Effects of STEM Based Activities on In-Service Teachers' Views

Serkan TİMUR[1]

Çanakkale Onsekiz Mart University

Betül TİMUR[2]

Çanakkale Onsekiz Mart University

Nagihan İMER ÇETİN[3]

Çanakkale Onsekiz Mart University

Abstract

In this study we investigated the effect of STEM based activities on in-service teachers' views about STEM teaching. Pre-test and post-test research design was employed to investigate teachers' reactions to STEM based activities. The participants were 39 in-service teachers from different majors who were working as teachers in public schools in Turkey. The teachers attended a 40-hour STEM training course in which STEM based activities were performed. "Pre-service Teachers' Integrative STEM Teaching Intention Questionnaire" was used to measure teachers' views on STEM teaching. The results showed that STEM based activies had a positive effect on teachers' views about STEM education.

Keywords: STEM, STEM teaching, STEM based activities, teachers

1 Assoc. Prof. Dr., Faculty of Education, Çanakkale Onsekiz Mart University, Turkey, ORCID ID: 0000-0002-4949-2275
Correspondence: serkantimur42@gmail.com

2 Assoc. Prof. Dr., Faculty of Education, Çanakkale Onsekiz Mart University, Turkey, ORCID ID: 0000-0002-2793-8387,

3 Assist. Prof. Dr., Faculty of Education, Çanakkale Onsekiz Mart University, Turkey

Introduction

In recent years interdisciplinary teaching has gained increasing importance in the field of education (Jones, 2009). Because disciplinary-based teaching brought along a big problem, it caused students to think "Teachers teaching us only academic information, and these are not necessary for me to learn about how to live in real life." Education is more meaningful and valuable to students when it reflects real life rather than teaching the curriculum in subjects (Antov & Pancheva, 2016). Therefore, as time has changed, the way we teach must be changed. The role of the school should not only teach learning and academic performance but also prepare students for life. Students should be equipped with innovative and creative thinking skills to solve problems in authentic contexts (Larson & Miller, 2011). According to Greenberg et. al. (2003), fundamental mission of school is to teach not only basic skills as reading, counting, writing, it should teach beyond these basic requirements. Today's school has to connect lessons into real life applications and clarify students how they can use the learning materials in the outside world. Teachers should enable students to see the relevance of subjects with each other. There is a general consensus among educators about the common problem in schools today is that the separate subject approach in education (Furner & Kumar, 2007). It is asserted that students' problem solving skills depends on their understandings about the context within the problem (Frykholm & Glasson, 2005). Furner and Kumar (2007, p. 186) likened separate subject curriculum as "a jigsaw puzzle without any picture". At this point, a new educational approach which defends integrated curriculum has emerged in education called STEM.

What is STEM Education?

STEM defined as acronym for science, technology, engineering, and mathematics (Bell, 2016; Dugger, 2015). But it means much more than this acronym (Ostler, 2012). STEM education aims to teach the disciplines of science, technology, engineering and mathematics as a whole (Breiner, Harkness, Johnson & Koehler, 2012). Thus, students who are taught with these integrated disciplines have ability to solve problems faced in real life. Because problems in real life are not in the form of separate disciplines as taught in lessons (Czerniak et al., 1999; Wang, Moore, Roehrig, & Park, 2011). Since real life problems are very complex, it is impossible for discipline-based teaching to solve and define these problems (Antov & Pancheva, 2016). Bybee (2010) stated that the modern world problems as energy, health, and the environment could be solved by only integrated curricular. STEM education gives chance students to have learning experience in real world issues instead of teaching bits and pieces (Tsupros, Kohler & Hallinen, 2009) and help them to be aware of how subjects are relevant to their lives. It helps students to appreciate the value of what is taught in school (Moore, 2008). These lead to increase in students' interest, motivation, persistence and success in school (Honey, Pearson & Schweingruber, 2014). For all these reasons, STEM education has received

increased attention. Many countries have shaped their curriculum across STEM disciplines (Corlu, Capraro & Capraro, 2014).

