JOURNAL OF BALTIC SCIENCE EDUCATION

ISSN 1648-3898 /Print/
ISSN 2538-7138 /Online/

https://doi.org/10.33225/jbse/19.18.06

USING STEM APPLICATIONS FOR SUPPORTING INTEGRATED TEACHING KNOWLEDGE OF PRE-SERVICE SCIENCE TEACHERS

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Abstract. *In this research the effects of STEM applications, which are aimed to support the integrated teaching knowledge of pre-service science teachers on the problem solving skills of pre-service science teachers were examined. The research was carried out in scope of the mixed method design of convergent parallel design. The research was conducted with pre-service science teachers of experimental group (n=31) and control group (n=31) who were studying at Fırat University. STEM applications including Algodoo were carried out with the pre-service teachers in the experimental group for one term. The data of the research were collected through the problem solving inventory test (PSIT), prospects diaries during the process of the pre-service science teachers in the experiment group. Quantitative data were analyzed using unpaired samples t-test. Statistically significant differences were found in favor of the experimental group when the PSIT post-test scores of the pre-service teachers in the experimental and control groups were analyzed. They said that STEM education is necessary and important for them, much better products arise as a result of gathering different disciplines, but integration of four disciplines is not easy.*

Keywords: *Algodoo software, integrated teaching knowledge, pre-service science teachers, problem-solving skills, STEM education.*

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Introduction

The fact that technology started to take place in every area has created the need to educate individuals who adapt these developments in their lives. Facing with the rapid development of science and technology, it has been commonly recognized that students should engage in real-world tasks from an interdisciplinary curriculum, joining theory and practice, and develop their skills in creative problem solving (Chang, Ku, Yu, Wu, & Kuo, 2015). In order to meet this need, STEM (Science, Technology, Engineering and Mathematics) curriculum model has been proposed. STEM approach, adopted by many countries around the world especially in America, has also become the subject of research in Turkey (Bozkurt Altan, Yamak, & Kirikkaya, 2016; Corlu, Capraro, & Capraro, 2014; Gencer, 2015). STEM education, the result of the interests and experiences of teachers and students, is defined as the integration of special knowledge and skills of the discipline in the center with at least one other STEM discipline (Corlu, Capraro, & Capraro, 2014). The current education system, which gives students discrete knowledge of science, mathematics and technology, can be called "Traditional STEM" (Akgunduz et al., 2015).

While the disciplines such as science, technology, mathematics and engineering are studied independently from each other, it is expected that the individuals who understand STEM to combine at least two fields such as science, technology, mathematics and engineering to reveal new products (Corlu, Capraro, & Capraro, 2014). However, there are many definitions of STEM education in different sources. According to NRC (2012), the STEM is defined as the integration of two or more STEM disciplines to solve a problem or to develop a project. According to Sanders (2009), STEM education was defined as an integrated teaching of at least two or more disciplines. STEM education is a course or unit module where all four disciplines or at least two of them are combined around a real-life problem (Moore et al., 2014). Corlu et al. (2014) remarked STEM education was shaped by the interests and experiences of teachers and students. STEM training is to integrate the special knowledge and skills of a discipline with at least another STEM discipline.The definitions

https://doi.org/10.33225/jbse/19.18.158

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

made suggest that it is possible to carry out STEM education with the integration of at least two disciplines (Bybee, 2010; Moore et al., 2014; NRC, 2009; NRC, 2014; Sanders, 2009).

New generation is needed that can do what machines cannot as Howard Gardner says, and that depends on creating innovations that can bring real value to life by combining the theoretical knowledge of physics, biology, chemistry and mathematics with the practice of technology and engineering. All these requirements have led to a holistic understanding that reflects an integrated view of more than one discipline. Wang (2012) defined the holistic teaching approach or strategy as an integration of knowledge, skills and values in different subject areas in order to teach concepts more meaningfully and effectively.

Problem of Research

21st century's knowledge-based life problems can be quite dynamic and complex. Gaining expertise in different branches within this complex and dynamic structure is beyond the competencies of individuals and it makes it compulsory for individuals to research together. Professionals need to be familiar with the expertise of the individuals they research together with and be open to learning. Professionals working in developed countries or working in partnership with their counterparts in these countries will be successful if they adopt this new profile (Corlu & Calli, 2017; Ministry of National Education, 2017).

