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INVESTIGATION OF PRE-SERVICE TEACHERS' AWARENESS OF STEM AND STEM TEACHING INTENTION

Research article

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INVESTIGATION OF PRE-SERVICE TEACHERS' AWARENESS OF STEM AND THEIR STEM TEACHING INTENTION

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Abstract

STEM education is an interdisciplinary educational implementation, and can easily be designed via collaborative efforts of teachers in order to provide students with comprehensive, meaningful and unique learning experiences. For effective STEM practices, the role of teachers is very important. The teachers who are able to handle STEM education are supposed to integrate different disciplines in the teaching/learning situations in the achievement of course objectives. In this sense, awareness and intention of pre-service teachers have a very important place for their future professional implementations. In this study, pre-service teachers' awareness of and intention towards STEM education were examined. . The study adopted one group pre-test post-test research design. The participants were composed of 192 pre-service teachers in the departments of Computer Education and Instructional Technology, Science Education, Elementary Mathematics Education and Turkish Language Education in a state university in central Anatolia. The results revealed that the participants who could adopt STEM education, make use of interdisciplinary activities, and who were interested in developing their interdisciplinary knowledge were more aware of STEM and had positive intention towards STEM education.

Keywords: STEM, awareness, intention, pre-service teacher, interdisciplinary activities

1. Introduction

STEM education is an interdisciplinary approach aimed at holistic teaching of science, technology, engineering and mathematics disciplines. STEM education has emphasized four different disciplines but today the emphasis is placed on the integration of these disciplines and other fields. Integrated STEM education is very important for students to have relationship building skills and holistic perspective. STEM education allows students to apply what they have learned in the learning environment to their future professions in the real world (Ejiwale, 2013). Regarding economic growth in the 21st century, employees must have science and math skills, creativity, expertise in information and communication technologies, and the ability to solve complex problems (Jayarajah, Saat & Rauf, 2014). A strong STEM education uses pre-school based problem and inquiry based approaches and offers students practical activities (Tanenbaum, 2016). STEM education in K-12 and higher education should be seen as an undoubted necessity in meeting the needs of a scientifically and technologically literate workforce in a modern and technology oriented country (Hossain & Robinson, 2012). STEM education prepares students for the challenges and opportunities of the 21st century economy and STEM is the basis for the workforce. Research shows that basic cognitive knowledge, skills and abilities associated with STEM education are in demand in almost all business sectors and professions (Carnevale, Smith & Melton, 2011). STEM education builds trust in one's own abilities and encourages self-study to learn education in formal and informal learning environments and at the same time ensures the involvement of family and society (Wang, 2012). STEM education enhances awareness of the professions of STEM fields and the relationship between in-school and out-of-school learning opportunities, providing introduction and foundation to courses leading to success throughout pre-school levels (Nathan, Atwood, Prevost, Phelps & Tran, 2011). STEM education equips learners with the skills and confidence to think and act in relevant aspects of civil life. Therefore, individuals who want advanced learning opportunities in STEM fields for success in higher education institutions should be supported (Dejarnette, 2012).

STEM education is an interdisciplinary application of knowledge and is a philosophy designed around collaborative efforts to provide students with comprehensive, meaningful and unique learning experiences (Albrecht & Gomez, 2014). Banks and Barlex (2014) stated that it is important to teach science and technology in a wider context with mathematics and engineering, because when disciplines are taught discrete, students are not able to recognize the connection between different contents and cannot develop a systematic comprehensive view of the world around them. While STEM education makes use of different disciplines in finding solutions to daily life problems related to each other in different subjects; enables students to develop a holistic perspective (Berlin & Lee, 2005; Daugherty, 2013; Kuenzi, 2008).

STEM education will have an effective role in the solution of the problems of the 21st century, daily life problems (Brophy, Klein, Portsmore & Rogers, 2008; National Research Council [NRC], 2012). In this sense, it is obvious that countries will need individuals trained in STEM. For an effective STEM education, the role of teachers is very important. It is presented in the literature that teachers and prospective teachers should receive in-service and pre-service training on STEM education (Akaygün & Aslan- Tutak, 2016; Tezel & Yaman, 2017). The interdisciplinary view of pre-service teachers while they are studying at the undergraduate level will enable them to have an important role in raising qualified individuals in the STEM areas when they start working as teachers. Through teachers who know STEM education, they will be able to handle different disciplines in an integrated way. In order to achieve the objectives related to STEM education, teachers who have sufficient knowledge and skills regarding STEM education are needed.