Promoting Teachers in STEM Education

All scientists came to consensus on the benefits of STEM education. But, the crucial question is that "How do teachers perceive "STEM" and how do they implement STEM education while teaching their subjects?". A major problem here is that the disconnection between how teachers teach STEM subjects in schools and teachers' skills and knowledge necessary for STEM education (Cuadra & Moreno, 2005). According to Srikoom, Hanuscin and Faikhamta (2017), being a STEM teacher requires special knowledge beyond being a teacher and the central role of teachers is to teach STEM activities. Several studies show that teachers are well versed in their subject matter knowledge but they lack of skills in STEM education (EL-Deghaidy, Mansour, Alzaghibi & Alhammad, 2017). According to Wang et. al. (2011), this problem primarily depends on the lack of instructions for teachers to the use of STEM education effectively in classrooms. Srikoom, Hanuscin and Faikhamta (2017) claimed that teachers should be given guidelines on how to integrate STEM education into their classrooms. Another limiting factor is that teachers' inadequate content knowledge in other disciplines because STEM education means interaction with four disciplines. Sanders (2009) indicated that STEM education requires teachers to be expert not only in their subject but also requires them to be informed at least one other STEM subject. All of these inadequacies affect teachers' STEM implementation (National Academy of Engineering and National Research Council, 2014). In this regard Kline (2005) proposed to reconstructe pre-service training and in-service training program within the scope of innovative and contemporary STEM education. On the other hand, teachers' perceptions regarding STEM is likely to be the most important factor for educators should take into consideration. Because teachers' perceptions, knowledge and beliefs affect how teachers shape their teaching practice and their decisions in the classroom (Srikoom, Hanuscin & Faikhamta, 2017). Little research exists in the field of inservice education to accurately determine the benefits of STEM education in promoting inservice teachers' views about STEM teaching (Aydın & Şahin, 2018). It is also important to examine in-service teachers as a sample group because in-service teachers are the pioneers of teaching process. Their views, perceptions, beliefs etc. on a subject will directly affect their teaching. Due to these reasons, in this study we focused on how STEM based activities will affect teachers' views about STEM education.

Aim of Research

The aim of this study is to investigate the effect of STEM based activities on teachers' views about STEM teaching. The research questions are as follows:

- Is there a significant difference between pre-test and post-test scores in teachers' views about STEM teaching?

- Do the increase in teachers' test scores differ according to teachers' gender?

- Do the increase in teachers' test scores differ according to their majors?

- Do the increase in teachers' test scores differ according to their professional seniority?

Research Methodology

Research Model

In this study, pre-test and post-test design without control group was chosen to determine the effect of STEM based activities on teachers' views about STEM teaching. The aim of this design is to test the effectiveness of an intervention. Therefore, pre-test and post-test are used to measure the difference in participants' test score which indicates the change in the value of the dependent variable (Dimitrov & Rumrill, 2003).

Participants

A total of 39 in-service teachers from different majors who were working as teachers in public schools participated in this study. Teachers' detailed demographic information is shown in Table 1.

Table 1. Descriptive statistics of teachers' general characteristics

Variable	Category	N	%
Gender	Female	22	56.4
	Male	17	43.6
Majors	Computer teacher	3	7.7
	Chemistry teacher	5	12.8
	Math teacher	7	17.9
	Physics teacher	4	10.3
	Science teacher	2	5.1
	Biology teacher	6	15.4
	Geography teacher	2	5.1
	Child development teacher	3	7.7
	English teacher	3	7.7
	Guidance teacher	1	2.6
	Pre-school teacher	1	2.6
	Visual arts teacher	1	2.6
	Speacial education teacher	1	2.6
Professional seniority	10 years and less	9	23.1
	11-19 years	19	48.7
	20-more	11	28.2

Procedure

The teachers attended 40 hours STEM training course carried out by researchers in which STEM based activities were performed. The detailed information about the content of the training was shown in Table 2.

