African Educational Research Journal
Vol. 8(4), pp. 784-790, October 2020
DOI: 10.30918/AERJ.84.20.164
ISSN: 2354-2160
Full Length Research Paper

Examination of the relationships between gender, mathematics achievement and STEM activity preparation skills of prospective teachers with a structural equation model

Özlem Özçakır Sümen

Department of Elementary Education, Faculty of Education, Ondokuz Mayıs University, Samsun, Turkey.

Accepted 6 October, 2020

ABSTRACT

This study investigated the relationships between prospective teachers' STEM activity preparation skills (STEMaps), genders, and mathematics achievements (MA). In the research, a total of 89 prospective elementary school teachers participated. Data were collected by STEM Activity Preparation Forms requiring prospective teachers to prepare STEM activities about science experiments at the elementary school level. Relational screening model was used in the research and the relationships between STEMaps, gender and MA were tested using structural equation modeling. The findings indicated that MA has significant effects on STEMaps whereas gender has no significant effects. The path from MA to STEMaps was found to be a medium effect. It was also concluded that MA explains 20.25% of total variance of STEMaps. More longitudinal and experimental studies are needed to better understand the teachers' and prospective teachers' skills to prepare STEM activities.

Keywords: Mathematics achievement, prospective elementary school teachers, STEM education, STEM activities preparation skills.

E-mail: ozlem.ozcakir@omu.edu.tr.

INTRODUCTION

STEM education considers science, technology, engineering, and mathematics disciplines not separately but as a whole (Breiner, Harkness, Johnson and Koehler, 2012) and aims to ensure that students can use the basic content and practices of STEM disciplines in real-life situations (Bybee, 2013). Regarding to the welfare in the twenty-first century, T and E in STEM play a critical role, so the call for support has shifted from “science and mathematics” to “STEM and STEM education.” That is why integrative STEM education is more compelling today than in decades past (Sanders, 2009). With the increasing importance of STEM education, in the literature, many studies on variables related effective STEM education is available (Cohen and Kelly, 2020; Borrego and Henderson, 2014; Lin, Hsiao, Williams, and Chen, 2020; National Research Council [NRC], 2011; Thibaut et al., 2018). But there is no research investigating the variables related to prospective teachers' STEM activity preparation skills (STEMaps). Therefore, in this study, the relationships between STEMaps, gender, and mathematics achievements (MA) were examined.

Theoretical framework

STEM is based on relationships between science, technology, engineering and mathematics, and real-world problems and it aims to unite them in a holistic learning paradigm, rather than the separation of the branches of science and mathematics (Hom, 2014; Riechert and Post, 2010; Stohlman, Moore and Roehrig, 2012). It allows students to develop in many ways; it makes the students better problem solvers, inventors, innovators, logical thinkers, self-confident individuals, technology literates using various activity-based learning models and it offers opportunities to master the skills and content that are important for 21st-century learning (Meyrick, 2011; Morrison, 2006).

Integrated STEM encompasses information and practices from multiple STEM disciplines to learn and solve transdisciplinary problems (Nadelson and Seifert, 2017). STEM can be taught in four different ways by teaching independent subjects, emphasizing one or two subjects, integrating a STEM discipline into the other three, and combining four disciplines (Dugger, 2010). It can be also carried out by including technology and engineering design within the scope of science and mathematics courses in the curriculum (Bybee, 2010; Felix et al., 2010; Sanders, 2012). The integration of engineering design into STEM education is important because STEM education should develop students' understanding of how things work and their understanding of technology. It should also introduce students to engineering before university education because engineering is directly related to problem solving and innovation (ByBee, 2010).

Studies show that STEM education increases students' academic success (Freeman et al., 2014; Han, Capraro and Capraro, 2014; Nite et al., 2014; Öner and Capraro, 2016; Öner et al., 2016) and interests for STEM careers (Mohr Schroeder et al., 2014). But students with insufficient STEM knowledge do not choose science and engineering-related professions (Merrill and Daugherty, 2010). Teachers can provide their students with STEM knowledge and interest in STEM, thus enabling them to choose professions related to numerical fields. Teachers already show positive attitudes towards STEM integration and find STEM education important (Brown, Brown, Reardon and Merrill, 2011). Therefore, it is too important for teachers to execute effective STEM training.