Awareness is defined as social groups and individuals being conscious and sensitive towards the environment. By the gain of awareness, there is an increase in the consciousness of the individual about himself and his environment. It is possible to increase the levels of awareness about the thoughts and feelings that direct the behavior of the individual. The intention towards STEM education includes many areas such as awareness and knowledge, value, attitude and behavioral tendency. In this context, it is important to determine the intention and awareness of teachers and pre-service teachers regarding STEM education. In this study, the pre-service teachers' awareness status and their intention towards STEM education were examined. The research question of the study was formulated as ***"What is the pre-service teachers' awareness of and intention to the use of STEM education in their classes?"***

2. Method

The study utilized one group pre-test post-test research. The details about the components of the study are given as follows:

2.1. Participants

The participants of this study were 192 teacher candidates in the departments of Computer Education and Instructional Technology, Elementary Science Education, Elementary Mathematics Education and Turkish Language Education in a state university in Central Anatolia.

Some demographic information of the participants is given in Table 1.

Table 1. *Some demographic information of the participants*

	Gender		
Program	Female	Male	Total
Turkish Language Education	54	24	78
Elementary Mathematics Education	18	7	25
Elementary Science Education	46	18	64
Computer Education and Instructional Technology	9	16	25
Total	127	65	192

2.2. Implementation Process

There are many models and teaching strategies that can be used to relate/integrate areas in STEM education. Dugger (2010) proposes four models for associating/integrating STEM areas, and Bybee (2013) proposes nine models. We can express the most frequently used of these models in the literature. A model where all STEM areas are given separately. The model is expressed as S-T-E-M or "silo". There is no association or little association between domains (Dugger, 2010). A model that focuses on two STEM areas and the other two less. This model can be expressed as SteM (Dugger, 2010). The model is based on the association of science and mathematics by emphasizing technology and engineering (Bybee, 2013). The other model is the model in which a STEM field is integrated with the other three areas (Dugger, 2010). The last model is the model given as an integrated area by integrating all fields (Dugger, 2010). Advocates of integrated approaches in STEM education state that STEM can be tailored to students by integrating them in the context of real-world issues and challenges, thereby increasing learning, student achievement and motivation (Honey, Pearson & Schweingruber, 2014). With the integrated STEM pedagogy, students are expected to use mathematics, science and engineering concepts and practices to design, implement and evaluate solutions to authentic problems (Sanders, 2012). Integrated STEM activities are examples of constructivist practices in education. For this reason, integrated STEM education pedagogy is based on learning and information center (Bransford, Brown & Cocking, 2000).

The study was based on an integrated STEM education, and project based learning. Project-based learning is a model in which learning is organized around projects. Projects are difficult and complex tasks involving design, problem solving, decision-making activities, and the process results in a concrete product (Thomas, 2000). In project based learning; As in STEM education, research is carried out by combining real-life problems of different disciplines, data are analyzed, data is collected and the project is presented at the end (McGrath, 2002).

In the study, pre-service teachers from diverse fields of education carried out group works with the instructors in their own department. In the group works, pre-service teachers from each department developed activities that allow higher-level thinking skills. All groups worked to get their activities to promote interdisciplinary thinking. In STEM activities, students' work with different disciplines on projects is similar to the collaboration of STEM experts in real life (Capraro, Capraro & Morgan, 2013). This event development process was considered as the first stage for an interdisciplinary perspective. Following this activity of the developmental process, each department provided some essential theoretical information about STEM. Then, they came together and developed their projects through interdisciplinary cooperation in groups. The formative assessment of the project process was carried out on Flipgrid platform.