Table 2. The content of STEM training course

Content	Duration (Hours)
Applications to Create Project Based Course Design in STEM Education Designing Project-based course in STEM education Evaluation of project-based course designs in STEM education	4
Applications to Create Inquiry Based Course Design in STEM Education Designing Inquiry-based course in STEM education Evaluation of inquiry-based course designs in STEM education	4
Applications to Create Context-Based Course Design in STEM Education Designing Context-based course in STEM education Evaluation of context-based course designs in STEM education	4
Applications to Create Modelling Design in STEM Education Designing a model in STEM Education Designing concrete models by using origami in STEM education Evaluation of models in STEM Education	4
Coding Applications in STEM Education Designing STEM Coding Project Evaluation of STEM Coding projects	5
Robotic Project Applications in STEM Education Designing STEM Robotics Project Evaluation of STEM Robotics projects	5
Effective Presentation Techniques / Application Examples Designing effective presentation in STEM education Evaluation of presentations in STEM education Web 2.0 Tools in STEM education	4
Evaluation of STEM Activities / Application Examples Designing alternative measurement tools in STEM education Creation and evaluation of rubrics in STEM education	4
Teaching Methods and Techniques to be used in STEM Education / Application Examples	4
Measurement and Evaluation	2
Total	40

Data Collection Tools

We utilized "The Pre-service Teachers' Integrative STEM Teaching Intention Questionnaire" (Lin & Williams, 2015) to measure teachers' views on STEM teaching. The instrument consists of 31 items and distributed over five subscales, including knowledge (α=0.93), value (α=0.86), attitudes (α=0.87), subjective norms (α=0.69), perceived behavioral controls, and attitudes on the behavioral intention (α=0.86). The scale's adaptation to Turkish was done by independent researchers (Hacıömeroğlu & Bulut, 2016). Cronbach alpha reliability coefficient of the Turkish version of the scale was found to be .94.

Data Analysis

Statistical analyses were performed by using SPSS.21 Package program. Parametric tests are used when the data are normally distributed and the sample size is above 30. Statistical differences between two groups are evaluated by using t-test. If sample size is below 30 and data has not a normal distribution, non-parametric tests are used. In this study, statistical differences were tested using Paired Sample t-test, Mann in Whitney U test, and Kruskal Wallis H- Test.

Research Results

Research results of the study are given below in the direction of the research questions.

Research question 1: Is there a significant difference between pre-test and post-test scores in teachers' views about STEM teaching?

Paired sample t-test was used to determine whether there is significant difference between pretest and posttest scores. The results are shown in Table 3.

Table 3. Paired Sample t test results according to the pre-test and post-test results of pre- service teachers' integrative STEM Teaching Intention Questionnaire

	N	X	Sd	df	t	P*
Pre test	39	175.71	20.29	38	-8.36	.000
Post test	39	196.15	17.20			

*p<.05

The results of paired sample t tests show that teachers' views regarding STEM teaching differs before (X= 175.71) and after implementing STEM based activities (X=196.15) at the .05 level of significant. According to these data, there is a significant difference between pre-test and post-test scores in Pre-service Teachers' Integrative STEM Teaching Intention Questionnaire.

Research question 2: Do the increase in teachers' test scores differ according to teachers' gender?

The Mann Whitney U test was used to determine whether the increase in teachers' test scores differ or not according to their gender. The results are shown in Table 4.

Table 4. Teachers' views on STEM education according to their gender by Mann Whitney U Test

Gender	N	Mean Rank	Sum of Ranks	U	p
Female	22	19.23	423	170	.630
Male	17	21	357		

p>.05

According to Table 4, there is no a significant difference in the increase of both male's and female's test scores (p >.05). So, we can say that teachers' views on STEM teaching are independent of gender.

Research question 3: Do the increase in teachers' test scores differ according to their branches?

