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The Impact of STEM Project Writing Education on Candidate Female Teachers' Attitudes, their Semantic Perceptions and Project Writing Skills Towards STEM Education

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Abstract

This reserach investigated the impact of Scientix STEM (Science, Technology, Engineering and Maths) on female candidate teachers' attitudes towards STEM education, their semantic perceptions of STEM discipline scopes, specifying their needs in writing STEM projects, their learning outcomes from education, and the difficulties they face in the process of project writing. Prior to the education process, the participants were given a STEM educational attitude scale, a STEM semantic contrast scale, and a questionnaire with open-ended questions to make them understand the semantic background. At the end of the training, they were given a STEM education evaluation questionnaire with open-ended questions and the same scales were used. The contents of the projects they wrote were evaluated. In the end, a meaningful difference was observed in the attitudes of female teachers towards STEM education. As for STEM semantic discrepencies, a meaningful difference was observed only in the sub-dimension of technology. Although the female candidate teachers had not received any education in project writing before (%72.72), they seemed higly confident of themselves in writing STEM projects (%87.87). The results of the content analysis showed that female teachers' learning outcomes from STEM project development were in the themes of knowledge, skills, professional and individual development, awareness, and affective development contributing to the skills of the 22nd century. The difficulties they faced during developing projects were specifying project topics/problems, budget calculations, writing reports, forming a time schedule, overviewing literature and drawing prototype product. According to the document analysis of project reports, problems arise from project expenses and calculations of budget, advertisement activities, specifying project output and writing, and formation of job and time table. This research is considered to be important with the expectation that it will enlighten female candidate teachers who are expected to be role models in their education in preparing STEM projects in the future.

Keywords: STEM education, project based, female candidate teacher, attitude and perception

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1. Introduction

Due to the importance of interdisciplinary studies and particularly the need for science, mathematics, engineering and technology presented as an interwoven approach by STEM have become an important issue for students for workforce rivalry in the 21st century. STEM is connected with the integration of science, technology, engineering and mathematics in daily life (Gonzales & Kuenzi, 2012). Countries, today, have set their targets to raise individuals examining education systems, questionning, with critical thinking skills, problem solving, discovering, productive, innovative, contributing to social and eonomic development, with the skills of the 21st century, competitive, and supporting workforce. Although the need for STEM graduates is rapidly growing, there is still a strong need for it (Wang, 2013).

Women have serious problems with the workforce in the fields of STEM. Their employment levels are very low compared to men. According to the report by UNESCO (2015), women's rate among scientist researchers is only 28%. As it is stated in National Center for Education Statistics (2008-2011), there is an increase in the demand by female students in STEM areas. However, it has been observed that there is not any demand in some STEM fields such as petroleum engineering and enrgy (The 2030 Agenda for Sustainable Development, 2015).

When labour force participation in Turkey is considered, it can be seen that the country is on the 130th order among 142 countries (Global Gender Gap Report, 2015. The rate of women participation in labour force is %30.8 and %17.4 are illiterate, %26.3 are secondary school graduates, %31.1 are high school graduates, %39.3 are voacational shool graduates, and %72.2 are graduates from higher education. The rate of students preferring STEM fields in Turkey was %85.63 in 2000, but this rate dropped to %27.88 in 2010. Among the first 1000 students entering the university, %81.39 male students find a place in STEM fields. Only %18.6 of female students find a place in STEM fields (STEM report, Turkey, 2015).

Beliefs and patterns, in terms of gender, have a strong effect on behaviors and attitudes of both male and female (Lane, Goh & Driver-Linn, 2012). Although compared to the past, bias towards STEM skills among women working in STEM fields is falling, it has not come to an end (Carli, Alawa, Lee, Zhao & Kim, 2016; Moss-Racusin, Dovidio, Brescoll, Graham & Handelsman, 2012). Researches have pointed at tacit social gender inclination as the biggest handicap in women's promoting to better positions Farrell & McHugh, 2017). STEM and gender stereotypes interact in ways that limit and disadvantage women interested in STEM (Hill, Corbet & St Rose, 2010). Gender inequality, in this respect, the issue has become the main point of many studies and projects. Creating opportunities for women will lead to economic development (Global Gender Gap Report, 2015). Women in the U.S.A are encouraged more through various academic and common programs to make them prefer STEM fields as their careers (Balackburn, 2017).