It is possible to train individuals who can cope with the difficult conditions of the 21st century with well-prepared curricula that include the holistic approach of STEM education (Bybee, 2010). In STEM education, there are knowledge, skills and beliefs that are formed in the integration of multiple STEM fields (Corlu, 2013; Corlu, Capraro, & Capraro, 2014). And this necessitates the integrated nature of STEM fields. Students in STEM schools should be able to produce, think creatively, bring new ideas together to produce solutions, and specialize in the practice of STEM disciplines (Marshall, 2009). And the ability of students to gain the mentioned features and solve problems like a scientist depends on their integrated STEM knowledge.

Researches in the field of STEM education have been increased especially between the years 2014-2018 in Turkey. Most of the studies are carried out with secondary school students (Baran, Canbazoglu Bilici, Mesutoglu, & Ocak, 2016; Ceylan, 2014; Ercan 2014; Ercan & Sahin, 2015; Gokbayrak & Karisan, 2017; Irkicatal, 2016; Kececi, Alan, & Kirbag Zengin, 2017; Koyunlu Unlu & Dokme, 2016; Koc, 2017; Marulcu & Hobek, 2014; Pekbay, 2017; Yamak, Bulut, & Dundar, 2014; Yildirim, 2016). In the studies conducted with secondary school students, students' academic achievement, problem solving skills, creativity, STEM views, attitudes toward science courses, scientific process skills, questioning learning skills and persistence of knowledge were researched. In the studies conducted with teacher and pre-service teachers, STEM awareness, STEM attitude, engineering design perspectives, critical thinking tendencies, scientific process skills and scientific creativity skills of STEM and its activities were examined (Akaygun & Aslan Tutak, 2016; Bozkurt Altan et al., 2016; Aslan Tutak, Akaygun, & Tezsezen, 2017; Eroglu & Bektas, 2016; Hacioglu, 2017; Marulcu & Sungur, 2013; Sungur Gul & Marulcu, 2014; Yenilmez & Balbag, 2016; Yildirim & Altun, 2015).

Within the scope of STEM education, there are many skills that students are expected to gain. However, when it is considered that there are no teachers who have enough knowledge about STEM nor teachers that have adopted the integrated STEM curriculum, the need can be seen for supporting teachers' and pre-service teachers' on this path and conducting case studies on what needs to be done in the future to create good STEM practitioners.

This research was planned for this need. In this research, it was tried to develop *pre*-service science teachers' integrated teaching knowledge using Algodoo software which is a simulation program and to use STEM in four disciplines. When they design the simulations they also integrate their content knowledge, mathematics knowledge and technology knowledge. In this respect, the research is envisaged as a STEM application. With the research conducted, pre-service teachers did not only use STEM disciplines in active form, but also created a simulation pool which could be used in science education. Thus, it was hoped that the pre-service teachers would contribute to the integrated teaching knowledge.

Research Focus

In this research, which was conducted with an aim to support integrated teaching knowledge of pre-service science teachers, the effects of STEM applications on problem-solving skills were examined.

In this research, Algodoo computer program was used and it was aimed to support the integrated teaching knowledge of pre-service science teachers via a different STEM application case. In addition, the pre-service science

https://doi.org/10.33225/jbse/19.18.158

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

teachers were aimed to have information on STEM disciplines outside their field after these activities, as well as field knowledge and field training information. Diaries were kept by pre-service science teachers throughout the process. In addition, original designs developed using Algodoo software were presented by pre-service science teachers with microteaching technique and necessary arrangements were made as a result of peer and teacher evaluations.

This research aimed to answer the following questions:

1. What is the effect of STEM activities conducted with an aim of supporting the integrated teaching knowledge of pre-service science teachers on their problem-solving skills?
2. What are the feelings and thoughts about the STEM activities carried out in support of the integrated teacher knowledge of pre-service science teachers and what are the student assessments of the problems they encountered throughout the process?

Research Methodology

General Background

The research was conducted with pre-service science teachers who were studying at Fırat University in the academic year of 2016-2017. This research was conducted within the framework of a mixed method in which quantitative and qualitative methods are used together. Creswell and Plano Clark (2007) stated that the mixed method is a combination of qualitative and quantitative data and allows the research problem to be understood better than any single method. The research was carried out in scope of the mixed method design of convergent parallel design. The researcher equates the quantitative and qualitative methods with the converging parallel pattern of the mixed method, keeps these steps separate from each other during analysis, and combines the results in interpretation, the final stage (Creswell & Plano Clark, 2007).