Current research

Students' having an interest in STEM areas at an early age plays an important role in their pursuit of a career in STEM fields (Dabney et al., 2012; Maltese and Tai, 2010; NRC, 2011) and the selection of a STEM profession is associated with the beginning of secondary school education (Wang, 2013). It is important to discover the students' interest in STEM disciplines at an early age and that they are guided towards STEM-related fields in the following years (NRC, 2011; Raju and Clayson, 2010). Therefore, the development and implementation of effective STEM activities will shape the future career of the students. It is emphasized that there is a need for teachers who will design learning environments where students can conduct STEM research and use these designs effectively (Corlu, 2014; Merrill and Daugherty, 2010). But prospective teachers have difficulties in transforming their knowledge of physics and mathematics into educational practice (Aydın and Delice, 2007; Çorlu and Çorlu, 2012) and their abilities to associate mathematics with different disciplines and everyday life are at very low levels (Özgen, 2013). It was also found that they have difficulty in reflecting integrated mathematics and science to the designs and adding technology to this process (Delen and Uzun, 2018). Consequently, prospective teachers' STEM activity preparation skills are important and have to be developed for effective STEM learning. In this study, the relationships between STEMaps, gender, and MA were examined. The hypotheses of the study are as follows:

Hypothesis 1: Gender is positively associated with STEMaps.
Hypothesis 2: MA is positively associated with STEMaps.

The hypothetical model of the study is in Figure 1.

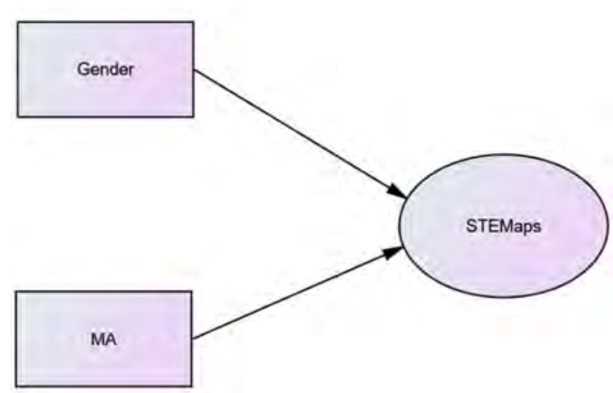

Figure 1. The hypothetical model of the study.

MATERIALS AND METHODS

Relational screening model was used in the research. Relational screening models are research patterns that determine the existence and degree of co-variation between two or more variables (Karasar, 2009). This study examines the relationships between STEMaps, gender, and MA using structural equation modeling.

Participants

The study was conducted in the faculty of education of a public university in the north of Turkey. The study was carried out in the Science and Technology Laboratory course of the elementary education department. A total of 89 prospective teachers participated in the research. Sample sizes of 70 to 80 participants were adequate for structural equation modeling (Sideridis, Simos, Papanicolaou and Fletcher, 2014). The information about the participants was presented in Table 1.

Data collection tools

The data of the research was collected with STEM Activity Preparation Form including questions about gender, mathematics achievement, and required to prepare STEM activities about the science experiments at elementary school level of prospective elementary school teachers. STEM activity preparation form was developed by using the Science Program of the Ministry of National Education (MNE, 2018). Prospective teachers were asked to design a STEM activity in the form. The form was as follows:

> *"The field of Engineering and Design Skills includes to look at the problems with an interdisciplinary perspective by integrating science with mathematics, technology, and engineering; to provide students with the ability to invent and innovate so creating products using the knowledge and skills acquired by the students and to develop strategies to enrich these products. In this process, it is aimed to integrate science with mathematics, technology, and engineering so that students can look at the problems from an interdisciplinary point of view. In this context, the role of teachers is to provide the students with the guidance to integrate science, technology, engineering, and mathematics to reach the level of higher-order thinking, product development, invention and innovation (MNE, 2018).*
> *Design a STEM activity following the science education program by integrating any experiment within the scope of this science course with mathematics, technology, and engineering."*

Table 1. The information about participants.

		f	%	Total
Gender	Female	50	56.2	89
	Male	39	43.8	
Mathematics achievement scores	100-91	2	2.2	89
	90-81	8	9	
	80-71	19	21.3	
	70-61	27	30.4	
	60-51	25	28.1	
	50-41	6	6.8	
	40 and lower	2	2.2	

Application

The research was executed in the Science and Technology Laboratory course. In the research, firstly prospective teachers were trained about STEM education. Information about STEM education, its objectives, and STEM applications were explained to prospective teachers. Then prospective teachers were asked to complete the STEM Activity Preparation Forms, once having completed the STEM training. Prospective teachers were given an hour to fill the forms. Prospective teachers' mathematics achievement scores in the basic mathematics course were used as MA in the study.