Rol models have a big effect on students (Oyserman & Destin, 2010). Effective role models are authoritative (Marx & Jko, 2012; Marx, Monroe, Cole & Gilbert, 2013) and are considered either in the same gender or someone from an ethnic group. In general, regardless of gender, role models are effective in guiding female students to STEM fields (Drury, Siy & Cheryan, 2011). However, more effective role models are considered to be the same gender or someone from an ethnic group (Lockwood, 2006; Marx & Goff, 2005; Marx & Roman, 2002). Therefore, a female role model has more effect on female students (Barbecheck, 2001; Cheryan & Plaut, 2010; Herrmann et al., 2016; Schmader, Johns & Forbes, 2008; Steele, 1997). One's career motivation and attitude raise when working with a role model (Buunk, Peiro' & Griffioen, 2007; Stout et al., 2011).Motivational processes strenghtened with role models are helpful in setting and reaching targets (Collins, 1996; Lockwood & Kunda, 1997; Sassler, Glass, Levitte & Michelmore, 2017). Female models help young women chose STEM as their careers (Cheryan et al., 2011; Corbett & Hill, 2015). Even more female students prefer women advisors duringt their education (Leavey, 2016). Destin and Oyserman (2010), argue that active models develop students' academic performance. According to Expectation-value theory, (Wifield & Eccles, 2000), individuals' success expectations indicate their academic motivtion and decisiveness in making decisions, Thus, existence of female models increase the other females' success expectations (Robnett & Thoman, 2017).

Teachers are the ones to raise individuals to provide quality contribution to labour force. Thus, this was the reason to work with female candidate teachers who are expected to be role models in the future. While doing so, it was mainly aimed to develop female candidate teachers' skills in Scientix project education and project writing skills in the fields of STEM. The role of Project Based Learning (PBL) in Science, Technology, Engineering and Maths (STEM) has been attracting interest since the beginning pf the 21st century (Thomas, 2000) because it has been observed that students learn much more from skillful and experienced STEM PBL teachers. It has also been observed that teaches with insufficient skills in PBL affected the students' performance negatively (Han et al., 2015; Craft & Capraro, 2017).

The Scientix project, is open to all teachers, academicians, school directors, families and all other individuals who are interested in questionning, researching, developing products, and inventions through Scientix Portal in STEM education in Europe. The Scientix project (The Community for Science Education in Europe) representing the European Commissin and run by the European Schoolnet (EUN) is a union composed of 30 European countries aiming to widespread the use of technology in education and good samples of the issue. Worksops and conferences are orgnized to widespread STEM education all around Turkey. In this research, the data were collected from the final year female candidate teachers studying Science, Biology and Mathematics and who participated in the Scientix STEM Workshop in the process of preparing STEM projects(N=34). During the workshops and conferences, the Scientix project in education was introduced, presentations in the importance of STEM education were explained, creative drama activities based on collaborative work were carried out, STEM projects were prepared under the supervision of experts (n=8), and the prepared projects were presented.

1.1. Aim of the Research

This research investigated the effect of Scientix STEM education on the attitudes of female candidte teachers towards STEM education, on their perceptions of STEM discipline fields, and their needs in writing STEM projects as well as the difficulties they faced in the process of writing projects and their learning outcomes from the ducation. In order to clarify these issues, the following questions were directed;

1. What attitutes do Biology, Science, Primary Education Maths candidate teachers exhibit towards STEM before and after STEM project writing?

2. What are Biology, Science, Primary Education Maths candidate teachers' semantic perceptions of STEM fields before and after project writing teaching?

3. What are candidate teachers' learning outcomes from STEM project writing teaching and project preparing process?

4. What are the difficulties the candidate teachers face while writing STEM projects?

5. What are the deficiencies in the project reports prepared by the candidate teachers?

2. Method

Blended methodology researches are defined as unifying qualitative and quantitative methods, approaches and concepts in one or in consecutive studies by the researcher (Creswell, 2003; Tashakkori & Teddlie, 1998; Johnson & Onwuegbuzie, 2004).A convergence blended method design was used in this research. Both qualitative and quantitative data were collected simultaneously, were united and the results were referred to understand research problems (Creswell & Plano Clark, 2011).