Sample

The sample of the research was determined according to the concurrent mixed method sampling which was created by using the probabilistic and purposeful sampling procedures in order to obtain common data for both quantitative and qualitative sequences (Baki & Gokcek, 2012). STEM applications in the research required content knowledge. Basic content knowledge subjects are generally taught in the first and second grade level in the faculty of education programs in Turkey. According to the purpose of the sampling method, 3rd grade pre-service science teachers were selected. 3rd grade pre-service teachers were assigned to the experimental and control groups using random sampling method. In order to test the consistency of the groups, t-test was performed for the dependent samples according to year-end grade averages of the pre-service teachers in the experimental and control groups. There was no statistically significant difference between the end of year grade point average scores of the pre-service science teachers and the end-of-year grade points of the experimental group and the control group according to the t-test results, $t(30)=.403$, $p>.05$. This finding indicated that the experiment and control groups were equivalent. It was conducted with a total of 62 pre-service science teachers including 11 male and 51 female who were studying at a state university in the province of Elazığ, Turkey.

Instrument and Procedures

The data of the research were collected through the problem solving inventory test and prospects diaries during the process of the pre-service science teachers in the experiment group.

The Problem Solving Inventory Test (PSIT) developed by Heppner and Peterson (1982) was adapted to Turkish by Sahin, Sahin and Heppner (1993). The Cronbach Alpha reliability coefficient of the inventory was found to be .90 by the researchers who developed the PSIT. The least likelihood point that can be taken from the problem solving inventory consisting of 35 items with Likert type scoring 1-6 points is 32 points and the maximum score is 192 points.

Experiment and control groups were determined in the 1st week of the application and pre-tests were applied. Throughout the process, the current program has been implemented without any intervention in the control group. In the second week of the practice, STEM education and Integrated Teaching Knowledge were explained to pre-service science teachers in the experimental group and the importance of integration of different disciplines was mentioned. Then, Algodoo software to be used in STEM application to be realized in order to

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support integrated teaching knowledge was introduced and various designs were made using Algodoo software. Pre-service science teachers in the 3rd, 4th, 5th, 6th and 7th week of the application designed the simulation by using the Algodoo software and selecting the desired theme from the 5th, 6th, 7th and 8th grade subjects of the Science Curriculum. The prepared simulations have been presented by the members of each group at 8, 9 and 10th weeks with micro-teaching technique. The videos shooted during the micro-education were given to the groups and pre-service science teachers made necessary arrangements in the direction of peers and instructor criticism. Pre-service science teachers shot two videos for the simulations they designed. When the first video simulation contains the steps of how it was designed, the subject was narrated according to the class level of the selected subject using the simulation designed in the other video. A YouTube channel has been created for the videos that were taken, and it is therefore intended to reach wider masses (https://www.youtube.com/channel/UCHpLI321ho1Xl3FODeMAIRA). Teachers in the experiment group kept diaries throughout the process. In the 10th week, pre-service science teachers were subjected to post-tests.

Using Algodoo in STEM Training

Algodoo software was chosen for the integration of different disciplines in this research which was carried out in order to support integrated teaching knowledge of pre-service teachers. Algodoo software is a software that can make physics simulations. Therefore, there are tools for physics in the context of the program. Pre-service science teachers are freed from the in terms of choosing any information learning area to design a simulation. Although the program is physics-based, pre-service teachers are also designed of simulation for the chemistry and biology branches. In addition to field knowledge for designing simulations with Algodoo of pre-service teachers, there is a need of technology knowledge, engineering knowledge and mathematics knowledge. Pre-service science teachers were asked to convert their science knowledge into simulation examples. In this process, pre-service teachers used simulation techniques such as computer engineer. When they design the simulations they also integrate their content knowledge, mathematics knowledge and technology knowledge. In this respect, the research is envisaged as a STEM application. Any lack of knowledge in any of these four disciplines will adversely affect the design of the simulation. Throughout the process, the pre-service science teachers have been helped by their colleagues and department chiefs in science, technology, engineering and mathematics dimensions when designing simulations.

The explanations of STEM disciplines used by pre-service teachers were as follows:

Science discipline: Pre-service teachers had to use content knowledge in designing simulation in science education. The pre-service teachers would not be able to design the simulation if the content knowledge was missing. Therefore, during the course of the research, pre-service teachers updated and developed their content knowledge.

