeti ölçeğinin bilgi, değer, tutum, algılanan davranışsal kontrol ve davranışsal niyet, öznel norm alt boyutlarına ait katılımcıların ön ve son test puanları arasında anlamlı farklılık vardır. Cohen'e (1988) göre bütünleştirici STEM öğretimi niyetine ait alt boyutlardan öznel norm harici tüm alt boyutlarda etki değeri büyüktür. STEM'e yönelik tutum ölçeğinin fen, matematik, mühendislik ve teknoloji, 21. yy becerileri altboyutlarına ait katılımcıların ön ve son test puanları arasında anlamlı farklılık bulunmuştur. Cohen'e (1988) göre etki değeri fen için büyük, matematik için küçük, mühendislik ve teknoloji ile 21. yüzyıl becerileri için hesaplanan etki büyüklüğü ortadır. Katılımcıların çoğunluğu hidroelektrik enerji, güneş enerjisi ve rüzgâr enerjisi ile ilgili tasarımlar yaparken, az sayıda katılımcı biyokütle enerjisi ve titreşim yoluyla enerji üretimi (piezoelektrik) ile ilgili STEM ürünleri tasarlamıştır. Bu bulgular ışığında, fen bilgisi öğretmen adaylarının bütünleştirici STEM öğretme niyetlerini ve fen bilgisi öğretmen adaylarının STEM'e yönelik tutumlarını geliştirmek için STEM temelli alternatif enerji etkinliklerinin uygulanabileceğini söylenebilir.

Anahtar kelimeler: *Alternatif enerji, Tutum, STEM, Öğretim niyeti*

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Genişletilmiş Özet

Problem: Son zamanlarda, dünya çapında karbon ayak izini azaltmak için büyük bir çaba sarf edilmektedir. Devletler, topraklarındaki karbon ayak izlerini azaltmaya odaklanmaktadır. Fosil yakıtların kullanımına bağlı olarak ortaya çıkan karbon miktarı ile alternatif enerji kaynaklarının karbon salınımları karşılaştırıldığında alternatif enerji kaynaklarının çok düşük bir karbon salınıma sebep olduğu görülmektedir (Kumbur, Özer, Özsoy ve Avcı, 2005). Bu yüzden, küresel iklim değişikliğinin önemli bir etkisinin olduğu düşünülen sıcaklık değişimlerini ve hava olaylarını engellemek için alternatif enerji kaynaklarının teşvik edilmesi ve alternatif enerji kaynaklarına dayanan iş fırsatının yaratılması beklenmektedir. Gelecekte ortaya çıkacak işgücü ihtiyacının karşılanabilmesi için bugünden başlanarak genç nesillerin STEM becerileri ile yetiştirilmesi önemlidir. Bu nedenle fen eğitimi açısından konuyu ele aldığımızda STEM temelli uygulamaların farklı konu ve bağlamlarda gerçekleştirilmesi gerekmektedir (Subramanian, 2019). Ek olarak, STEM eğitiminde alternatif enerji kaynakları göz önünde bulundurularak gelecek nesillerin yetiştirilmesinde önemli görev ve sorumluluk öğretmenlerimize düşmektedir (Karakul, 2016). Bu çalışmaya katılan katılımcılar, günlük yaşam problemlerini ve alternatif enerji kaynaklarına yönelik mühendislik tasarımlarını içeren etkinliklerle tasarımlarını gerçekleştirmeye çalışmışlardır. Bu çalışmanın amacı, STEM temelli alternatif enerji dersinin katılımcıların STEM öğretme niyeti ve STEM tutumları üzerindeki etkisini belirlemektir. Araştırma soruları:

1) STEM temelli alternatif enerji kaynakları dersini alan katılımcıların STEM'e yönelik tutumlarında ön test ve son test puanları arasında anlamlı bir fark var mıdır?
2) STEM temelli alternatif enerji kaynakları dersini alan katılımcıların bütünleştirici STEM öğretme niyetlerinde ön test ve son test puanları arasında anlamlı bir fark var mıdır?