2.1. Sampling/Working Group

The participants in this research were picked through maximum diversity sampling method, one of purposeful sampling methods (Creswell et al., 2003). The variables likely to affect the answers given in maximum diversity sampling method were specified. These variables refer to the female candidate teachers' branches and their being final year students. The participants, teachers of Biology, Science, and maths teachers, voluntarily took part in this research (N=34).

2.2. Data collection tools

Both qualitative and quantitative data collection tools were used in the study. As the qualitative data collection tool, a Preliminary Information form before the the application and a feedback form after the application was given. The candidate teachers reflected their past experiences in STEM and projects. The project reports prepared by them are another source of data. Documents were overviewed. The quantitative data collection tool was conducted in two separate scales, pre-test and post-test.

One of the scales used was "STEM" (Science-Technology-Engineerin-Mathematics), Education Attitude Report, applied and developed by Derin, Aydın and Kırkç (2017). The alpha value of the meaningfullness dimension of the 32 item scale was .92, the alpha value of its applicability dimension was .84, and its total apha value was .77. It is an Osgood type of scale, which organizes the lexical differences of words and meaures the approvable attitudes and inclinations in a simple and clear way without wasting time. In such scales, the participants marks one of two opposite words that addresses them.(For example: boring __: __: ___; ___ exciting). The participants mark their attitudes and conceptions as 1, 2, 3, 4 or 5 for every single item.

Another scale used was the "STEM Semantic Diversity Scale" adapted and developed by Kızılay (The Red Crescent, 2017) , which was picked to specify candidate teachers' semantic perceptions related to STEM fields. The total reliability coefficiency of the scale, consisted of five factors (science, technology, engineering, maths, and carreer). The Croncbach alpha reliability coefficiency was measured as α=.82. The coefficieny of the sub-factors was determined as; science α=.91, technology α=.84, engineering α=.86, maths α=.92, and career α=.87. The Turkish version of the form consisted of 25 items. In semantic diversity scales, unlike in likert scales, pairs of adjectives are used. These pairs can be either opposites or positive-negative pairs of adjectives. The "STEM Semantic Difference Scale", with two separate adjective categories, composed of seven categories.

2.3. Data analysis

The data of STEM Education Attitude Scale and STEM Semantic Differences Scale were applied as pre and post-tests. The data were analysed through SPSS 22 package program. The data in both scales were analysed through related sampling t-test.

The qualitative data were collected through pre and post view forms. In order to evaluate the participant teachers' views in the workshop, the data were subjected to content analysis (Strauss & Corbin, 1990).

The reliability formula by Miles & Huberman (1994) was referred to measure the reliability of the research, which was measured as %88 reliable. Any reliability measurement over %70 indicates the reliability of a research (Miles & Huberman, 1994). Therefore, the result of this research proves its reliability.

3. Findings

3.1. The Findings From The Qualitative Data

3.1.1. Findings in The Primary Information Form

When the levels of the candidate teachers' (N=34) in project writing are examined, it is seen that 13 teachers had not gone through STEM education (application and seminar), 12 had not written a project before, and 24 had not received any education in project writing (%72.72). Even though, they were highly confident in writing STEM projects.

3.1.2. Findings in The Primary Information Form

Female candidate teachers' learning outcomes from STEM project writing ducation

The answers by the female candidate teachers who participated in STEM project writing were subjet to content analysis. 6 themes were formed related to participnts' answers. Codes related to the themes are presented.

