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| Research Article / Araştırma Makalesi |

Investigation Of The Effects Of Tinkercad Based Stem Implementations On Computational (Computer) Thinking Skills And Technology Use Standards Of Teacher Candidates[1]

Tinkercad Temelinde Stem Uygulamalarının Öğretmen Adaylarının Bilgisayarca Düşünme Becerisi ve Teknoloji Kullanım Standartlarına Etkisinin İncelenmesi

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Keywords

1. STEM education
2. Tinkercad
3. 3D Press
4. Technology usage standards
5. Computational thinking

Anahtar Kelimeler

1. Stem eğitimi
2. Tinkercad programı
3. 3d baskı
4. Teknoloji kullanım standartları
5. Bilgisayarca düşünme becerisi

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Abstract

Purpose: This study investigates the effect of STEM implementations on computational thinking skills and technology usage standards of classroom teacher candidates. The experimental method "One-group Pretest-Posttest Design" has been used in the study. In line with the purpose of the study, data on Computer Thinking Skills and Technology Use Standards of pre-service teachers who participated in STEM education practices for 11 weeks were collected and analyzed at the beginning and end of the procedure.

Design/Methodology/Approach: The experimental method "One-group Pretest-Posttest Design" has been used in the study. Ninety pre-service teachers who took Science and Technology Laboratory Practices I and II courses from Kastamonu University Faculty of Education and the primary school teaching department participated in the study.

Findings: According to the results of the study, while it was seen that the candidates for STEM implementations were not generally effective in their classrooms, their preferences in one of the nearby backgrounds from one of the sub-dimensions considered only by the computer.

Öz

Çalışmanın amacı: Bu çalışmanın amacı Tinkercad Programı temelinde tasarlanan STEM uygulamalarının sınıf öğretmeni adaylarının Bilgisayarca Düşünme Becerisi ve Teknoloji Kullanım Standartlarına etkisini incelemektir. Çalışma amacı doğrultusunda 11 hafta boyunca Tinkercad Programı temelinde tasarlanan STEM eğitimi uygulamalarına katılan öğretmen adaylarının uygulama başında ve sonunda Bilgisayarca Düşünme Becerileri ile Teknoloji Kullanım Standartlarına yönelik veriler toplanmış ve analiz edilmiştir.

Materyal ve Yöntem: Tek grup ön test-son test deneysel modelinde desenlenen çalışmaya Kastamonu Üniversitesi Eğitim Fakültesinin sınıf öğretmenliği bölümünde öğrenim gören Fen ve Teknoloji Laboratuvar Uygulamaları II dersini alan 90 öğretmen adayı katılmıştır.

Bulgular: Çalışma sonuçlarına göre STEM uygulamalarının sınıf öğretmeni adaylarının Bilgisayarca Düşünme Becerileri ve Teknoloji Kullanım Standartlarının genel ortalaması üzerinde etkili olmadığı görülürken, sadece bilgisayarca düşünme becerilerinin alt boyutlarından biri olan eleştirel düşünme boyutunda anlamlı bir artış olduğu belirlenmiştir.

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INTRODUCTION

The changing needs of the world since the beginning of the 21st century have led individuals to be individuals who can acquire knowledge, be creative, think critically and be productive. This change paved the way for the transformation of educational needs. Because education has a vital role in raising individuals with the quality that society needs. In other words, most of the social dynamics, especially the economy, are based on the human workforce. Individuals with the required qualifications to meet this need are educated in schools that prepare their students for future business life (Robinson, 2010). This mission of educational institutions compels them to develop continuously in parallel with the change in society, science, technology and the economy.

Methods seem to be necessary. As a result of all these cycles, more and more education systems; it is noteworthy that it should be student-centered, innovative, integrated with technology, and oriented towards the discovery of information resources and production. With this aspect, it is seen that education and training environments should be reviewed and integrated with alternative methods such as problem-based teaching, project-based teaching, flipped classrooms and STEM (Science-Technology-Engineering Mathematics) that focus on digital skills and develop inquiry, problem-solving and production skills instead of traditional teaching methods. In this way, students who are part of the education system will be able to participate actively in the future society (Paul et al., 2014; Scaradozzi et al., 2019).

Along with alternative methods, many skills have been brought to the literature. It is noteworthy that many technology-based skills, such as programming, design, and computational thinking, have entered the literature with new methods. Skills can be differentiated for teachers and students. Today, the use of integrated alternative methods focusing on more than one skill in education environments provides an advantage in terms of realizing many teaching goals and developments together at the end of the process. In this way, students' high-level thinking and realization skills such as computer, creativity, critical and problem-solving can develop as a whole, with the help of technological content and tools, not only in the use of computers in educational environments (Korkmaz et al., 2014; Gulgun et al., 2017). When the sub-skill dynamics are examined, it can be said that all of them center on the student, can be customized according to the characteristics and needs of the students, and most importantly, the student is active in the process. Among the alternative methods, it can be said that STEM is the most skill-focused method since it simultaneously considers the skills in Science-Technology-Engineering-Mathematics.

The primary purpose of STEM education is; to produce a solution for situations encountered in daily life by associating multiple different fields; is to actively implement the analysis, design, implementation and evaluation processes (Bozkurt-Altan et al., 2016; Rogers & Porstmore, 2004). Although many definitions have been made for STEM education, which was first applied in the USA and named with the initials of the words science, technology, engineering and mathematics, all of them should be interpreted as a holistic, interdisciplinary interpretation of the science mentioned above, technology, engineering and mathematics and many skills at the same time. It is seen that it is considered to be implemented by taking into account (Bybee, 2010; Dugger, 2010; Guzey et al, 2014; Meng et al., 2014; Morrison, 2006; Smith & Karr-Kidwell, 2000; Yamak et al., 2014). Thanks to this feature, it is expected to develop individuals' skills such as problem-solving, scientific, critical and creative thinking, communication and collaboration, entrepreneurship, etc., during and after the STEM education process (Bybee, 2010; Morrison, 2006; Yüzbaşıoğlu et al., 2020).