Data analysis

STEM activities in the forms prepared by prospective teachers were evaluated with rubric developed by the researcher. The relevant studies were examined for rubric and the evaluation criteria in the rubric have been developed (Gülgün, Yılmaz and Çağlar, 2017). A rubric was developed using the four rating scale as in: not enough (1) - moderate (2) - good (3) - very good (4) and it was submitted to the expert opinion (studying in the field of mathematics education) and the adjustments were made. The evaluation criteria of the rubric were as follows:

1. Compliance with the elementary school level
2. Interdisciplinary association
3. Doable/applicable
4. Compliance with the education program
5. Taking real-life problems as a basis
6. About developing engineering design skills
7. About product development
8. Original/creative

The scores of prospective teachers' STEM activity preparation skills were found according to the rubric. The minimum and maximum score of the rubric ranges from 0 to 32 points. The total scores of prospective teachers on the STEM Activity Preparation Form were calculated by two different researchers and their percentage of accordance was examined. According to Miles and Huberman (1994)'s formula, *(Reliability = Agreement / (Agreement + Disagreement)* the percentage of accordance was found to be 85% and it was seen that it is at a sufficient level. The reliability coefficients of prospective teachers' STEMaps scores were found to be 0.97 for Cronbach alpha, 0.93 for Spearman-Brown split half, and 0.85 for Guttman.

In the data analyses, the hypothetical model of the study was tested using structural equation modeling. In the structural equation modeling, the latent variable of STEMaps was represented by oval and the rectangles represent observed variables that are gender, MA, and 8 items of rubric for STEMaps variable. Thus, a structural equation model was created and performed with a total of ten observed variables and a latent variable. Data were analyzed in SPSS and AMOS programs. In the research, examples of STEM activities prepared by prospective teachers were also presented.

RESULTS

The descriptive statistics of total STEMaps scores of prospective teachers were presented in Table 2.

As shown in Table 2, total scores indicate that the ability of the prospective teachers to prepare the STEM activities is at a medium level (M = 21.08) considering the minimum-maximum score (0 to 32 points) of the scale. In the next step, the correlations between the variables of the model were examined by Pearson correlation and the results were presented in Table 3.

There is a significant moderate level of correlation between MA and STEMaps (*r = .604, p < 0.01)*. But there are no significant relationships between gender and MA (*r = .130, p > 0.01)*; gender and STEMaps (*r = .191, p > 0.01)*.

The structural equation modeling with latent and observed variables was conducted and as a result of the path from gender to STEMaps not to be significant, this path was removed from the model. The structural model was presented in Figure 2.

As a result of the structural equation modeling, modification indices were examined. Since the modifications between the errors of STEMaps latent variable contributed to the fit indexes of the model, it was found appropriate to apply modifications. Fit indexes before and after modifications were presented in Table 4.

The results showed that the rate of chi-square value to the degree of freedom ratio was found to be 1.656 ($\chi2$/sd = 1.656). The difference between the observed covariance matrix and the one predicted by the specified model is examined by the chi-square goodness of fit index. A lower value of $\chi2$/sd than 3 indicates that the hypothesized model is a good fit (Kline, 2005).

Table 2. Descriptive statistics of total STEMaps scores.

	N	M	SD	Min	Max
STEMaps	89	21.08	10.18	0.00	32.00

Table 3. Pearson correlation coefficients between the variables.

		Gender	MA	STEMaps
1	Gender			
2	MA	.130		
3	STEMaps	.191	.604**	

**p < 0.01.

$\chi2$/sd = 1.656 was found to be a good fit. Goodness fit index (GFI) is .919, comparative fit index (CFI) is .990, root mean square error of approximation (RMSEA) is .086, normed fit index (NFI) is .975, non-normed fit index (NNFI) is .981 and Standardized Root Mean Square Residual (SRMR) is .0621. The structural equation modeling results after modifications in Table 4 showed that fit indexes are good and acceptable cohesiveness (Brown, 2006; Hu and Bentler, 1999; Jöreskog and Sörbom, 1993; Kline, 2005; Özdamar, 2007; Thompson, 2004).