In the process, initially, the participant teacher candidates were divided into 20 groups of 10 or 11 members each. In each of groups, there were at least two members from Mathematics Education, Two Turkish Language Education, one Science Education, and 1 Computer Education and Instructional Technology departments. The accounts were defined to represent the group numbers so that each teacher candidate in the groups in the study can login to the system. In the first project meeting, where the Flipgrid platform was also introduced, groups were brought together, account names and passwords of each group were shared with the group members. The aim was to make it easier to follow the project steps of all groups. In this meeting, the groups were given a basic training on the use of the Flipgrid platform. At the end of this training, each group was allowed to login to the platform, to share videos and to provide feedback for other groups. In order to provide formative evaluation of the STEM project steps of the groups in the classroom, the tasks were defined with date ranges according to the project schedule. These tasks were listed as trial application, preparation of draft project topics, STEM project topic selection, determination of project objectives, preparation of project plan, implementation of the project plan, evaluation of the project, presentation of the project. The project process was carried out with the feedback given by faculty members and groups to each other.

If we look at the examples from STEM projects developed by the groups; In the Turn Brighten project, the group designed a product that meets the electricity needs of the parks by converting and storing the energy of motion as a result of the use of sports equipment in the parks. In the Smart Irrigation System project, the group has developed an irrigation system, which activates the irrigation system according to the needs of the plant by controlling the moisture content of the soil. In the Water Expense Electric Income project, the group has developed a product that provides electrical energy from wastewater in the living areas. In the Safe with Radar Project, the group has developed a radar system that is designed for pedestrian crossings and integrated with traffic lights in order to ensure the safety of the students crossing in front of the school.

2.3. Data Collection Tools

In the study, STEM Awareness Scale (SAS) developed by Buyruk and Korkmaz (2014) was administered as a post-test to prospective teachers. In the scale with 17 items the five point Likert scale was used. Cronbach’s alpha reliability coefficient was calculated as .89.

In the study, Integrative STEM Teaching Intention Questionnaire was also adminitered to pre-service teachers as a pre-test and a post-test in order to examine the intention of pre-service teachers to STEM teaching. This questionnaire was developed by Lin and Williams (2015) and adapted to Turkish by Hacıömeroğlu and Bulut (2016). It consisted of 31 items and 7-point Likert type was used. Cronbach’s alpha coefficient was determined as .94 (Hacıömeroğlu & Bulut, 2016). In this study, Cronbach's alpha internal consistency coefficient of the scale was calculated as .97 for the pretest and .90 for the posttest. Both values indicated high reliability.

2.4. Data Analysis

The qualitative data obtained within the scope of the study were analyzed via SPSS. Two-way analysis of variance was utilized in order to interpret the STEM awareness of the teacher candidates on the basis of program and gender. Awareness scores were used as dependent variables, and program and gender data were used as independent variables.

In addition, another two-way analysis of variance was used to determine whether STEM Teaching Intention Questionnaire pre-test results differ on the basis of program and gender. Repeated measures analysis of variance was used to determine whether the pre-test and post-test results of this scale differ significantly on the basis of program and gender. Intention pre-test and post-test scores were used as dependent variables, and program and gender data were used as independent variables.

Before analyzing the data, the assumptions for the statistical method to be applied were tested. Primarily, outlier analysis has been carried out. Descriptive, graphical and statistical methods were used in the analyzes conducted to determine whether the data provided the normality assumption. Within the scope of these evaluations, it was observed that the analysis of variance used for STEM awareness and intention questionnaire provided the normality assumption. Graphically, it was determined that the data were distributed in the form of a bell shaped curve, the expected and observed values with the Q-Q graphics were consistent, and the results obtained from the Kolmogorov-Smirnov test were not statistically significant. These results reveal that the data show a distribution close to normal. Box's M-test and Levene test results were examined for the assumption of variance-covariance matrixity homogeneity and the p-value was not found significant for both tests in the related comparisons.

3. Findings

The findings obtained from the research are discussed within the context of STEM Awareness Situations and Intention to Integrative STEM Teaching as given in the following.

3.1. STEM Awareness

Under this heading, there are findings on the level of STEM awareness of the students and whether these values differ significantly according to the program and gender.

Table 2. *Distribution of STEM awareness scores*

	N	Lowest Score	Highest Score	$\bar{x}$	SD
STEM Awareness Status	192	2.65	5.00	4.24	.48

When Table 2 is examined, it is seen that the average of the STEM Awareness Status scores of the teacher candidates is 4.24, the standard deviation is .48, the highest score is 5.00 and the lowest score is 2.65. This finding shows that pre-service teachers have high awareness of STEM.