Countries make arrangements in their central education policies depending on the changing educational status and needs. By incorporating integrated teaching methods into teaching environments, educational situations suitable for the needs of the age are created. The most important example in our country is that the Ministry of National Education started to prefer the methods for STEM education and coding skills in the curriculum under the title of Science, Engineering and Entrepreneurship Practices (MEB, 2018b). According to the STEM Education Report, which was first prepared in 2015 by the Ministry of National Education, General Directorate of Innovation and Educational Technologies, there was no action plan for STEM education in our country. It is seen that both the 2015-2019 and Vision-2023 action plans prepared in line with this report include strategies for the development of STEM, computational thinking and digital skills (MEB, 2020; YEĞİTEK, 2015).

Although it was aimed to increase the quality of education at the international level with STEM education, which was started be implemented in the fourth grade of primary education in 2017, with the decision to include it in the curriculum in our country in 2015, the lack of the sufficient number of specialist teachers to provide this education was a limitation. Although many in-service training courses were organized for teachers to eliminate this limitation, it was insufficient. At this point, the most appropriate solution is that STEM education should be added to the curriculum of science, mathematics, computer, classroom and pre-school teaching programs as a module on its own, instead of being treated as a sub-topic in the main module. In this way, it is aimed for students to find solutions to the problems they encounter in their daily lives from a perspective they have developed by considering more than one discipline. It is thought that these gains will indirectly enable countries to reach productive individuals, question, acquire and process information, be enterprising and innovative and have a high workforce (Lacey & Wright, 2009; Wang, 2012). At this point, it is essential to define the skills above correctly to determine and implement the teaching methods, techniques, and contents to be used in gaining these skills.

Skills needed today; 21st-century skills are defined as ATC21S (Assessment and Teaching of 21st Century Skills), P21 (Partnership for 21st-century learning), World Economic Forum skills and Ministry of National Education skills and are grouped into six categories (ATCS2, 2012; MEB, 2017; PFCL, 2014; WEF, 2016). When the skills are evaluated holistically, it can be said that the common point of all of them is that they focus on their skills following technology standards (technology literacy, computational (computer) thinking, digital literacy, etc.), problem-solving, innovation, creative and critical thinking, and productivity skills. Although it is seen that subjects such as creativity, innovation and critical thinking are frequently covered in the studies (e.g. Gülhan & Şahin, 2018; Dilber, 2020; Sağsöz, 2019; Soros et al, 2018), the studies on computational (computer) thinking skills It is seen that the number of studies has only increased compared to the past (Şahiner & Kert, 2016). In this context, it would be appropriate to define this skill first.

Computational (computer) thinking skill is defined as a skill that all individuals should have in order to produce an innovative and creative solution with the help of technological tools in the face of a problem, within the steps of the scientific process, with a focus on production (Berikan, 2018; Gürel & Emre, 2017; Light, 1999; Wing, 2006; Şendurur, 2018; Şimşek, 2018; Taş, 2018; Yolcu, 2018). To be explained in more detail, the computational (computer) thinking skill is defined by Çetin and Toluk Uçar (2017) as "the process of creating new information or decisions that gain meaning as a result of a certain algorithmic process by making calculations and inferences". When STEM education is considered, it can be said that STEM and Computational (computer) thinking overlap in terms of using many stages and disciplines to solve a problem (Yıldız, 2017). The most crucial factor to be considered for both is that a structured and planned teaching environment and evaluation steps should be prepared carefully and meticulously. It would be correct to define the level of skills to design these process steps healthily and effectively. Another common point of STEM and Computational (computer) thinking skills is using technological tools in problem-solving. In this case, it is expected to pay attention to the technology usage standards of individuals to produce the right solution or to include the tools in the production process.

With the inclusion of computational (computer) thinking skills and STEM education in the curriculum, many scientific studies have begun to be conducted to determine its effect and the gains as a result of the implementation process. To take a look at some of the studies on STEM, the following results emerge. It is seen that STEM education studies often focus on science education and coding, are widespread in the period from pre-school to higher education, and results are given in terms of attitude, academic achievement, problem-solving, computational (computer) thinking, creativity, technology use standards (Alan, 2020; Akgündüz, & Akpınar, 2018; Aydın et al., 2017; Aydın, 2019; Benitti, 2012; Benitti & Spolaôr 2017; Canbazoğlu & Tümkaya, 2020; Çakır et al., 2019; Khanlari, 2016; Karaahmetoğlu & Korkmaz, 2019; Koç, 2019; Rubio et al., 2013; Saeli et al., 2011; Sağat, 2020; Yıldırım, 2016). As another result of the studies on STEM education, it can be said that the least number of studies among the sub-dimensions it focuses on is on computational (computer) thinking skills (Gülbahar et al., 2019; Lockwood & Mooney, 2018). In this context, conducting studies on STEM, technology usage standards, and computational (computer) thinking skills is essential. From this point of view, this study aimed to determine the primary school teacher candidates' information-process (computer) thinking skills and technology usage standards in the STEM Education process. In this context, answers to the following questions were sought.

- Does the STEM education received by the primary school teacher candidates affect their Computational (computer) Thinking Skills?
- Does the STEM education received by the primary school teacher candidates affect the Digital Skills Technology Standards?