Occupations were categorized into two groups as numerical and oral majors due to the inadequate sample size in some professions and it is not appropriate for analysis. Computer teacher, chemistry teacher, math teacher, physics teacher, science teacher and biology teacher were categorized as numerical majors and geography teacher, child development teacher, english teacher, guidance teacher, pre-school teacher, visual arts teacher and speacial education teacher were categorized as

verbal majors. The Mann Whitney U test was used to determine whether the increase in teachers' test scores differs or not according to their branches and the results are shown in Table 5.

Table 5. Teachers' views on STEM education according to their branches by Mann Whitney U Test

Major	N	Mean Rank	Sum of Ranks	U	p
Numerical	27	20.30	548	154	.808
Verbal	12	19.33	232		

As seen Table 5, there is no meaningful difference in teachers' increase in test scores by means of majors (p>.05). So we can say that teachers' increase of test scores are independent of their majors.

Research question 4: Do the increase in teachers' test scores differ according to their professional seniority?

The Kruskal Wallis H- Test was used to determine whether the increase in teachers' test scores differs or not according to their professional seniority and results are shown in Table 6.

Table 6. Teachers' views on STEM education according to their professional seniority by Kruskal Wallis H- Test

	N	Mean Rank	sd	X^2	p
10 years and less	9	21.83	2	.392	.822
11-19 years	19	19.92			
20-more	11	18.64			

p>.05

As seen in Table 6, there was no significant difference between the groups with respect to professional seniority (p >.05). It can be said that the increase in teachers' test scores do not differ according to their professional seniority.

Conclusions and Discussion

The aim of the current study was to understand in-service teachers' perceptions about STEM education before and after receiving STEM training course. We found that STEM based activies had positive effect on teachers' views about STEM education.

Teachers' positive view development after development program may be due to teachers' enjoying the practices in STEM training course. The results of similar studies in the literature also support the result obtained from this study (Acar, Tertemiz & Tasdemir, 2018; Eroglu & Bektas,2016; Ugras & Genç, 2018; Siew, Amir & Chong, 2015; Wang, Moore, Roehrig, & Park, 2011, Yıldırım & Türk, 2017). It concluded that STEM training course promoted teachers' views about STEM integration. We can make inference from this result that teacher professional development program plays cruical role in training teachers, because it can not be expected of pre-service teacher training programs to prepare teachers throughout their careers due to the role of schools are changing over

time. Also this result supports the view that teachers' positive view development regarding STEM education is important for future science education. Because teachers' views regarding a subject were positively associated with the good teaching.

Gender difference is one of the most important problem in STEM education. A major concern is that reduction of girls' interest in STEM subjects over time with age, education level (UNESCO,2017). Girls positive view development regarding STEM education is desired as well as boys. The finding that motivates our study is that there is no significant difference between teachers' gender and their views on STEM teaching (Table 3). This result show us female teachers are eager to STEM as much as male teachers. The literature has emphasized the effect of lecturers' gender on students learning. (Appiah & Agbelevor, 2015). Because teachers play vital role in determining students' interest in subjects and they have greater influence on students' future career due to their role model function. If women are encouraged to pursue science, technology, engineering and math jobs (STEM), we can prevent girls lose interest in STEM.

A growing consensus is that STEM education enable students to apply knowledge gained in one disipline to another different dicipline by breaking different disciplinary boundaries. As the opinion of Wang, Moore, Roehrig and Park (2011) that interdisciplinary integration requires students to combine the components taught in different courses at different times. This means that students can make connections between their ideas which they learn in different disciplines as geography, art, history, science or mathematics etc. Therefore, STEM should not be seen as an educational approach that just used by science or math teachers. In this study, our analyses demonstrated that teachers' increase of test scores regarding STEM teaching are independent of their branches. This shows that teachers in all branches (computer teacher, chemistry teacher, math teacher, geography teacher, english teacher, guidance teacher, pre-school teacher etc.) are positively influenced by STEM training course.