Yöntem: Bu çalışmada tek gruplu ön test ve son test deneysel desen kullanılmıştır (Fraenkel, Wallen ve Hyun, 2012). Tasarım temelli STEM etkinliklerinin etkisinin incelenmesi amaçlandığından ve çalışmada kontrol grubu bulunmadığından bu tasarımın kullanılmasına karar verilmiştir. Araştırmada kontrol grubunun olmamasının nedeni, araştırmacının tüm ikinci sınıf öğretmen adaylarını araştırmaya dâhil etmek istemesidir. Bu nedenle araştırmacılar bu çalışmaya dersi alan tüm öğretmen adaylarını dâhil etmişlerdir. STEM entegre edilmiş alternatif enerji kaynakları dersinden önce ve sonra, lisans öğrencilerinin STEM öğretmeye yönelik niyetlerini ve STEM'e yönelik tutumlarını incelemek için Bütünleştirici STEM Öğretimi Niyet Anketi ve STEM'e Yönelik Tutum Ölçeği ön test ve son test olarak kullanılmıştır. Çalışmaya 29 kız ve 11 erkek lisans öğrencisi katılmıştır. Öğrencilere tüm dönem boyunca STEM entegre edilmiş alternatif enerji kaynakları dersi uygulanmıştır. Öğrencilerin alternatif enerji kaynakları ile ilgili bilgilerini geliştirmek ve öğrencilerin alternatif enerji kaynakları hakkında bilgilerini geliştirmek için su (hidroelektrik kaynaklar), rüzgâr, güneş enerjisi, bitki materyalleri (biyokütle), dünyanın ısısı (jeotermal), dalgalar, okyanus akıntıları ve gelgit enerjisi ile ilgili sunumlar gerçekleştirilmiştir. Ayrıca öğrencilerin STEM tasarım becerilerini geliştirmek için mühendislik tasarım süreci ile ilgili örnek etkinlikler ve sunumlar yapılmıştır.

Bütünleştirici STEM öğretim niyeti anketi Lin ve Williams (2015) tarafından geliştirilmiştir. Bu anket, öğretmen adaylarının STEM niyetlerini belirlemek için Hacıömeroğlu ve Bulut (2016) tarafından Türkçe'ye çevrilmiş ve uyarlanmıştır. Beş alt boyut değer, bilgi, tutum, algılanan davranışsal kontrol ve davranışsal niyet ve öznel normdur. Bu çalışmada anketin tamamı için Cronbach Alfa katsayısı .92 olarak hesaplanmıştır. Anket 7'li likert tipinde 31 madde içermektedir. Ankette değer (α=.82), bilgi (α=.71), tutum (α=.85), algılanan davranışsal kontrol ve davranışsal niyet (α=.89) ve öznel norm (α=.83) alt boyutları yer almıştır.

The Friday Institute for Educational Innovation (2012) tarafından STEM'e yönelik tutum ölçeği geliştirilmiştir. Öğrencilerin STEM'e yönelik tutumlarını belirlemek için bu ölçek Özcan ve Koca (2018) tarafından Türkçe'ye çevrilerek uyarlanmıştır. Ölçeğin uyarlanmış hali, 5'li likert tipi 37 maddeden oluşmaktadır. Ölçeğin uyarlanmış versiyonunun dört alt boyutları fen, matematik, teknoloji ve mühendislik ile 21. yüzyıl becerileridir. Ölçeğin tamamı için (α=.92) ve bilim (α=.72), matematik (α=.90), teknoloji ve mühendislik (α=.86) ve 21. yüzyıl becerileri (α=.91) için Cronbach Alfa katsayıları hesaplanmıştır.

Nicel veriler Wilcoxon testi ve eşleştirilmiş örneklem t testi ile analiz edilmiştir. 14 haftalık uygulama sürecinin sonunda ve başında bütünleştirici STEM öğretim niyetleri ile STEM'e yönelik tutum ölçeği kullanılmıştır.