Table 1. The learning outcomes by female candidate teachers from STEM project writing education

education

Themes	Codes
	K
nowledge	Field knowledge
	Detailed information about STEM
	Information about STEM project writing
	Learning something new from different fields
	Permanent learning
	The skill in putting different disciplines together
Skills	Developing research skills
	Skills in finding different ways for solutions
	Developing questionning skills
	Creative thinking skills

	Analitical thinking skills Problem solving skills Critical thinking skills Self-evaluation skills Skills in making joint decisions Development in communication skills Skills in team and group work Drawing skills
Professional/ Personal Development	Contribution to professional development Skills in encouraging students Skills in guiding student Development in general culture Providing personal development
Awareness	Use of collaborative work The importance of working with people from different fields The importance of arranging group dynamics Being aware of the contribution of different branches and views to product development Awareness of encouraging students Awareness of helping students Developing different views about the environment Awareness of adapting attitudes
Developing perceptions	Overcoming bias and fear related to project development Self-confidence in developing a product Willingness in being decisiveness Raising interest Motivation Eagerness Developing interest Developing self-confidence

The First Learning Outcomes Female Candidate Teachers Acquired Through STEM Project Writing Education

During the STEM project writing education female candidate teachers experienced working in collaboration with different disciplines and developing products by putting these disciplines together. They also experienced the steps in project writing for the first time.

Table 2. The First Learning Outcomes Female Candidate Teachers Acquired

***The First* Learning Outcomes**	Information from different sources Developing different views about engineering Developing products through putting different disciplines

together

Interacting their field of interest in different disciplines

The idea of integrating STEM in other fields rather than science

Carryin out different studies than their own field

Working in collaboration with different branches

Being aware of the relationship among all disciplines

Being aware of team spirit

Mastering all the processes of the project

Writing project in STEM fields

Experiencing the use of STEM projects in classroom

Willingness in finding solutions to problems related to the society and nature

Experience in project issues

Getting rid of bias in project writing issues

Developing problem solving skills by doing

Preparing project reports

Finding project topics

Specifuing problems

Participating in drama education

Learning 21st century skills

Becoming aware of and finding ways to solve environmental problem

Difficulties female candidate teachers faced during STEM project writing education

The difficulties and percentages are as shown in the Table below

Table 3. Difficulties faced by female candidate teachers during STEM project writing education

Difficulties faced	%
1.Project topic/specifying problems %90	76.47
(finding a new,feasible and low-cost subject)	
1. Budget calculation	32.35
2. Writing a report	20.58
3. Prototype drawing	11.76
4. Overviewing literature	7.64
5. Drawing time schedule	5.58

As it can be seen, specifying the problem is the top difficulty (%76.47) and in the second place is budget and reporting (%32.35).

Suggestions by female candidate teachers related to STEM project writing education

The female candidate teachers suggested a longer training period, an applied training, and working with different groups with different branches (e.g. computer technologies, engineering etc). They also suggested shorter presentations and particularly emphasized the need for a longer period of time for sessions of specifying project topics. Another suggestion was a two-day study on the project followed by a one-day presentation and discussion period.

3.1.3. Findings From Document Analysis

STEM project proposal form includes STEM project steps (see;http://scientix.meb.gov.tr/). Besides students' responses, the document analysis of STEM project proposal form reports (N=8) indicated that candidate teachers faced difficulties particularly with some topics. The problem sections in the reports are project expenses, calculating the project budget (n=8), advertising activities (n=8), specifying project output and writing (n=6), and drawing time schedules (n=5).

The technical features of the products shown under the title of project expenses and budget calculation shown on the STEM project form were not specified. Even more, all the expenses were not considered. The advertising activities which were only slogans and advertisements on billboards were very limited and addressing big groups of people was ignored. Time management on the schedule was not realistic to respond to activity items. In the specification and writing of project output, work plans and project aims were written instead of the features of the product/findings to be achieved at the end of the project. Even more, all the features.

3.2. Findings from quantitative data

STEM (Science-Technology-Engineerin-Maths) education attitude scale findings

The average scores by the female candidate teachers, before and after writing projects in STEM were overviewed for any possible significant differences. Due to the number of students in the research group (34), their success scores were assumed as a normal distribution and the data were analysed through related sampling t-test, one of parametric tests. The data of the research were analysed through SPSS 22 package program. The related sampling t-test results are as shown in Table 4.