Technology discipline: Pre-service teachers needed to be technology literate to use the program. The pre-service teachers who were using the algodoo program would be able to control the software and use the computer related equipment in this process.

Engineering discipline: Pre-service science teachers had to use the algodoo software to master the program like a computer engineer and develop simulation. This process helped the pre-service teachers to develop themselves in engineering. In particular, they had understood the logic of the algorithm.

Mathematics discipline: Pre-service science teachers made calculations by using mathematical information while designing simulation by using algodoo software, calculated angles of geometric shapes, calculated diameters and they made scaling studies while adapting the field information to the simulation. Thus, the mathematical dimension was completed.

Data Analysis

In this research, descriptive statistical analysis was conducted on the data of each variable for the experimental group and the control group. Arithmetic means, standard deviation, kurtosis coefficient, skewness coefficient, minimum and maximum values of the data belonging to the groups were calculated. Descriptive statistical results were used to have an opinion on the data and to check the assumptions before analysis. In the literature, the application of the Shapiro-Wilks test is recommended if the group size is less than 50 to examine the normality of the scores (Buyukozturk, 2015; Rovai, Baker & Ponton, 2014). In this direction, the Shapiro-Wilks test was conducted to see if the scores were normal. SPSS 22 package program was used to analyze quantitative data.

https://doi.org/10.33225/jbse/19.18.158

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

The pre-service science teachers in the experimental group kept diaries throughout the process. In the analysis of the data obtained from the pre-service science teachers' diaries, content analysis was used. Content analysis is more detailed than descriptive analysis. The basic process in content analysis is to collect data similar to each other within the framework of specific concepts and themes, and then organize and interpret the collected data in a way that the reader can understand (Cepni, 2014). After reading the diaries several times, the codes were created by marking meaningful sections. The relation of the codes to each other had been examined. The diaries of pre-service science teachers were collected under the themes; "feelings and thoughts about STEM application, feelings and thoughts related to integrated teaching knowledge, feelings and thoughts related to Algodoo program, problems encountered throughout the process and solutions to these problems, student evaluations for presentation of the materials created."

Research Results

A STEM application was carried out with the pre-service science teachers in the experiment group for one term within the scope of the Science Teaching Laboratory Application course. In order to investigate the research questions of the research, two headings were created; "Descriptive Statistics" and "Inferential Statistics".

Results of Pre-Service Science Teachers' Problem-Solving Inventory Pre3-Test and Post-Test

The mean distribution of scores of problem-solving inventory test pre-test (pre-PSIT) and problem-solving inventory test post-test (post-PSIT) applied to the research group was examined. Table 1 compares the mean scores of the pre-service science teachers' PSIT test scores among groups, skewness and kurtosis values, standard deviation, Shapiro-Wilk values, minimum and maximum values.

Table 1. Descriptive statistics of pre-test and post-test scores of problem-solving inventory test of pre-service science teachers

Tests	Groups	Gender	*N*	$\overline{X}$	*SD*	Skewness	Kurtosis	Range	Min	Max	Shapiro-Wilk
Pre-PSIT	Experimental	Female	23	84.26	11.77	.476	.687	46	64	110	.143
		Male	8	94.50	11.45	-.330	-1.182	30	78	108	.392
		Total	31	86.90	12.37	.241	-.282	46	64	110	.185
	Control	Female	28	84.04	15.34	.067	-.559	54	57	111	.522
		Male	3	96.12	11.51	.394	1.044	39	78	117	.954
		Total	31	87.16	15.24	-.104	-.425	60	57	117	.819
Post- PSIT	Experimental	Female	23	68.60	9.07	.196	-.892	35	52	87	.194
		Male	8	75.50	11.37	-.130	-1.529	31	59	90	.681
		Total	31	70.38	9.99	.253	-.895	38	52	90	.148
	Control	Female	28	75.56	14.85	-.009	-1.235	50	50	100	.253
		Male	3	93.12	11.89	.280	.869	40	74	114	.887
		Total	31	80.09	15.99	-.085	-.753	64	50	114	.353

As shown in Table 1, before the application, the average of the pre-PSIT score ($\overline{X}$ =86.90) in the experimental group is very close to the average of the post- PSIT ($\overline{X}$ =87.16) of the control group. It seems that the problem-solving skills in the test among the groups were close to each other before the application.