Sonuçlar: STEM entegre edilmiş alternatif enerji kaynakları dersi katılımcıların bütünleştirici STEM öğretim niyetlerini ve tutumlarını önemli ölçüde geliştirilmiştir. Alan yazındaki bu konu hakkında yapılan çalışmalar, bu çalışmanın sonuçları ile benzer sonuçları sahiptir (Capraro & Jones, 2013; Çepni ve Ormancı, 2018). STEM eğitimi hakkında yapılan bir çalışmada katılımcıların alternatif enerji kaynakları hakkındaki niyetlerini ve tutumlarını olumlu yönde etkilemiştir. Buna ek olarak, bütünleştirici STEM eğitiminin uygulanması STEM ürünlerini tasarlama ve geliştirme niyet ve becerilerini aktif hale getirererk ve bilgilerini kullanarak mühendislik tasarmı yapmalarını sağlamıştır (Aygen, 2018). Benzer şekilde, lisans öğrencileri katıldıkları STEM dersinde çevrimiçi STEM laboratuvar uygulaması ile gerçek laboratuvarlarda elde edilmiş verileri kullanarak güneş panelleri ve güneş enerjisi hakkında alternatif enerjiyle ilgili STEM temelli tasarım projeleri yapma fırsatını elde eetmişlerdir. Bu çalışmada, alternatif güneş enerjisi konusunda lisans öğrencilerinin akademik bilgi ve başarıları araştırma öncesine göre artmıştır. Ek olarak, güneşten daha fazla enerji alması amacıyla güneş panellerini için uygun tasrımların eklendiği orijinal STEM projelerinin yapıldığı, katılımcıların grup olarak çalışmaya ve mühendislik tasarımı sürecini kullanmaya daha istekli ve etkin oldukları belirlenmiştir (Yıldırım ve Selvi, 2016).

Katılımcıların STEM'e yönelik tutumları istaiksel olarak ölçüde artmıştır. Tutum ölçeğinin altboyutları olan bilim, teknoloji ve mühendislik, matematik ve 21. yüzyıl becerilerine yönelik tutumlar da önemli ölçüde artmıştır. Öğretmenlerin STEM'e yönelik olumsuz görüşleri nedeniyle, matematik ve fen öğretiminde STEM eğitiminde daha az zaman harcanmakta ve öğrencilerin karmaşık sorgulamaya dayalı uygulamalara katılımına daha az vurgu yapıldığı alan yazında görülmektedir (Appleton ve Kindt, 2002). Bu durum öğretmenlerin STEM tutumları, niyetleri ve STEM öğretim yöntemleriyle ilişkilidir (Thibaut ve diğerleri, 2018). Sonuç olarak, fen bilgisi öğretmen adaylarının tutumlarının belirlenmesi ve iyileştirilmesi kritik öneme sahiptir. Probleme dayalı bir öğrenme ortamında öğrencilerin STEM'e yönelik tutumları STEM etkinliklerinden olumlu etkilenmektedir (Sarı, Alıcı ve Şen 2018). Bu çalışmanın bulguları yapılan önceki araştırmalarla paralellik göstermektedir. STEM temelli uygulamalarda fen bilgisi öğretmen adaylarının STEM tutumlarını artırmaktadır (Wahono ve Chang, 2018). STEM eğitim programlarına katılan öğretmen adaylarının çoğunluğu olumlu görüşlere sahiptir (Affouneh vd., 2020). Fen bilgisi öğretmen adaylarının mühendislik tasarım sürecinin basamaklarına aktif katılımları, görüşlerini olumlu yönde değişmesine neden olmuş olabilir. Alternatif enerji kaynakları dersleri, öğretmenlerin STEM hakkındaki düşüncelerini değiştirmede son derece yardımcı olabilir. STEM'e yönelik iyi tutumlar oluşturan öğretmenlerin ilerleyen günlerde STEM'i sınıflarına entegre etmeleri beklenmektedir (Adams vd., 2014). Proje tabanlı öğretim yaklaşımları ile gerçekleştirilen STEM uygulamalarında teknoloji enstitüsündeki birinci sınıf öğrencilerinin STEM tutumlarını artırdığı belirlenmiştir (Tseng vd., 2013).