Table 4. The related sampling t-test analysis of the female teachers' pre and post tests attitude scores

Measurement	n	x	s	sd	t	p	
First test		34	4.07	0.23	33	-2.178	.037
Last test		34	4.16	0.26			

P<.05

Before the STEM project education, the candidate teachers' attitude average scores were 4.07 and their standard deviations were 0.23. The students' attitude average scores after the application were 4.16 and standard deviation scores were 0.26. According to the related t-test results, the students' attitude scores showed a significant increase, t(33)=-2.17, p<.05, r2=.16. Cohen (1998) assumes this difference as an average impact. As a result, it can be said that the education process had an effect on the increase of the candidate teachers' average attitude scores.*to research sample*

The findings from STEM Semantic Difference Scale

The average scores by female candidate teachers (N=34) in STEM education attitude scores in project writing before and after the education were analysed through related sampling t-test. The data were analysed through SPSS 22 package prograam. The results of the related t-test are as shown in Table 5.

Table 5. The related sampling t-test aanalysis results of the female candidate teachers' semantic perceptions of STEM fields

Participant		**Number**			**Sub-dimension**		**Pre-test**			**Post-test**
	Mean		**SD**	**Mean**	**SD**	**t**				
Female student		34		Science		6.02	1.94	6.55	0.39	-1.610**
				Maths		0.571	2.05	5.28	0.81	.572**
				Engineering		4.93	2.06	4.82	0.73	.350**

	Technpology	5.67	2.17	6.55	0.63	2.342*
	Career	5.80	2.22	5.67	0.61	.773**

*p<.05 **p>.05

From the related sampling t-test results in the semantic perception scores in STEM fields by the female candidate teachers a significant difference was not observed in the average points in the sub-dimensions of science t(33)=-1.61, p>.05, mathematics t(33)=.571, p>.05, engineering (33)=.729, p>.05, and career . In the sub-dimension of technology, however, the score averages raised significntly, t(33)=-2.34, p>.05, r2=.13. Cohen (1988) assumes this difference as an average impact. As a result, it can be said that the semantic perception points were factors only in the average of technology sub-dimensions.

4. Discussion and Conclusion

This study aimed at investigating the effect oF STEM project writing education on female candidate teachers' attitudes, their semantic perceptions of STEM discipline fields, specifying their future needs in this field, their learning outcomes, and the difficulties they faced while writing STEM projects. The work group was composed of candidate biology, scince, and primary school maths teachers. Both qualitative and quantitative data were collected and put together AND the results were used to specify problems (Creswell & Plano Clark, 2011). At the end of the research, the difficulties and their learning outcomes in the process of preparing STEM projects were specified. This study is quite important considering its contribution to the female teachers to be role models in the future.

In this study female teachers' views about STEM education applications were examined in general. The primary information forms showed that 13 candidate techers have not received any STEM education (application and seminar), 12 teachers have not written a project before, and 24 teachers have not received any education in project writing (%72.27). Even though, it can be seen that they are highly confident in being able to write STEM projects (%87.87). One of the critical factors in STEM PBL applications is the students' being present (Han et al., 2015), which is quite positive in terms of this education.

Through the STEM project development education, the female candidate teachers' learning outcomes were in knowledge, skill, professional and personal development, awareness raising, and sensorial development categories. Their learning outcomes in "Knowledge" are that they learned about the scope of the field, had detailed information about STEM and project writing, long-lasting learning, and learning new things from different fields, in “Skills” like developing questionning thinking skills, creative thinking skills, analytical thinking skills, problem solving skills, critical thinking skills etc., in “Development” contributing to teaching skills, contributing to professional development etc., in “Awareness” the importance of working with individuals with different branches, the benefits of collaborative work, and self-development etc., and in ”Perception development” developing attitude, developing projects, overcoming bias and fear, self-confident in developing products, willing to be successful etc. Their first learning outcomes through project development education are project writing in STEM field, experience in project issues, collaborative work with different branches, becoming aware of team-spirit, and interacting different disciplines in their fields etc .

Project based methods are considered to be one of the best ways to develop 21 century skills (Galvan & Coronado, 2014). It has been noticed that the education has contributed to candidate teachers’ 21st century skills. Researches in literature support the assumptions that STEM applications developed field knowledge, problem solving, creative thinking, critical thinking, understanding the nature of technology, systematic thinking, self-confidence, problem solving, collaboration, adapting to new developments, entepreneurship, analysing and evaluating information, interest and creativity, and communication skills (Bybee, 2010; Moore et al., 2014; Morrison, 2006; NRC,2011; NSF, 2010; Partnership for 21st Century Learning; Wang, Lavonen & Tirri, 2018).