METHOD/MATERIALS

Research Design

This study was designed in the "single group pre-test-post-test" experimental model. Since the researchers in the experimental designs manage the variables, data can be collected to determine the relationship between the variables. According to this model, measurement is carried out before and after the experiment. In this design, the pretest and post-test results of the study group are compared in terms of the dependent variable. The difference between the tests indicates the effect of the independent variable or variables on the dependent variable. In addition, the model is applied to a single study group with the easy case sampling method (Büyüköztürk et al., 2018; Cohen et al., 2007; Karasar, 2000; Sencer & Sencer, 1978). Although there are many experimental designs, it is considered more appropriate to use single-group experimental designs due to the nature of studies investigating the effect of a new training method (Creswell, 2012).

This study used a single group pre-test and post-test experimental design without a control group since the changes in pre-service teachers' computer thinking skills and educational technology standards scores before and after STEM applications were examined. The control group was not preferred; It is the examination of the effect of STEM application's independent variable on the dependent variables of computational thinking skills and educational technology standards by limiting it to the activities in the Science and Technology Laboratory Practices II course. In this context, it was thought that comparing the experimental and control groups was not significant within the scope of the study.

Study Group

A total of 90 pre-service teachers, 78 female and 12 male, who studied in the Primary School Education Program of an Education Faculty in the Western Black Sea Region and took the Science and Technology Laboratory Practices II course, participated in the study. In the Science and Technology Laboratory Practices II scope, they were divided into sub-study groups according to their wishes and participated in the activities during the implementation process. In this direction, since the participants in the study group were selected, pre-service teachers were included in the study with the appropriate sampling method (Dörnyei, 2007).

Data Collection Tools

In the study, two separate scales were applied to the participants at the beginning and when the application was completed. These scales;

1- Computational (Computer) Thinking Skill Scale: The scale was adapted by Korkmaz et al. (2015). It is a five-point Likert-type scale and consists of five factors. There are 22 items on the scale. Creativity, algorithmic thinking, collaboration, critical thinking, problem-solving and total Cronbach Alpha reliability coefficients are respectively; It was determined as 0.640, 0.762, 0.811, 0.714, 0.867 and 0.809. These values for the project, respectively; 0.854, 0.831, 0.874, 0.799, 0.882.

2-Technology Standards Scale: The scale was developed by Mısırlı (2013). It consists of 21 items and four dimensions. It is a 5-point Likert type. Reliability coefficients in the dimensions of technology literacy, creativity, digital citizenship and participation, and innovation, respectively, were 0.874, 0.729, 0.574 and 0.620. These values in the project; 0.773, 0.893, 0.621, 0.653.

Data Collection Process

To determine whether there is a difference between pre-service teachers' computational (computer) thinking skills and technology usage standards before and after the STEM applications designed based on the Tinkercad Program during the data collection process in the research, the Computational (Computer) Thinking Skill Scale and the Technology Standards Scale pre-test and post-test has been applied.

Data Analysis

SPSS 22 Package Program was used to analyze the data in the research. In addition to descriptive statistics, dependent groups t-test was used to determine the effect of STEM education designed based on the Tinkercad Program on pre-service teachers' computational (computer) thinking skills and technology usage standards.

Implementation Process

A summary of the STEM applications carried out based on the Tinkercad Program in the research is given in Figure 1.

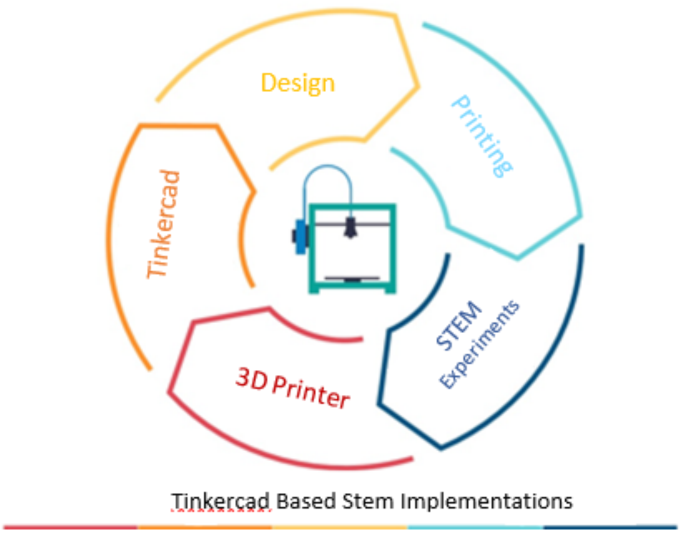

Figure 1. Implementation Process

Within the scope of the practices carried out within the framework of the study, the implementation process of which is summarized in Figure 1, pre-service teachers participated in the STEM training designed based on the 11-week Tinkercad Program within the scope of the Science and Technology Laboratory Practices II course. Students were divided into groups of 3-5 people. Firstly, theoretical information about 3D printers and printing processes was given. Then, the Tinkercad program was started, and the program was introduced. The training was given on the tools and how to use them. The pre-service teachers were asked to design a keychain, pen holder and an item that they would use to learn the program and see the products they designed in the 3D printer before proceeding with the practical applications. Then, four experiments were selected from TÜBİTAK "Design and Build" experiments. These experiments were determined as I Become the Wind, Let's Design a Wheeled Ship, Catapult Design, and Balloon Car. Each group planned the materials needed for these experiments and how they would design them. After making their own interpretations, they designed them in the Tinkercad Program. Design examples of pre-service teachers are given in Figure 2 below.