There was the more difference ($\overline{X}_{dif}$=16.52) between the pre-PSIT score ($\overline{X}$ =86.90) and post-PSIT ($\overline{X}$ =70.38) scores in the experimental group, while the control group had a smaller difference ($\overline{X}_{dif}$=7.07) between the pre-PSIT score ($\overline{X}$ =87.16) and post-PSIT scores ($\overline{X}$ =80.09).

T test was conducted for unrelated samples to test the research question of the research. The results of the t test for the experimental group and the control group before and after the application are given in Table 2.

https://doi.org/10.33225/jbse/19.18.158

Table2. T-test results of problem solving inventory of pre-test and post-test scores of pre-service science teachers

		N	$\overline{X}$	*SD*	*df*	*t*	*p*
Pre-PSIT	Experimental	31	86.90	12.37	60	-.073	.942
	Control	31	87.16	15.24			
Post-PSIT	Experimental	31	70.38	9.99	60	-2.866	.006
	Control	31	80.09	15.99			

As shown in Table 2, there was no significant difference between the experimental and control pre-PSIT scores before application, $t(60)=-.073$, $p>.01$. However, there was a significant difference between the experimental and control group post-PSIT scores after the application, $t\ (60)= -2.866$, $p<.05$.

Results of Pre-Service Science Teachers' Diaries

The diaries maintained by pre-service science teachers during the semester were analyzed by inductive content analysis. After reading the diaries several times, the codes were created by marking meaningful sections. The generated codes were examined in terms of their relation to each other. Diaries of pre-service science teachers; feelings and thoughts about STEM application, feelings and thoughts towards integrated teaching knowledge, feelings and thoughts towards Algodoo program, problems encountered throughout the whole process and solutions for these problems are collected under the theme of student evaluations for presenting the created materials. The names of the pre-service science teachers were indicated by pseudonyms since they were not ethical.

The pre-service science teachers' feelings and thoughts about the practice of STEM were examined, it was seen that none of them had any information about STEM education before. When they were told what they needed to do during the process, they did not fully understand what they were going to do in the beginning, and after they were included in the process, they found that the question marks in their minds were going on.

Ayse: *"I heard about STEM education for the first time. I will first attend such an event. I sure will be interesting."*

Nese: *"I learned today what STEM education means. We are going to make an STEM event this semester. It sounds good. I hope we can do good research."*

Leyla: *"It was the first day of the lab and I learned a lot of things today. Obviously the eye is scared."*

Ahmet: *"I learned what STEM is and how it relates to the Algodoo program. We've always used ready-made simulations before. But now we will design the simulations. I already have crazy questions in my mind."*

Yusuf: *"A training I have not heard before and a program I have not heard yet. It scared me very much in the beginning. I did not understand the integration of the STEM disciplines before designing Algodoo. I understood the importance of STEM education in the application part much better."*

Asel: *"So far we have developed ourselves in the field of science only. We have never done such a research. We have not done anything other than use it to give a presentation the technology in particular. I wish we had met with this understanding of education before."*

The pre-service science teachers' feelings and thoughts about integrated teaching knowledge were examined, it was analyzed that it was not easy to combine different disciplines related to integrated teaching knowledge, but it was necessary that teachers should develop their selves not only in their own content knowledge but also in other disciplines.

Selin: *"We had a tough process. But in order to be a good science teacher, I only realized that the field knowledge was not enough. "*

Tugce: *"We did not have enough field knowledge to produce a product. We had to spend extra time with him too. "*

Yusuf: *"The contribution of this challenging process was really great. I think that the field knowledge, technology knowledge, imagination and creativity develops. I wish that every difficulty would end up in such a beautiful bit. "*

https://doi.org/10.33225/jbse/19.18.158

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Taha: "I can say that designing a simulation by combining our science, technology, mathematics and engineering knowledge on the program has really helped me in many ways."

The pre-service science teachers' feelings and thoughts about Algodoo program were examined, it was seen that many of them are anxious and at the same time excited because they have never heard of the Algodoo program before. In addition, the lack of computer skills of pre-service science teachers in the use of computers, lack of computers of every candidate and the foreign language of Algodoo program brought with them the pre-judgements of Algodoo program.

Pelin: "This period will be devoted to virtual experiments, unlike traditional, real experiments. These experiments will be done with the Algodoo program we heard for the first time. "

Tuba: "Algodoo program seems to be hard and time will ask. But I feeling very fortunate to be able to create virtual experiments and simulations with this program. When I am a teacher, I do not want to use classical teaching methods while teaching. I want to teach by adapting the science course to technology. Thus, I aim to make students love the lesson, increase their visibility, and make it permanent."