According to the analysis results, it was rejected Hypothesis 1 *(Gender is positively associated with STEMaps)* while Hypothesis 2 *(MA is positively associated with STEMaps)* was accepted. Because MA has significant effects on STEMaps whereas gender has no significant effects in the structural equation model. The path form MA to STEMaps was found to be 0.45. According to Kline (2005), an absolute standardized direct effect < .10 may be considered a smaller effect; values around .30 a medium effect; and values > .50 a larger effect. The path from MA to STEMaps can be interpreted as medium effect. It can also be concluded that STEMaps increases as MA increases and MA explains 20.25% of total variance of STEMaps (R^2 = 20.25).

Here is an example of the activities prepared by elementary school prospective teachers on STEM education:

*"**Name:** Heated Air Expands*
***Learning outcome:** Student understands that the heated air expands and the cooled air shrinks.*
***Grade:** Grade of 4*
***Purpose:** Observing that the heated air expands, the cooled air shrinks and making balloons traveling in the sky using this principle.*
***Materials:** Bottle, balloon, cold water, hot water, container, small basket, rope.*
***Preparation:** Fill a container with hot water and the other container with cold water. Place the balloon onto the top*

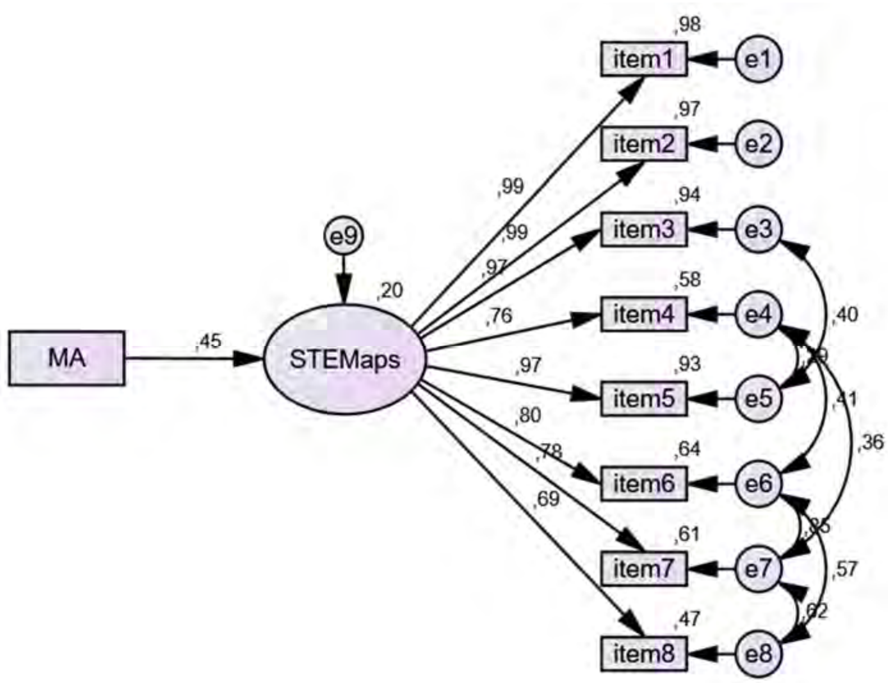

Figure 2. The structural equation model.

Table 4. Fit indexes of the structural equation modeling.

Fit indexes	χ2 /sd	GFI	RMSEA	RFI	NFI	NNFI	CFI	IFI	SRMR
Before modifications	9.274	.609	.307	.745	.809	.766	.825	.826	.1032
After modifications	1.656	.919	.086	.955	.975	.981	.990	.990	.0621

of the bottle. First, the bottle is placed in hot water and the balloon is observed to expand. The bottle is then placed in the container with cold water and the balloon deflates. This is due to the expansion of the heated air. The hot air balloons can travel thanks to the expanding hot air. Engineers make hot air balloons using this principle and technology. Thus, we can also create a hot air balloon by attaching a basket under an expanding balloon. We also explain to the students that in hot air balloons fire is used and that this fire heats the air and expand it." (S85)

The example shows that a prospective teacher associated an experiment from the laboratory course with technology. After explaining how the experiment was done, she explained the construction of balloons which is a technological tool in accordance with the level of elementary school students, and gave examples of how to make it to students associating with the experiment.