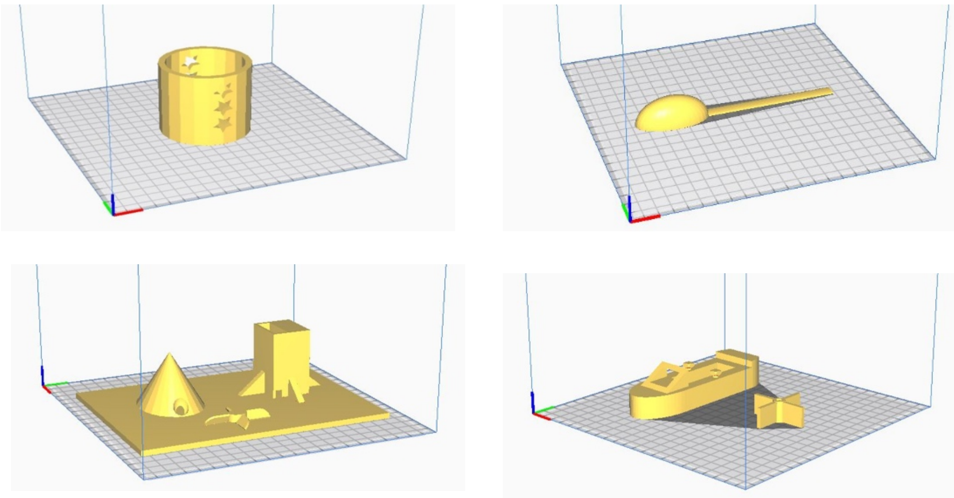

Figure 2. Examples of designs made by pre-service teachers

The designed objects and experimental materials were also printed on the 3D printer. Student groups carried out their experiments with printed materials. The unsuccessful groups during the experiments re-examined the materials and rearranged their designs. The 3D printed outputs of the pre-service teachers' designs are shown in Figure 3.

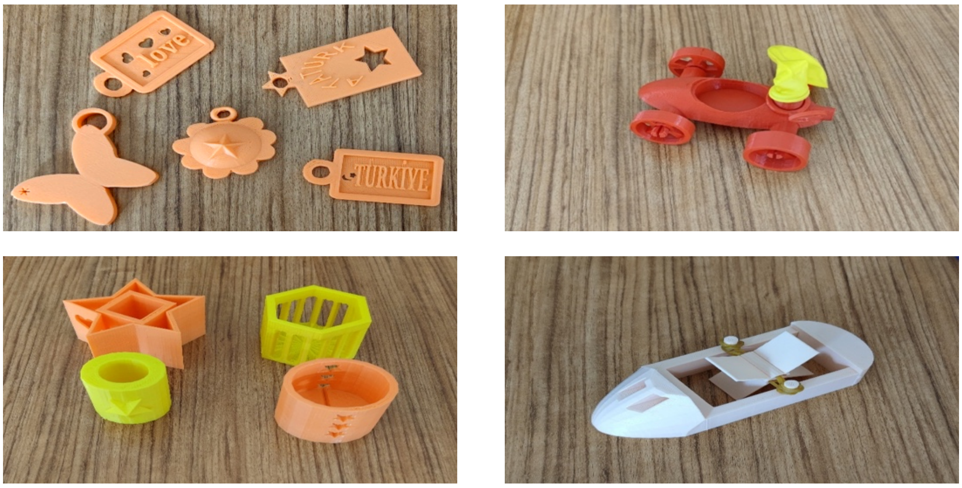

Figure 3. Examples of products printed on a 3D printer

Figure 3 shows printed and assembled samples of the experimental materials designed by the pre-service teachers both in preparation for the design process and during the experiments.

FINDINGS

Within the scope of the study, the effect of STEM applications designed based on the Tinkercad Program taken by the primary school teacher candidates on computational (computer) thinking skills and digital skill technology standards was investigated. In this context, scales for both variables were applied before and after. The dependent group's t-test findings regarding the data obtained at the end of the application are presented in the tables below. According to this:

The paired t-test results performed to determine the primary school teacher candidates' computational thinking skill test scores at the end of the experimental process are presented in Table 1 in terms of general and sub-dimensions.

Table 1. T-test results for dependent groups regarding pre-test and post-test scores of pre-service teachers' computational thinking skills

Factor	Test	N	$\bar{X}$	ss	sd	t	p
Creativity	Pre-Test	90	16,54	3,25	89	0,074	0,941
	Post- Test	90	16,51	3,27			
Algorithmic thinking	Pre-Test	90	13,42	3,71	89	-1,934	0,056
	Post- Test	90	14,18	3,42			
Cooperation	Pre-Test	90	15,95	3,53	89	0,298	0,766
	Post- Test	90	15,80	3,79			
Critical thinking	Pre-Test	90	13,36	3,54	89	-2,532	**0,013***
	Post- Test	90	14,33	3,44			
Problem-solving	Pre-Test	90	22,44	4,00	89	2,232	**0,028***
	Post- Test	90	20,96	5,92			
Total	Pre-Test	90	81,72	13,13	89	-0,043	0,966
	Post- Test	90	81,79	13,14			