The increase in teachers' test scores was not significantly related to teachers' professional seniority. This means that professional seniority has no real effect on the teachers' views about STEM teaching. It might be due that teachers' get enjoy from STEM activities and might be due to the teachers' feeling which people of all ages can perform STEM activities. Teachers' positive view towards STEM education regardless their professional seniority is very important for STEM's educational aims come true. Because it will cause learning environment in which teachers will raise successful students.

This study has some limitations. One of the limitation is that the small sample size of the study due to time constraints and teachers' voluntary participation. Nevertheless, larger sample size than the current one may be better for the statistical power of the study.

Implications and Recommendations

Several important implications and recommendations for future studies can be drawn from the findings of this study. The main finding is that STEM based activies had positive effect on teachers' views about STEM education. But this finding did not explain why teachers were affected positively by STEM education, since this study was conducted quantitatively. Therefore, we recommend for future studies to use qualitative and quantitative research methods together to gain deeper and detailed information.

A limited number of teachers participated in this in-service training. Therefore, online courses should be provided to make these trainings accessible for more teachers. An other recommendation is that teachers especially in pre-service training should be trained with full of STEM education. As proposed by Pimthong and Williams (2018), pre-service teacher education programs should aim to build teachers' content and pedagogical knowledge regarding STEM education as component of four main disciplines.

Early childhood education is important for a child so as to reveal its full potential with regard to social, emotional and physical and this is the basis for its lifelong success. For these reasons, STEM education should be started in the early years. Due to the cruical role of early childhood educators in child development, these teachers should be trained in STEM education and engage children in STEM related learning activities. In this context, early childhood teachers' or teacher candidates' understandings about STEM education can be investigated.

References

Acar, D., Tertemiz, N. & Tasdemir, A. (2018). Academic Achievement of 4th Graders in Science and Mathematics and their Views on STEM Training Teachers. *International Electronic Journal of Elementary Education,* 10 (4), 505-513.

Angier, N. (2010). STEM education has little to do with flowers. The New York Times. Retrieved from http://www.nytimes.com/2010/10/05/science/05angier.html

Antov, P. & T. Pancheva (2016). What is interdisciplinary team teaching and content and language integrated learning? Retrieved from http://cd.dictyon.net/Teacher-Manual-8.

Appiah, S. O., & Agbelevor, E. A. (2015). Impact of Lecturers' Gender on Learning: Assessing University of Ghana Students' Views. *Journal of Education and Practice,* 6(28), 30-37.

Aydın, G. & Şahin, N. (2018). Öğretmenlerin stem farkındalıkları: bir hizmetiçi eğitim çalışması. Erişim adresi: http://www.cizgikitabevi.com/kitap/855-ines-egitim-bilimleri-calismalari-2018

Bell, D. (2016). The reality of STEM education, design and technology teachers' perceptions: a phenomenographic study. *International Journal of Technology and Design Education.* 26 (1), 61-79.

Bybee, R. (2010). Advancing STEM education: a 2020 vision. *Technology and Engineering Teacher, 70*(1), 30–35.

Corlu, 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.

Cuadra, E., & Moreno, J. M. (2005). Expanding opportunities and building competencies for young people: A new agenda for secondary education. Washington, DC: The World Bank.

Czerniak, C.M., Weber, W.B., Sandmann, Jr., A., & Ahern, J. (1999). Literature review of science and mathematics integration. *School Science and Mathematics*, 99(8), 421–430.

Dimitrov, D. M., & Rumrill, P. D. (2003). Pretest-posttest designs and measurement of change. *Work*, 20, 159-165.

Dugger, W. E. (2010). *Evolution of STEM in the united states. the 6th Biennial International Conference on Technology Education Research*. (8-11 December), Gold Coast, Queensland, Australia.

EL-Deghaidy, H., Mansour, N., Alzaghibi, M. & Alhammad, K. (2017). Context of STEM Integration in Schools: Views from In-Service Science Teachers. *EURASIA Journal of Mathematics, Science & Technology Education,* 13(6), 2459-2484.