Two-way analysis of variance was conducted to examine the effects of program and gender variables on the awareness score. Participants were examined in 4 groups on the basis of the program as Group 1 (Turkish Language Education), Group 2 (Elementary Mathematics Education), Group 3 (Elementary Science Education) and Group 4 (Computer Education and Instructional Technology). The effect of interaction between gender and program variables is not statistically significant, $F(3,184) = 1.28$, $p = .28$. Main effect for the program, $F(3, 184) =$

1.95, p = .12 did not reach statistical significance. Similarly, there is no statistically significant main effect for gender, F (1, 184) =. 07, p = .80.

3.2. Comparison of Intention for Integrative STEM Teaching

The results of the Integrative STEM Teaching Intention Questionnaire are given below with different comparisons.

3.2.1. Pre-test Results of the Questionnaire of Intention to Integrative STEM Teaching According to Program and Gender

A two-way analysis of variance was conducted to examine the effect of program and gender variables on the intention pre-test score. Participants were examined in four groups based on program as Group 1 (Turkish Language Education), Group 2 (Elementary Mathematics Education), Group 3 (Elementary Science Education) and Group 4 (Computer Education and Instructional Technology). The effect of interaction between gender and program variables is not statistically significant, F (3,184) =. 45, p = .72. The main effect for the program reached statistical significance, F (3, 184) = 8.39, p = .00, but the effect size found was small (partial eta squared = .12). Post-hoc comparisons made by using Bonferroni were determined as the mean scores obtained for Group 2 (M = 5.05, SD = .67) and Group 3 (M = 5.10, SD = .76) in Group 1 (M = 4.40, SD = .93) and It shows that it is significantly different from the mean scores obtained for Group 4 (M = 4.42, SD = .80). There was no significant difference between the scores of Group 2 and Group 3 and similarly between the scores of Group 1 and Group 4. For another variable, gender, the main effect, F (1, 184) =. 47, p = .49 did not reach statistical significance.

3.2.2. Comparison of Pre-test and Post-test Scores of the Integrative STEM Teaching Intention Scale by Program and Gender

Participants in the study are based on the program in Group 1 (Turkish Language Education), Group 2 (Elementary Mathematics Education), Group 3 (Elementary Science Education) and Group 4 (Computer Education and Instructional Technology) in four groups. It was determined that there was a statistically significant increase in the intention of the participants to integrative STEM teaching from pre-test scores (M = 4.71, SD = .87) to post-test scores (M = 5.68, SD = .60); F (1,184) = 184.57, p = .00. However, repeated measures variance analysis was performed to determine whether the pre-test and post-test scores differ on the basis of program and gender. As a result of the analysis, it was seen that the interaction between the program and the pre-test and post-test scores within the scope of gender variables did not make a significant difference F (3, 184) =. 40, p = .75. It was determined that the pre-test and post-test scores differ only in the evaluations made on the basis of the program, F (3, 184) = 5.14, p = .00. However, the effect size obtained is small (partial eta squared = .08). In the post-hoc analysis conducted, no significant difference was found between Group 2 and Group 3. Similarly, there is no significant difference between Group 1 and Group 4. However, it was determined that the change in the pre-test and post-test scores of Group 2 and Group 3 differed significantly from the change in Group 1 and Group 4 pre-test and post-test scores. It was determined that pre-test and post-test scores did not differ only in the evaluations made on the basis of gender, F (1, 184) = 1.41, p = .24.

4. Discussion, Conclusion and Recommnendation

In the literature, the importance of STEM education and the need to increase awareness and intention regarding this education are stated in order for countries to keep up with the developments in the 21st century. For an effective STEM education, the role of teachers is very important. It is presented in the literature that teachers and prospective teachers should receive in-service and pre-service training on STEM education (Akaygün & Aslan- Tutak, 2016; Tezel & Yaman, 2017). Considering the importance of pre-service teachers to acquire interdisciplinary perspectives while studying at the undergraduate level, awareness and intention of pre-service teachers towards STEM education is of great importance. In this study, based on this finding, the pre-service teachers' intention and awareness status towards STEM education were examined.