STEM eğitiminin uygulanmasındaki en önemli zorluklardan biri, öğrencilerin enerji verimliliği, alternatif enerji kaynakları, küresel iklim değişikliği ve sosyo-bilimsel konular gibi STEM ile ilgili konularla karşı karşıya kalmalarıdır. Bu sorunun ele alınması sürecinde bütünleşmiş bir müfredat yaklaşımına ihtiyaç duyulmuş, öncelikle yaşam standartları ve küresel konulara odaklanılmış ve daha sonra konuyu bağlam temelli fen eğitimi olarak ele almak ve anlamak için STEM disiplinleri kullanılmıştır (Bybee, 2010). Mevcut çalışma, STEM öğretim niyetini ve katılımcıların STEM disiplinlerine yönelik tutumlarını geliştirmek için alternatif enerji kaynakları hakkında bütünleştirici STEM tabanlı eğitimin etkisi olduğu ortaya koyması açısından önemlidir.

Öneriler: Bu çalışmanın sonuçları ışığında, STEM temelli alternatif enerji kaynakları dersi fen bilgisi öğretmen adaylarının STEM alanlarına ve STEM öğretimine yönelik tutumlarının gelişmesinde etkilidir. Alteratif enerji kaynakları ile ilgili derslerde STEM eğitiminin entegre edilmesi ve öğretmen adaylarının enerji kaynakları hakkında projeler geliştirmesi öğretmen adaylarının STEM eğitimine yönelik niyetleri ve tutumlarını arttırdığı bulunmuştur. Bu nedenle STEM eğitiminin enerji kaynakları, yenilenebilir enerji ve çevre eğitimi gibi benzer ders içeriğine sahip derslere entegre edilmesi önerilmektedir. Yapılacak çalışmalarda, sadece enerji kaynakları ve STEM öğretim niyeti ve tutum ile ilgili değişkenlere odaklanmak yerine, öğretmen adaylarının STEM disiplinlerinin her birine özel ilgi ve niyetlerinin araştırılması önerilmektedir. Öğretmen adaylarının eğitim sürecindeki önceki ilgi ve niyetlerinin sunulan eğitime

katılma istekleri ve grup çalışmasına yönelik niyetleri üzerinde nasıl bir etkiye sahip olduğu bilinmemektedir. Bu yüzden gelecekte gerçekleştirrlecek araştırmalarda uygulama içeriğinin geliştirilmesinde ihtiyaçlara yönelik analiz yapılarak hazırlanacak etkinliklerin etkililiğinin daha fazla olacağı için eğitim içeriği hazırlanırken katılımcıların özelliklerinin ve isteklerinin dikkate alınması önerilmektedir. Bu araştırmanın önemli sınırlılıklarından birisi tek grup deneysel desenin kullanılmış olmasıdır. Bu kısıtlılığın aşılabilmesi için deney grubu ile karşılaştırma yapılabilecek niteliklere sahip kontrol grupları ile araştırmaların gerçekleştirilmesi önerilmektedir. Öğretmenlik lisans programları için kullanılan eğitim programlarında alternatif enerji ve yenilenebilir enerji ile ilgili seçmeli dersler bulunmaktadır. Bu derslerin içeriklerinin STEM tabanlı, proje veya problem temelli gibi yaklaşımlarla bütünleştirilmesi ve tüm öğretmen adaylarının ders kapsamında proje hazırlayabileceği, uygulama yapabileceği ve farkındalıklarını artırabileceği bir ders içeriği sunulması önerilmektedir.