Eroğlu, S., & Bektaş, O. (2016). STEM-trained science teachers' views on stem-based course activities. *Journal of Qualitative Research in Education*, 4 (3), 43-67.

Frykholm, J., & Glasson, G. (2005). Connecting science and mathematics instruction: Pedagogical context knowledge for teachers. *School Science and Mathematics*, 105 (3), 127-141.

Furner, J. M., & Kumar, D. D. (2007). The mathematics and science integration argument: A stand for teacher education. *Eurasia Journal of Mathematics, Science & Technology Education, 3*(3), 185-189.

Greenberg, M., Weissberg, R., O Brien, M., Zins, J., Fredericks, L., Resnik, H., et al. (2003). Enhancing school-based prevention and youth development through coordinated social, emotional, and academic learning. *American Psychologist*, 58(6/7), 466-474.

Hacıömeroğlu, G. ve Bulut, A. S. (2016). Entegre FeTeMM Öğretimi Yönelim Ölçeği Türkçe Formunun geçerlik ve güvenirlik çalışması. *Eğitimde Kuram ve Uygulama, 12*(3), 654-669.

Honey, M., Pearson G. & Schweingruber, H. (Eds.). (2014). *STEM Integration in K-12 Education, Status, Prospects, and An Agenda For Research,* Washington, DC: The National Academy Press.

Jones, Casey (2009). Interdisciplinary Approach - Advantages, Disadvantages, and the Future Benefits of Interdisciplinary Studies. *ESSAI*, 7(26), 76-81.

Larson, L. C., & Miller, T. N. (2011). 21st Century skills: Prepare students for the future. *Kappa Delta Pi Record* 47(3), 121–123.

Lin, K. Y., & Williams, P. J. (2015). Taiwanese Preservice Teachers' Science, Technology, Engineering, and Mathematics Teaching Intention. *International Journal of Science and Mathematics Education, 14*(6) 1-16.

Moore, F. M. (2008). The role of the elementary science teacher and linguistic diversity. *Journal of Elementary Science Education*, 20(3), 49–61.

National Academy of Engineering and National Research Council. 2014. *STEM Integration in K-12 Education: Status, Prospects, and an Agenda for Research*. Washington, DC: The National Academies Press.

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

Pimthong, P. & Williams, J. (2018). Preservice teachers' understanding of STEM education. *Kasetsart Journal of Social Sciences*, 16 (2), 1-7.

Siew, A. (2015). The perceptions of pre-service and in-service teachers regarding a project-based STEM approach to teaching science. *SpringerPlus*, 4 (8), 1-20.

Srikoom, W., Hanuscin, D. & Faikhamta, C. (2017). Perceptions of in-service teachers toward teaching STEM in Thailand. *Asia-Pacific Forum on Science Learning and Teaching. 18* (2), 1-23.

Tsupros, N., Kohler, R., & Hallinen, J. (2009). *STEM education: A project to identify the missing components.* Intermediate Unit 1: Center for STEM Education and Leonard Gelfand Center for Service Learning and Outreach, Carnegie Mellon University, Pennsylvania.

Uğraş, M. & Genç, Z. (2018). Investigating Preschool Teacher Candidates' STEM Teaching Intention and the views about STEM Education. *Bartın University Journal of Faculty of Education,* 7(2), 724-744.

UNESCO (2017). *Cracking the code: girls' and women's education in science, technology, engineering and mathematics* (STEM), UNESCO Publishing.

Wang, H., Moore, T. J. Roehrig, G. H. & Park, M. (2011). STEM Integration: Teacher Perceptions and Practice. *Journal of Pre-College Engineering Education Research*, 1 (2), 1-13.

Yıldırım, B. & Türk, C. (2017). Prospective classroom teachers' views on stem education: an applied study. *Trakya University Journal of Education Faculty*, 8 (2), 195-213.