In the study, the intention scale for STEM teaching was applied as pre-test and post-test. In the pre-test results obtained, the intention towards STEM teaching shows that the science and mathematics teacher candidates' intention towards STEM is higher when compared between the departments. It is thought that pre-service teachers of science and mathematics education have a high intention towards STEM education because they mostly see science and mathematics subjects in the program. The fact that more science and math applications are included in the science and mathematics teaching curriculum than other departments may be effective in the high level of intention towards STEM education. The studies in the literature support this view, and it is stated that science teacher candidates think that mathematics and technology are necessary in science, that STEM education will be beneficial in science education, and science-mathematics-engineering and technology are integrated (Kızılay, 2016). In the study of science teacher candidates, Altan, Yamak and Kırıkkaya (2016) stated that STEM education is beneficial in terms of developing education by making student candidates, making learning permanent, directing research and questioning, making learning enjoyable, and designs that are useful in learning subjects. It was seen that pre-service mathematics teachers did not have difficulties in designing a STEM based learning environment and this situation was interpreted as it could help in establishing the connection between mathematics and science considering the science-based lessons they took in previous years (Delen & Uzun, 2018). At the same time, this situation can be interpreted as the pre-service mathematics teacher candidates frequently deal with real-life problem situations in the mathematical modeling course and other courses they take in the curriculum.

According to the results of the repeated measures analysis of variance, a significant difference was observed from pre-test scores to post-test scores. When this difference is analyzed on the basis of program, it was determined that the intention scores of Turkish and CEIT programs increased significantly and with this increase, the intention scores of all programs approached each other. This situation can be interpreted with the effectiveness of the Project-based application model applied within the scope of the research. The pre-service teachers who study in each department can configure their own learning, develop their creativity, develop products in collaboration, and participate actively in this process, as the candidate teachers can show an intention towards education when they start working. Project-based learning is also mentioned in the literature as an effective model that can be used in STEM education approach (Breiner et al., 2012; McGrath, 2002; Selvi & Yıldırım, 2017). At the same time, it is thought that using the integrated approach in associating STEM areas has an important role in the effectiveness of the process. It supports this view in the studies in the literature. Çorlu, Capraro and Capraro (2014) stated that pre-service teachers who graduated from integrated teacher education programs, where pre-service teachers studying in different programs, received education together, more fully understand STEM. At the same time, the positive outcomes of the integrated STEM education approach are expressed in effective learning (Becker & Park, 2011). Advocates of integrated approaches in STEM education state that STEM can be tailored to students by integrating them in the context of real-world issues and challenges, thus increasing learning, student success and motivation (Honey et al., 2014,

p. 21). Integrated STEM activities are examples of constructivist practices in education. A framework and context are provided to understand abstract concepts in the event. It enables students to actively configure the information they use in context, to remember and to facilitate the transfer of learning. For this reason, integrated STEM education pedagogy is stated as learning and knowledge centered (Bransford, Brown & Cocking, 2000).

In this study, STEM awareness situations of pre-service teachers were discussed in terms of various variables. As a result of the study, when the scores and averages regarding STEM awareness level were examined, it was found that the students had a high average level. This shows that pre-service teachers have an awareness of STEM. As a result of the research, contrary to the literature, there was no significant difference between STEM awareness and intention status by gender. There are many studies in the literature stating that men dominate in the field of STEM than women (Goan, Cunnigham, & Carroll, 2006; Saucerman & Vasquez, 2014).

The results of this study have revealed the data about pre-service teachers' awareness of and their intention and towards STEM education. The teachers who are able to integrate STEM activities in their classes using their interdisciplinary knowledge and skills are more aware of STEM and have higher level of intention to conduct STEM education in their classes.

Based on the findings of this study, it can be recommended to include STEM education oriented courses in teacher education programs. Because all disciplines coexist, the integrated learning model can actively be used in facilitating STEM education with considerably ease.

5. Conflict of Interest

The authors declare that there is no conflict of interest.

6. Ethics Committee Approval

The authors confirm that the study does not need ethics committee approval according to the research integrity rules in their country.

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