DISCUSSION AND CONCLUSION

The presence of students' interests in the STEM fields at an early age plays an important role in continuing to pursue a career in STEM fields (Dabney et al., 2012; Maltese and Tai, 2010; NRC, 2011). To teach an effective STEM education of elementary school teachers, their ability to prepare STEM activities is of utmost importance. In this research, elementary school prospective teachers' STEM activities preparation skills and the relationships between STEMaps, gender and mathematics achievement were examined. As a result, it was seen that they were able to prepare STEM activities at a moderate level. In another study, it was found that mathematics prospective teachers could integrate mathematics and science in preparing STEM activities; but they had difficulty in reflecting this to the designs and adding technology to this process (Delen and Uzun, 2018). These results show that prospective teachers are not good enough to prepare effective STEM activities and training of successful students in STEM fields. However, in the success of STEM education, besides the teachers' efficacy in preparing activities, many factors are effective like teachers' pedagogical content knowledge, mastery of educational processes, and control of other variables affecting the education process. But the truth of prospective teachers' STEMaps have to be developed should not be overlooked.

STEM literacy includes elements such as being aware of the role of science, technology, engineering and mathematics in modern society, being familiar with basic concepts, and having a basic level of application knowledge (e.g. to solve math problems related to daily life) (NAE and NRC, 2014). Mathematics is an important component of STEM education. To what extent of teaching an effective STEM education of a teacher relates to his/her achievement in mathematics is important. Therefore, the relationships between prospective teachers' ability to prepare STEM activities and their mathematics achievement and genders were also examined in the research. As a result, it was found that there was a significant, positive relationship between prospective teachers' STEM activity preparation skills and mathematics achievement whereas there is no significant relationship between gender and STEMaps. MA has a medium effect on STEMaps. Therefore, the elementary school teachers' preparation of good STEM activities depends on their success in mathematics. Elementary school teachers have to be more successful in mathematics to be able to prepare effective STEM activities. Moreover, the coefficient of determination showed that 22.25% of the total variance of STEM activity preparation skills was due to one's mathematics achievement. This shows that mathematics achievement is playing an important role in the ability to prepare STEM activity. In this case, it can be argued that elementary school teachers have to succeed in mathematics as a prerequisite for successful STEM education. It has to be also noted that elementary school teachers who have years of experience may have forgotten their mathematics knowledge and have difficulties preparing effective STEM activities. For a successful STEM education, their mathematics achievements have to be increased.

In light of the results, effective STEM and mathematics training can be offered to all elementary school prospective teachers as well as the elementary school teachers for the development of STEM activities preparation skills. Besides, for the continuity of the research, it can be suggested to investigate the relationships between the ability to prepare STEM activities and other variables and to determine how the different variables affect the variance in the ability to prepare STEM activities.

REFERENCES

Aydın, E., and **Delice**, A. (**2007**, November). Experiences of mathematics student teachers in a series of science experiments. Proceedings of the 6th WSEAS International Conference on Education and Educational Technology, Venice, Italy.

Borrego, M., and **Henderson**, C. (**2014**). Increasing the use of evidence-based teaching in STEM higher education: A comparison of eight change strategies. Journal of Engineering Education, 103(2): 220-252.

Breiner, J., Harkness, S., Johnson, C. C., and Koehler, C. M. (**2012**). What is STEM? A discussion about conceptions of STEM in education and partnerships. School Science and Mathematics, 112(1): 3-11.

Brown, R., Brown, J., Reardon, K., and Merrill, C. (**2011**). Understanding STEM: Current perceptions. Technology and Engineering Teacher, 70(6): 5-9.

Brown, T. A. (**2006**). Confirmatory factor analysis for applied research. New York: Guilford.

Bybee, R. W. (**2010**). What is STEM education? Science, 329(5995): 996.

Bybee, R. W. (**2013**). The case for stem education, challenges and opportunities. NSTA Press.