Selin: "This year we learned that we will make a transition to a very different and new concept in the laboratory lesson that I think we will do similar things with last year. We will now learn to teach our experiments in virtual environment by integrating our lessons into technology."

Faruk: "I heard the Algodoo program for the first time and watched the studies for the first time. Thanks to this program, science and technology have met and wonderful things have emerged. I think it's going to help us a lot in our professional lives."

Gamze: "I think the Algodoo program is fun, but it is a difficult program."

Gulcan: "I hate Algodoo because it's not even in Turkish. First of all, we need to do a lot of translation. Also the program is very difficult."

Zuhal: "Actually, I have no idea about the program, but I'm very prejudiced. Because I'm not a very dominant person on the computer. I think this lack of will force me. "

Tuba: "Algodoo is a fun program. But I think the tongue will force and tire us. But as ıt grow up with new generation technology, I think that this program will increase the students' attitude."

Elif: "I have to admit that even talks of our teachers have scared the eye. I have no idea how to do it."

Zeynep: "I was surprised to see Algodoo. As technology develops, every generation becomes more lucky than any other generation. "

Ayse: "As a teacher, I will be able to offer a visual aided course through this program even if there is no school material to attend. I think I will better describe the abstract concepts."

Leyla: "Actually, I was a bit scared at first because I could not use the technology well. But we will be teaching science and technology. We must use technology well and make good use of our students. "

Fatma: "I'm starting to feel sorry for not having my computer. Because I am in the thought that I will remain passive."

The pre-service science teachers initially had preconceptions and concerns about the algodoo program, but they found that it was quite enjoyable, fun and tutorial to be familiar with the program.

Omer: "We have solved many of the features of the program through trial and error, even if we have difficulties in the beginning. It's actually a very enjoable and fun program."

Asel: "The program requires hands-on skill, a wide range of imagination, creativity and field knowledge. We will see how successful we will be in the matter."

Ayse: "Unintentionally, I learned so much through trial and error that I now think I can do a lot in the program. It will be very useful in the future."

Pelin: "Whatever you do, the important thing is not the difficulty of the research that you are dealing with, but the taste and taste that it gives."

While many of the pre-service science teachers included emotions and thoughts, some pre-service science teachers did not give an idea about the course or the program that would be used by typing in an individual description of what was done during the lesson.


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ISSN 2538–7138 /Online/

Faruk: "Our teacher said that we will do the experiments from now on through this program. He showed a few experiments with Algodoo. He said leave the groups."

Burak: "We were told that we will do a virtual research with the Algodoo program. It was said that we should choose what we want from the subjects of the physics, chemistry and biology branches in the primary school curriculum."

Tugce: "Our teacher gave information about the program. He told us what to do during the semester. He said that we should create groups. "

Teacher candidates made opinions in their choice of topic, their attitudes towards the branches and the limits of the program. Seyma:"I think this program can be done in most subjects in the field of physics. But our imagination needs to be strong because we can do chemistry and biology. We chose physics because we thought it would be difficult." Gulbahar:"The program is in accordance to the physics lesson, but my group and myself decided to make the nitrogen cycle and digestion system in the biology even though it is hard for us to like the biology very much."

Selin: "We were going to choose physics in the beginning, but after a few tests we changed our mind. We finally found something we could do. We will do to transmission event in plants from biology."

Merve: "We chose simple machines as subjects. In this regard, we wanted to create a product by integrating both science and mathematics with technology."

Asl ı: "While we were trying to solve the program, we decided to talk about what we would choose as a group and eventually we decided to do the matter of breaking the light from the physics."

Filiz: "The program is predominantly prone to physics. But we chose to biology. So everything seems to be a bit more complicated and difficult. But as a group I think we can do it. "

The diaries of the pre-service science teachers were examined what problems they had encountered during the process. It was seen that they had encountered various problems throughout the whole process (lack of hardware, language of software, lack of technology knowledge, elimination of studies) and they produced alternative solutions for these problems. The problems encountered had always been seen as a disadvantage for pre-service science teachers, but when they were developing solutions, they had accomplished much better and had learned to turn this disadvantage into advantage.

Elif: "We can not draw this week the pulleys we had drawn last week. We could not find out what the trouble was, and it would be much easier if we could find it already. We got help from another of friends who solved the program better."