*p<0,05

The average scores of the primary school teacher candidates before and after the experimental process from the computational thinking skill scale are shown in Table 1. According to Table 1, the total scores of the pre-test result of the primary school teacher candidates' computational thinking skill levels were $\bar{X}$ =81.72, while the post-test result was $\bar{X}$= 81.79. The scores were close, and no significant difference was observed between the pre-test and post-test scores. When the sub-dimensions are examined, the Creativity scores pre-test result is $\bar{X}$=16.54; the post-test result is $\bar{X}$=16.51, the Algorithmic Thinking score pre-test result is $\bar{X}$=13.42, the post-test result is $\bar{X}$=14.18, Collaboration scores pre-test $\bar{X}$=15, When it is 95, the post-test result is $\bar{X}$=15.80, the Critical thinking scores pre-test result is $\bar{X}$=13.36, the post-test result is $\bar{X}$=14.33, the problem-solving score pre-test result is $\bar{X}$=22.44, while the post-test result is $\bar{X}$=20.96 has been determined. When the sub-dimensions were examined within themselves, no statistically significant difference was found between the pre-test and post-test critical thinking and problem-solving scores ($p>0.05$). However, a significant difference was found in favor of the posttest in the critical thinking dimension and the pretest in the problem-solving dimension ($\bar{X}$=13.36; $\bar{X}$=14.33, p=0.013; $p<0.05$; $\bar{X}$=22.44; $\bar{X}$= 20.96, p=0.028; $p<0.05$). There was no significant difference in the Creativity, algorithmic thinking, and cooperation dimensions.

The paired t-test results performed to determine the primary school teacher candidates' educational technology standards test scores at the end of the experimental procedure are presented in Table 2 in terms of general and sub-dimensions.

Table 2. T-test results for dependent groups regarding pre-test and post-test scores of classroom teacher candidates in educational technology standards

Factor	Test	N	$\bar{X}$	ss	sd	t	p
Creativity	Pre-Test	90	14,71	2,87	89	-4,129	0,000*
	Post- Test	90	15,97	2,95			
Technology literacy	Pre-Test	90	42,47	6,07	89	-1,036	0,303
	Post- Test	90	43,21	6,48			
Innovation	Pre-Test	90	11,26	1,91	89	-3,082	0,003*
	Post- Test	90	12,01	2,33			
Digital citizenship and Participation	Pre-Test	90	14,83	2,73	89	-3,094	0,003*
	Post- Test	90	15,78	2,94			

Total	Pre-Test	90	83,27	11,09	89	-2,851	0,005*
	Post- Test	90	86,97	12,98			

*p<0,05

The average scores of the pre-service classroom teachers from the technology standards scale before and after the experimental procedure are shown in Table 2. According to Table 2, the total scores of the technology standards levels of the classroom teacher candidates were determined as $\bar{X}$=83.27 in the pre-test and $\bar{X}$=86.97 in the post-test. The scores were close, and no significant difference was observed between the pre-test and post-test scores. When the sub-dimensions are examined, the Creativity scores pre-test result is $\bar{X}$=14.71; the post-test result is $\bar{X}$=15.97, the technology literacy score pre-test result is $\bar{X}$=42.47, the post-test result is $\bar{X}$=43.21, the Innovation score pre-test result $\bar{X}$=11. At the age of 26, the post-test result was $\bar{X}$=12.01, the digital citizenship and participation scores were determined as pre-test results of $\bar{X}$=14.83, while the post-test result was $\bar{X}$=15.78.

When Table 2 is examined, it has been determined that the pre-test and post-test scores of the pre-service teachers in educational technology standards have increased in terms of all dimensions and total scores. This difference in the dimension of technology literacy was not significant. A statistically significant difference was found in creativity, innovation, digital citizenship and participation dimensions and total scores ($\bar{X}$=14.71; $\bar{X}$=15.97, p=0.000; $p<0.05$; $\bar{X}$=11.26; X=12). .01, p=0.003, $p<0.05$, $\bar{X}$=14.83, $\bar{X}$=15.78, p=0.003, $p<0.05$, $\bar{X}$=83.27, $\bar{X}$=86.97, p=0.005 ; $p<0.05$).

DISCUSSION and CONCLUSION

STEM education is an innovative approach that has become increasingly common in our country and the world and is trying to be added to many teaching contents. Due to this spread, much research and studies on the subject have been done and continue to be done. This research aims to examine the effects of STEM education on the technology use skills and computational thinking skills on which the design skills used in the education process are based on the Tinkercad Program. In this study, the effect of STEM education on basically two types of skills was investigated. In this context, STEM education activities were given to the teacher candidates participating in the study based on the systematically designed Tinkercad Program for 11 weeks. The relevant skills were measured and evaluated at the beginning and end of the process.

At the end of the research, it was determined that STEM applications performed based on the Tinkercad Program did not affect the general average of computational thinking skills of primary school teacher candidates, but only a significant increase in the critical thinking dimension, which is one of the sub-dimensions of computational thinking skills. Considering the coding and design dimensions within the STEM activities carried out based on the Tinkercad Program, this study, which is also used in STEM education, shows that the success of design and coding does not affect computational thinking skills, as in studies examining the effects of these dimensions on computational thinking skills by actively using these dimensions. It has been determined that there are other studies (Kukul, 2018; Yolcu, 2018). However, when the studies of Turan (2019), Ertuğrul-Akyol (2020) and Berkan (2018) are taken into account, it is noteworthy that there are also studies where the opposite is in question. According to studies indicating that the perceived benefit from STEM education has a positive effect on the implementation process and the result, it has been determined that there is no change in the average scores of individuals who perceive that they will not benefit from STEM education in their career processes (Bahar & Adiguzel, 2016; Mau et al., 2019). Within the scope of the Science Curriculum (MEB, 2018a), applications similar to STEM activities are carried out under the title of Science, Engineering and Entrepreneurship Applications. In this topic, students are expected to identify the problem, realize the design, turn it into a product, and use marketing strategies. In the current study, separating the design process from the curriculum, including technology skills, may have led the classroom teacher candidates to negative thoughts about their contribution to the teaching process in their teaching life. In other words, individuals who think they will not benefit from STEM applications professionally do not develop in terms of skills that are tried to be gained through STEM education. Based on these views, it brings to mind that the pre-service teachers' thinking that STEM applications are not a method that contributes to the teaching processes or that it is challenging to implement may affect the change in the average score.