Cohen, R., and **Kelly**, A. M. (**2020**). Mathematics as a factor in community college STEM performance, persistence, and degree attainment. Journal of Research in Science Teaching, 57(2): 279-307.

Çorlu, M. A., and **Çorlu**, M. S. (**2012**). Scientific inquiry based professional development models in teacher education. Educational Sciences: Theory & Practice, 12(1): 514–521.

Corlu, M. S. (**2014**). FeTeMM eğitimi makale çağrı mektubu [Call for STEM education research in the Turkish context]. Turkish Journal of Education, 3(1): 4-10.

Dabney, K. P., Tai, R. H., Almarode, J. T., Miller-Friedmann, J. L., Sonnert, G., Sadler, P. M., and Hazari, Z. (**2012**). Out-of-school time science activities and their association with career interest in STEM. International Journal of Science Education, 2(1): 63-79.

Delen, İ., and **Uzun**, S. (**2018**). Evaluating STEM based learning environments created by mathematics pre-service teachers. Hacettepe University Journal of Education, 33(3): 617-630.

Dugger, W. E. (**2010**). Evolution of STEM in the United States. 6th Biennial International Conference on Technology Education Research in Australia. Retrieved from: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.476.5804&rep=rep1&type=pdf.

Felix, A. L., Bandstra, J. Z., and Strosnider, W. H. (**2010**). Design-based science for STEM student recruitment and teacher professional development. Proceedings of the Mid-Atlantic American Society for Engineering Education Conference. Mid-Atlantic ASEE Conference, Villanova University.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., and Wenderoth, M. P. (**2014**). Active learning increases student performance in science, engineering, and mathematics. Proceedings of the National Academy of Sciences, 111(23): 8410-8415.

Gülgün, C., Yılmaz, A., and Çağlar, A. (**2017**). Teacher opinions about the qualities required in STEM activities applied in the science course. Journal of Current Researches on Social Sciences, 7(1): 459-478.

Han, S., Capraro, R., and Capraro, M. M. (**2014**). How science, technology, engineering, and mathematics (STEM) project-based learning (PBL) affects high, middle, and low achievers differently: The impact of student factors on achievement. International Journal of Science and Mathematics Education, 13(5): 1089-1113.

Hom, E. J. (**2014**). What is STEM education. Retrieved from: http://www.livescience.com/43296-what-is-stem-education.html

Hu, L. T., and **Bentler**, P. M. (**1999**). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Structural equation modeling: A Multidisciplinary Journal, 6(1): 1-55.

Jöreskog, K. G., and **Sörbom**, D. (**1993**). LISREL 8: Structural equation modeling with the SIMPLIS command language. Chicago: SSI Scientific Software International Inc.

Karasar, N. (**2009**). Bilimsel araştırma yöntemi [Scientific research method]. Ankara: Nobel Yayın Dağıtım.

Kline, R. B. (**2005**). Principles and practice of structural equation modeling (2nd ed.). New York, NY: The Guilford Press.

Lin, K. Y., Hsiao, H. S., Williams, P. J., and Chen, Y. H. (**2020**). Effects of 6E-oriented STEM practical activities in cultivating middle school students' attitudes toward technology and technological inquiry ability. Research in Science and Technological Education, 38(1): 1-18.

Maltese, A. V., and **Tai**, R. H. (**2011**). Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among US students. Science Education, 95(5): 877-907.

Merrill, C., and **Daugherty**, J. (**2010**). STEM education and leadership: A mathematics and science partnership approach. Journal of Technology Education, 21(2): 21-34.

Meyrick, K. M. (**2011**). How STEM education improves student learning. Meridian K12 School Computer Technologies Journal, 14(1): 1-6.

Miles, M. B., and **Hubermann**, A. M. (**1994**). Qualitative data analysis. Thousand Oaks, CA:Sage Publication.

Ministry of National Education [**MNE**] (**2018**). Fen Bilimleri Dersi Öğretim Programı (İlkokul ve Ortaokul 3, 4, 5, 6, 7 ve 8. Sınıflar) [Science Course Curriculum (Primary and Secondary School 3, 4, 5, 6, 7 and 8th Grades)]. Retrieved from: http://mufredat.meb.gov.tr/ProgramDetay.aspx?PID=325.