Rabia: "We came together to solve our problems last week as a group. The concretization of the lenses on the algodoo program forced us, the unit unit Prime center, the focal point, the center point, obviously difficult to adjust. It really requires patience."

Meryem: "It was a big trouble for me that the language of the program was English. So I started by translating every word in the program to Turkish before research. My familiarity with the programa increased as the tongue turned."

Ahmet: "I wanted to get information about how to make of the system by sending a message to someone who has made a solar system and has sent YouTube before. I e-mailed strangers when I couldn't get answers from them. I calculated the diameters of the sun and other planets mathematically to make the system real-scale. After this account, I calculated the distance of the planets to the sun. I adapted all of them to Algodoo."

Selin: "Everything we did was deleted. Because, there was a lot of cloning in the system. As a solution, we continued our way by registering each stage we made on Algodoo one by one. Whenever the system gives errors, we have to open the computer from the beginning. So we could finish the research."

Busra: "Everything we did when we did computer updates went away. We had to do it all over again. It took a little time, but ıt was much better than ıt old."

Filiz: "In the our simulation of the water cycle, which we're trying to explain, we solved the problem that we couldn't solve last week. In water cycle, we cut the mountains by using the razor feature of the program to show that water descends from the clouds to the mountains and enters the ground. We made it possible for the waters to penetrate the earth and form groundwater. Then we used the pulley system here to allow the water to evaporate and rise to the atmosphere. In this way, the water was able to move within the cycle. But we thought the reel system could lead to misconceptions in students. We are trying to produce a different solution."

https://doi.org/10.33225/jbse/19.18.158

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

The diaries of pre-service science teachers had been examined and the feelings and thoughts that they experienced during the presentation and evaluation of the studies which were the last stage of the process had been examined. It had been analyzed that all groups were very excited to present their research, they were curious about the other studies, and they made comments on the level of use of STEM disciplines in the studies.

Ahmet: *"My friends were eager to present their research to their class. It looks like they love Algodoo."*

Merve: *"I tried to score really objectively on the given observation formsI watched how much the study done for this was related to the STEM fields. Especially some friends are inadequate in the field of Science in explaining their study. I did not like some study."*

Gamze: *"Today we told about our own position, the "atomic models. It was so beautiful. It was the most exciting and beautiful day."*

Gulbahar: *"Everyone worked very hard to prepare the study. There was no activity in some studies. It seemed as though the topic was just a picture. However, using the program features, much more mobility could be achieved."*

Nida: *"There were very good study. But there are studies that need to be improved. …"*

Leyla: *"As a science and technology teacher by doing this practice, we have learned how to integrate math, engineering and technology to science."*

Ayse: *"I think this program should definitely be taught to pre-service teachers. We can enable our students to participate in the course, become more active in the course, and obtain permanent information."*

Elif: *"The design part is over and the sequence came to the presentations. The excitement of the first week was quite intense. I think our study represents our purpose very well."*

Faruk: *"Some studies have integrated STEM disciplines. But in the biology, for example, was not used because mathematical expressions were not very convenient."*

Burak: *"In physics, there were things I could not understand on some subjects. My problem was resolved today with the studies described."*

Discussion

In this research, which was conducted with the aim to support integrated teaching knowledge of pre-service science teachers, the effects of STEM applications on problem-solving skills, were examined.The problem-solving skills of pre-service science teachers in the experimental group in which the STEM application was performed were found to be significantly higher than the pre-service science teachers' in the control group. Based on this result, it is thought that the STEM application conducted with an aim to support the integrated teaching knowledge of pre-service science teachers is effective in developing the problem-solving skills of the pre-service science teachers. At the end of the research it was seen through the findings obtained from the analysis of the diaries kept during the process that pre-service science teachers had encountered many problems and had often been cited in the beginning that they thought they could not overcome these problems, but over time they dealt with these problems and they realized there was not a single way to solve a problem. When the relevant literature is examined, it is concluded that STEM education contributes significantly to the problem solving skills of individuals (Ceylan, 2014; Dewaters & Powers, 2006; Mauch, 2001; Pekbay, 2017; Kim & Choi, 2012; Sahin, Gulacar, & Stuessy, 2015; Gwon- Suk & Sun Young, 2012). In the majority of the studies, the effect of STEM education on the problem-solving skills of middle school students was investigated (Ceylan, 2014; Dewaters & Powers, 2006; Mauch, 2001; Pekbay, 2017; Sahin, Gulacar, & Stuessy, 2015). Pekbay (2017) investigated the effects of STEM activities on the problem-solving skills in everyday life in middle school students and found that STEM activities were effective in improving students' problem-solving skills. Ceylan (2014) examined the effect of the teaching method based on STEM education on the problem-solving ability of the students and found that the experimental group students were more successful in problem-solving skills than the control group students. Mauch (2001) found that the robotic application he made was effective in improving the problem-solving skills of middle school students. Kim and Choi (2012) researched the effect of the science-based STEAM program on problem solving skills. As a result of the research, it is found that the science-based STEAM program had a positive meaningful effect on elementary gifted students' problem-solving skills. Gwon- Suk and Sun Young (2012) determined that the science-technology-engineering-art-mathematics program (STEAM) contributed to the development of creative problem-solving skills