According to a study conducted by Wang et al. (2017), it is seen that STEM applications are challenging to overcome as the source of the negative results obtained for the skills aimed to be gained with STEM applications. Within computational thinking, individuals are expected to plan, overcome and adapt to new situations in problem-solving processes. As seen in the problem-solving sub-dimension, it is seen that primary school teacher candidates have problems with these skills. It can be thought that this result is because there are challenging situations for teacher candidates in STEM applications based on the Tinkercad Program.

Although there was no significant difference in computational thinking skills at the end of the study, it was determined that there was a decrease in the behaviors exhibited in the problem-solving sub-dimension, which is a sub-dimension of skills. This result contrasted with the studies conducted by Secer (2020), Öztürk (2018), Akkaya (2018), and Cho and Lee (2013), which showed that problem-solving skills increased as a result of STEM education. It can be said that this decrease determined as a result of the study is due to the direct use of exemplary design activities used in the current research instead of using mental processes in the solution of the activities used in the implementation process. At this point, Angeli et al. (2016) considered it appropriate to examine and test it in the context of level, content and method.

Considering the changing world dynamics and daily needs, the knowledge and skills expected to be possessed by the members of society can be gained by qualified teachers, especially in educational environments. At this point, solving technological problems and using the necessary cognitive processes will be easier, thanks to computational thinking skills (Bocconi et al., 2016; Gülbahar et al., 2019). Although it was determined in this study that STEM education did not have a direct effect based on the Tinkercad Program, it is recommended to increase studies that include alternative tools and methods during STEM applications. It is thought that the fact that these tools and methods will primarily increase their technology competencies will contribute to computational thinking. The results obtained in the current research in the dimension of technology literacy also support this situation.

When the study was examined in the context of educational technology standards of primary school teacher candidates, It was determined that the pre-test scores of the primary school teacher candidates from the educational technology standards scale differed significantly from the scores at the end of the application. This result is in line with the study by Aguila (2015) and Murat (2018) examining the effects of STEM education on 21st-century skills, which are technology usage standards among sub-dimensions. According to this increase seen in almost all dimensions, it is thought that STEM applications contribute to acquiring knowledge and skills of primary school teacher candidates about educational technology. This inference also finds a response from the studies of Uluyol and Eryılmaz (2015). The primary purposes of STEM applications realized based on the Tinkercad Program are to carry out a design process and to improve existing designs. It can be said that the realization of these applications within the research scope improves the teacher candidates' creativity and innovation skills at the point of the design process. When we look at technology standards in general, they first emerged in the 90s and then developed with the disciplines of engineering and science. As an effect of this development, the concept of technology literacy has entered the curriculum as a dimension of STEM applications. This situation can explain how STEM and technology usage standards are intertwined. In other words, thanks to the technology dimension that is a part of STEM education, it is natural to see an improvement in the technology usage standards of individuals participating in STEM applications. According to some studies, even individuals whose average score for technology usage standards is determined as moderate; is determined that technology, society and science are related in an integrated way, and technology usage standards are at a reasonable level, and the inference obtained from the study finds its counterpart (Aydın & Silik, 2018). Accordingly, it is thought that it will be essential to conduct studies on the impact of STEM practices on various other high-level skills, including technology standards.

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Statements of publication ethics

I/We hereby declare that the study has no unethical issues and that research and publication ethics have been observed.

REFERENCES

Aguila, M. G. T. (2015). 21st century skills of Nueva Vizcaya State University Bambang Campus, Philippines. *Asia Pacific Journal of Education, Arts and Sciences, 2*(2), 30-37.

Akgündüz, D., ve Akpınar, B. C. (2018). Okul öncesi eğitiminde fen eğitimi temelinde gerçekleştirilen STEM uygulamalarının öğrenci, öğretmen ve veli açısından değerlendirilmesi. *Yaşadıkça Eğitim, 32*(1), 1-26.

Akkaya, A. (2018). *The effects of serious games on students' conceptual knowledge of object-oriented programming and computational thinking skills.* [Yüksek Lisans Tezi]. Boğaziçi Üniversitesi.

Alan, Ü. (2020). *Okul öncesi dönem çocuklarına yönelik geliştirilen stem eğitimi programının etkililiğinin incelenmesi.* [Doktora Tezi]. Hacettepe Üniversitesi.

Angeli, C., Voogt, J., Fluck, A., Webb, M., Cox, M., Malyn-Smith, J., & Zagami, J. (2016). A K-6 computational thinking curriculum framework: Implications for teacher knowledge. *Journal of Educational Technology & Society, 19*(3), 47-57.

Assessment and Teaching of 21st Century Skills (ATC21S). (2012). *21st century skills*. http://www.atc21s.org/ adresinden 12 Eylül 2021 tarihinde erişilmiştir.

Aydın, N. (2019). *STEM ve STEM temelli robotik etkinliklerinin ortaokul öğrencilerinin problem çözmeye yönelik yansıtıcı düşünme, zihinsel risk alma ve öğrenmede motive edici stratejilerine etkisi*. [Yüksek Lisans Tezi]. Erzincan Binali Yıldırım Üniversitesi.