Mohr Schroeder, M. J., Jackson, C., Miller, M., Walcott, B., Little, D. L., Speler, L., Schooler, W., and Schroeder, D. C. (**2014**). Developing middle school students' interests in STEM via summer learning experiences: See Blue STEM camp. School Science and Mathematics, 114(6): 291-301.

Morrison, J. (**2006**). TIES STEM education monograph series, attributes of STEM education. Baltimore, MD: TIES. Retrieved from: http://www.wytheexcellence.org/media/STEM_Articles.pdf

Nadelson, L. S., and **Seifert**, A. L. (**2017**). Integrated STEM defined: Contexts, challenges, and the future. The Journal of Educational Research, 110(3): 221-223.

National Academy of Engineering and National Research Council [**NAE and NRC**] (**2014**). STEM Integration in K-12 education, status, prospects and an agenda for research. Retrieved from: http://www.middleweb.com/wp-content/uploads/2015/01/STEM-Integration-in-K12-Education.pdf

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

Nite, S. B., Margaret, M., Capraro, R. M., Morgan, J., and Peterson, C. A. (**2014**). Science, technology, engineering and mathematics (STEM) education: A longitudinal examination of secondary school intervention. Frontiers in Education Conference (FIE), Madrid.

Öner, A. T., and **Capraro**, R. M. (**2016**). Is STEM academy designation synonymous with higher student achievement? Education and Science, 41(185): 1-17.

Öner, A. T., Capraro, R. M., and Capraro, M. M. (**2016**). The effect of T-STEM designation on charter schools: A longitudinal examination of students' mathematics achievement. Sakarya University Journal of Education, 6(2): 80-96.

Özdamar, K. (**2017**). Ölçek ve test geliştirme yapısal eşitlik modellemesi IBM SPSS, IBM SPSS AMOS ve MINTAB uygulamalı.[Scale and test development Structural equation modeling IBM SPSS, IBM SPSS AMOS and MINTAB applied]. Eskişehir: Nisan Kitabevi.

Özgen, K. (**2013**). Problem çözme bağlamında matematiksel ilişkilendirme becerisi: Öğretmen adayları örneği [Mathematical connection skill in the context of problem solving: The case of pre-service teachers]. E-Journal of New World Sciences Academy, 8(3): 323-345.

Raju, P. K., and **Clayson**, A. (**2010**). The future of STEM education: An analysis of two national reports. Journal of STEM Education: Innovations and Research, 11(5/6): 25-28.

Riechert, S., and **Post**, B. (**2010**). From skeletons to bridges and other STEM enrichment exercises for high school biology. The American Biology Teacher, 72(1): 20-22.

Sanders, M. (**2009**). Stem, stem education, stemmania. The Technology Teacher, 68(4): 20-26.

Sanders, M. E. (**2012**). Integrative STEM education as best practice. In H. Middleton (Ed.), Explorations of best practice in technology, design, & engineering education, (pp. 103-117). Griffith Institute for Educational Research, Queensland, Australia. ISBN 978-1-921760-95-2.

Sideridis, G., Simos, P., Papanicolaou, A., and Fletcher, J. (**2014**). Using structural equation modeling to assess functional connectivity in the brain: Power and sample size considerations. Educational and Psychological Measurement, 74(5): 733-758.

Stohlmann, M., Moore, T. J., and Roehrig, G. H. (**2012**). Considerations for teaching integrated STEM education. Journal of Pre-College Engineering Education Research, 2(1): 28-34.

Thibaut, L., Knipprath, H., Dehaene, W., and Depaepe, F. (**2018**). How school context and personal factors relate to teachers' attitudes toward teaching integrated STEM. International Journal of Technology and Design Education, 28(3): 631-651.

Thompson, B. (**2004**). Exploratory and confirmatory factor analysis: Understanding concepts and applications. Washington, DC: American Psychological Association.

Wang, X. (**2013**). Why students choose STEM majors: Motivation, high school learning, and postsecondary context of support. American Educational Research Journal, 50(5): 1081-1121.

Citation: Sümen, Ö. Ö. (2020). Examination of the relationships between gender, mathematics achievement and STEM activity preparation skills of prospective teachers with a structural equation model. African Educational Research Journal, 8(4): 784-790.