https://doi.org/10.33225/jbse/19.18.158

of gifted students in elementary school. Few studies were found that were done to determine the effect of STEM education on problem-solving skills of university students (Elliott et al., 2001). Elliott et al. (2001) examined the effects of STEM education on the problem-solving skills, critical thinking skills, and attitudes toward mathematics of university students in the study research they conducted. As a result of the research, there was no increase found in problem-solving skills but there was a slight increase in critical thinking skills and a positive increase in the students' attitudes towards mathematics. In order to be able to use and communicate such approaches, the aim of which is to improve the problem solving skills of individuals, teachers and pre-service teachers should have these skills. Shahali et al., (2015), in their study research, have found significant increases in STEM teachers or facilitators' efficacy, attitudes, beliefs, and knowledge of integrated STEM teaching. The fact that STEM training has led to an increase in the attitudes and beliefs of pre-service teachers and the increase in problem solving skills in this study research revealed that the effects of integrated STEM applications should be investigated more comprehensively. It is important to note that there is a need for further research with the pre-service science teachers in this regard, given the shortcomings of the pre-service teachers who will start their career in the near future. Therefore, it is thought that the contribution of pre-service teachers to be familiar with STEM education and practices will be important for the generation they will be educated. Researchers are advised to do studies in line with this deficiency.

Conclusions

Developments and breakthroughs have been made in Turkey in many areas to educate the younger generation equipped with 21st-century skills that can play an active role in today's social and economic conditions in accordance with the rapidly changing conditions in the world. These are important reforms on education such as; weekly course schedules, educational programs, physical environments, technological infrastructure, textbooks and other educational tools. However, the reality is that teachers have a key role in education. Any reform initiative that a teacher does not adopt and cannot internalize fails to succeed and therefore these reforms cannot be transferred to the classroom environment. Therefore, it is necessary for teachers and pre-service teachers to be dominant in the education reforms. In this research, it was found that the STEM application conducted with an aim to support the integrated teaching knowledge of pre-service science teachers is effective in developing the problem-solving skills of the pre-service science teachers. Pre-service teachers had concerns before the research process because of lack of sufficient knowledge about STEM education. At the end of the process, they were very excited to present their research and they made comments on the level of use of STEM disciplines in their peers' studies. Most of the problems the pre-service science teachers had encountered in the process were about lack of technology knowledge. However, it was determined that pre-service teachers tried to solve these deficiencies and solved their problems.

This research was an example of STEM education by using simulation program. This research has helped pre-service science teachers to understand the difference between STEM education and the current education system by increasing their awareness of STEM education. Pre-service science teachers studied in groups throughout the process. Pre-service science teachers, particularly while designing a simulation using the Algodoo software, had received help from friends and instructors in the knowledge of science, technology, engineering and mathematics. During the process, pre-service science teachers were forced to use the most technology. However, keeping up with the technology age we live in is within the objectives of the curriculum. Pre-service teachers can not be expected to transfer to the students who will raise an area that they do not know. It is recommended that education faculties train pre-service teachers better in terms of technology knowledge. It is also recommended that the number of in-service training be increased in order for teachers to be good STEM practitioners.

Acknowledgements

This research was conducted from the related parts of master thesis entitled "Supporting Preservice Science Teachers' Integrated Teaching Knowledge: Preparation Training Practices To STEM". This research was supported by Fırat University Scientific Research Projects Unit.

https://doi.org/10.33225/jbse/19.18.158

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

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ISSN 2538–7138 /Online/

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Received: *December 21, 2018* Accepted: *March 10, 2019*

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https://doi.org/10.33225/jbse/19.18.158