Aydın, G., Saka, M., ve Guzey, S. (2017). 4-8. sınıf öğrencilerinin fen, teknoloji, mühendislik, matematik (STEM= FETEMM) tutumlarının incelenmesi. *Mersin University Journal of the Faculty of Education*, *13*(2), 787-802.

Aydın, F. ve Silik, Y. (2018). Teknoloji okuryazarlığı: tarihsel bir betimleme. *Ihlara Eğitim Araştırmaları Dergisi, 3*(2), 107-126.

Bahar, A., & Adiguzel, T. (2016). Analysis of factors influencing interest in STEM career: Comparison between American and Turkish high school students with high ability. *Journal of STEM Education: Innovations and Research*, *17*(3), 64-69.

Benitti, F. B. V. (2012). Exploring the educational potential of robotics in schools: A sySTEMatic review. *Computers & Education*, *58*(3), 978-988.

Benitti, F. B. V., & Spolaôr, N. (2017). How have robots supported STEM teaching?. In *Robotics in STEM education* (pp. 103-129). Cham: Springer.

Berikan, B. (2018). *Bilgi işlemsel düşünme becerisine yönelik tasarlanan "veri setleriyle problem çözme" öğrenme deneyiminin biçimlendirici değerlendirmesi.*[Doktora Tezi]. Gazi Üniversitesi.

Bocconi, S., Chioccariello, A., Dettori, G., Ferrari, A., & Engelhardt, K. (2016*). Developing computational thinking in compulsory education-Implications for policy and practice*.

Bozkurt-Altan, E., Yamak, H. ve Buluş-Kırıkkaya, E. (2016). FeTeMM eğitim yaklaşımının öğretmen eğitiminde uygulanmasına yönelik bir öneri: Tasarım temelli fen eğitimi. *Trakya Üniversitesi Eğitim Fakültesi Dergisi, 6*(2), 212-232.

Büyüköztürk, Ş., Kılıç Çakmak, E., Akgün, Ö. E., Karadeniz, Ş. ve Demirel, F. (2008). *Bilimsel araştırma yöntemleri*. Pegem Akademi Yayıncılık.

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

Canbazoğlu, H. B. ve Tümkaya, S. (2020). İlkokul dördüncü sınıf öğrencilerinin fen, teknoloji, mühendislik, matematik (FeTeMM) tutumlarının çeşitli değişkenler açısından değerlendirilmesi. *Turkish Journal of Computer and Mathematics Education (TURCOMAT), 11*(1), 188-209.

Cho, B., & Lee, J. (2013). *The effects of creativity and flow on learning through the steam education on elementary school contexts*. Paper presented at the International Conference of Educational Technology, Sejong University, South Korea.

Cohen, L., Manion, L., & Marrison, K. (2007). *Research methods in education*. Routledge.

Creswell, J. W. (2012). E*ducational research: Planning, conducting, and evaluating quantitative and qualitative research*. Pearson Education, Inc.

Çakır, Z., Altın Yalçın, S. ve Yalçın, P. (2019). Montessori yaklaşım temelli STEM etkinliklerinin okul öncesi öğretmen adaylarının yaratıcılık becerilerine etkisi. *Uluslararası Bilimsel Araştırmalar Dergisi (IBAD), 4*(2), 392-409.

Çetin, İ. ve Toluk Uçar, Z. (2017). Bilgi işlemsel düşünme tanımı ve kapsamı. Y. Gülbahar (Ed). *Bilgi işlemsel düşünmeden programlamaya* içinde (ss. 41-74). Pegem Akademi Yayıncılık.

Dilber, A. (2020). Öğretmenlerin problem çözme becerilerinin ve davranışlarının yaratıcı düşünmenin gelişimine katkısının yordanmasında STEM farkındalıklarının rolü. *Academia Eğitim Araştırmaları Dergisi, 5*(1), 77-89.

Dörnyei, Z. (2007). *Research methods in applied linguistics.* Oxford University Press.

Dugger, W. E. (2010, Aralık). Evolution of STEM in the United States. 6th Biennial International Conference on Technology Education Research, Australia.

Ertuğrul Akyol, B. (2020). *STEM etkinliklerinin fen bilgisi öğretmen adaylarının bilgi işlemsel, eleştirel, yaratıcı düşünme ve problem çözme becerilerine etkisi.* [Doktora Tezi]. Erciyes Üniversitesi.

Guzey, S. S., Harwell, M., & Moore, T. (2014). Development of an instrument to assess attitudes toward science, technology, engineering, and mathematics (STEM). *School Science and Mathematics, 114*(6), 271-279.

Gülbahar, Y., Kert, S. B., & Kalelioğlu, F. (2019). Bilgi işlemsel düşünme becerisine yönelik öz yeterlik algısı ölçeği: Geçerlik ve güvenirlik çalışması. *Turkish Journal of Computer and Mathematics Education (TURCOMAT), 10*(1), 1-29.

Gülgün, C., Çağlar, A., & Yılmaz, A. (2017). The effect of primary school teachers attitudes towards science teaching for students academic achievements. *Journal of Current Researches on Educational Studies, 7*(1), 28-43.

Gülhan, F. Ve Şahin, F. (2018). Fen bilimleri dersine STEM entegrasyonu etkinliklerinin 5. sınıf öğrencilerinin bilimsel yaratıcılıklarına etkisi. *Sakarya University Journal of Education, 8*(4), 40-59.

Gürel, A., & Emre F. B. (2017). *Fen bilimleri dersinde teknoloji ve 3D yazıcıların kullanımı.* 1. Uluslararası Bilgisayar ve Öğretim Teknolojileri Sempozyumu, Malatya.