The participants in the education in this study admitted that it was their first experience in interdisciplinary studies and added that they became well aware of the issue. In fact, as the nature of problems, interdisciplinary approaches are necessary in problem solving (Roehrig, Moore, Wnag & Park, 2012). Project- based STEM applications are examples of STEM experts’ collaborative work with different disciplines in problem solving (Capraro, Capraro & Morgan, 2013). Apart from that, interdisciplinary learning speeds student learning (Tseng, Chang, Lou & Chen, 2013).

Deciding on project topics, specifying problems (%76.47), budget calculation (%32.35), reporting (%20.58)forming time schedule (%5.88), overviewing literature (%7.64), prototype drawing of the product (%11.76) are the difficulties participants experienced in the process of developing STEM projects. The most difficult was to specify project topics and specifying the problem. Timur and İmer Çetiner (2017) dealt with the same issue and stated that science teachers in their professional development programe to increase their skills in project dvelopment experienced difficulties in determining project topics. The difficulties teachers faced in writing project reports have common similarities with the results in previous studies (Alves et al., 2016; Timur & Imer Çetin, 2017; Ward & Lee, 2002).

When candidate teachres’ project reports are overviewd, it was observed that they faced difficulties and shortages in calculating project expenses and project budget, advertising activities, specifying and writing project outcomes, and drawing work-time schedule. It is clearly known that in spite of seminars and conferences related to STEM, they still have difficulties in applications (Han et al., 2015). Whereas, teachers are expected to guide their students in reaching resources, making use of Information Technology, writing reports, providing references, and presentations. Therefore, teachers are expected to participate in STEM based project education and experience this process. Teachers' suggestions for allocation of a longer period of time for the education is because they do not still feel fully equipped in this field.

Project based learning helps students develop their data analysis, problem solving, and decision making skills, which include cognitive skills and raise their responsibilities towards physical and social environment (Dori & Tal, 2000). Active participation in project process helps students shape their ideas and specify their way of looking into issues (Zoller, 1991). When the findings in this research are examined, it was observed that at the end of the project writing process teachers had similar learning outcomes.

According to the quantitative findings in the research, there is a significant increase in female teachers' attitude towards STEM education. Attitude is one of the most important factors in interpreting and applying new teaching methods effectively (Roehrig, Kruse, & Kern, 2007). A teacher's positive changes in STEM teaching application indicates the changes in attitudes towards the teaching of STEM (Pinto, 2005). Therefore "attitude" should be seriously considered. It is quite pleasing to notice the increasing positive changes the education brought about among female candidate teachers.

The analysis of the semantic difference scale applied to specify candidate teachers' perceptions related to STEM fields before and after the STEM project writing education, showed a significant difference and rise only in the sub-dimensions of technology. A significant difference was not observed in the average scores of the sub-dimensions of science, maths, engineerin g, and career. This result shows the teachers' perceptions of science, maths, engineering, and career separately. It can be interpreted that they had experience in this field, but working in production affected their perceptions of technology. Therefore, teachers are in the key roles as advisors in STEM ptojects for their students in the future.

5. Suggestions

While training candidate teachers for the profession, STEM project education should predominantly be given.

Candidate teachers should be provided with the opportunity to experience project writing in collaboration with teachers of other subjects (e.g. maths, computer,arts teaching etc), but not only in their own branches. Experiencing such a process will contribute to their 21st century skills.

From the deficiencies in project reports, it was observed that more contents should be included to consolidate teachers' learning outcomes in STEM projects such as calculating expenses and advertising. In this regard, such deficiencies should be considered.

Increasing the effectiveness of female candidate teachers as role models in project advisory issues will attract more women's interest in STEM occupations. Students at secondary and high school levels play a great role at his point, because even a %1 increase in the number of female students in secondary and high schools will lead to a %0.3 rise per capita income (STEM Turkey Report, 2015). As the gap between genders closes, competitive power in economy rises.

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