Karaahmetoğlu, K., & Korkmaz, Ö. (2019). The effect of project-based arduino educational robot applications on students' computational thinking skills and their perception of basic STEM skill levels. *Participatory Educational Research*, *6*(2), 1-14.

Karasar, N. (2000). *Bilimsel araştırma yöntemleri: Kavramlar, ilkeler, terimler*. Ankara: Nobel Yayın Dağıtım.

Khanlari, A. (2016). Teachers' perceptions of the benefits and the challenges of integrating educational robots into primary/elementary curricula. *European Journal of Engineering Education, 41*(3), 320-330.

Korkmaz, Ö., Altun, H., Usta, E., & Özkaya, A. (2014). The effect of activities in robotic applications on students' perception on the nature of science and students' metaphors related to the concept of robot. *International Journal on New Trends in Education and Their Implications, 5*(2), 44-62.

Koç, A. (2019). *Okul öncesi ve temel fen eğitiminde robotik destekli ve basit malzemelerle yapılan STEM uygulamalarının karşılaştırılması.* [Doktora Tezi]. Erciyes Üniversitesi.

Kukul, V. (2018). *Programlama öğretiminde farklı yapılandırılan süreçlerin öğrencilerin bilgi işlemsel düşünme becerilerine, özyeterliliklerine ve programlama başarılarına etkisi.* [Yüksek Lisans Tezi]. Gazi Üniversitesi.

Lacey, T. A., & Wright, B. (2009). Employment outlook: 2008-18. Occupational employment projections to 2018. *Monthly Labor Review, 132*(11), 82-123.

Light, J. S. (1999). When computers were women. *Technology and Culture, 40*(3), 455-483.

Lockwood, J., & Mooney, A. (2017). Computational thinking in education: Where does it fit? A systematic literary review. https://arxiv.org/ftp/arxiv/papers/1703/1703.07659.pdf adresinden 14 Eylül 2021 tarihinde erişilmiştir.

Mau, W. C., Chen, S. J., & Lin, C. C. (2019). Assessing high school student's STEM career interests using a social cognitive framework. *Education Sciences, 9*(2), 151-162.

Meng, C. C., Idris, N., & Eu, L. K. (2014). Secondary students' perceptions of assessments in science, technology, engineering, and mathematics (STEM). *Eurasia Journal of Mathematics, Science and Technology Education*, *10*(3), 219-227.

Millî Eğitim Bakanlığı (MEB). (2017). *STEM Eğitimi Öğretmen El Kitabı.* http://scientix.meb.gov.tr/images/upload/Event_35/Gallery/STEM%20E%C4%9Fitimi%20 %C3%96%C4%9Fretmen%20El%20Kitab%C4%B1.pdf, adresinden 12 Eylül 2021 tarihinde erişilmiştir.

Milli Eğitim Bakanlığı (MEB). (2018b). *Bilişim teknolojileri dersi öğretim program*ı. Milli Eğitim Bakanlığı.

Milli Eğitim Bakanlığı (MEB) (2018a*). Fen bilimleri dersi öğretim programı (İlkokul ve ortaokul 3, 4, 5, 6, 7 ve 8. sınıflar).* Milli Eğitim Bakanlığı.

Millî Eğitim Bakanlığı (MEB). (2020). *Fırsatları artırma ve teknolojiyi iyileştirme hareketi.* http://fatihprojesi.meb.gov.tr adresinden 23 Eylül 2021 tarihinde erişilmiştir.

Morrison, J. (2006). STEM education monograph series: Attributes of STEM education the student, the school, the classroom. *Teaching Institute for Essential Science*, 20, 2-7.

Murat, A. (2018). *Fen bilgisi öğretmen adaylarının 21.yüzyıl becerileri yeterlik algıları ile STEM'e yönelgik tutumlarının incelenmesi.* [Yüksek Lisans Tezi]. Fırat Üniversitesi.

Öztürk, S. C. (2018). *STEM eğitiminin fen bilgisi öğretmen adaylarının problem çözme ve eleştirel düşünme becerileri üzerine etkisi.* [Yüksek Lisans Tezi]. Erzincan Binali Yıldırım Üniversitesi.

Partnership for 21st Century Skills (PFCL). (2014). *Resources for educators.* http://www.p21.org/our-work/resources/for-educators adresinden 12 Eylül 2021 tarihinde erişilmiştir.

Paul, G. M., Michelle, R. O., Colin, R. M., & Justin. W. A. (2014). The production of anatomical teaching resources using three-dimensional (3D) printing technology. *Anatomical Sciences Education,* 7, 479-486.

Robinson, K. (2010). *Changing education paradigms*. [Video]. TED Talk.

Rogers, C., & Portsmore, M. (2004). Bringing engineering to elementary school. *Journal of STEM Education*, *5*(3), 17-28.

Rubio, M. A., Hierro, C. M., & Pablo, A. P. D. M. (2013). *Using arduino to enhance computer programming courses in science and engineering*. EDULEARN13 Conference, IATED Barcelona, Spain.

Saeli, M., Perrenet, J., Jochems, W. M., & Zwaneveld, B. (2011). Teaching programming in Secondary school: A pedagogical content knowledge perspective. *Informatics in Education, 10*(1), 73-88.

Sağat, E. (2020). *STEAM temelli fen öğretiminin üstün zekâlı ve yetenekli öğrencilerin STEAM performanslarına, tasarım temelli düşünme becerilerine ve STEAM tutumlarına etkisi.* [Yüksek lisans tezi]. Mersin Üniversitesi.

Sağsöz, G. (2019). Resimli çocuk kitaplarında STEAM: "yaratıcı ve eleştirel düşünme becerisi". *Bilim, Teknoloji, Mühendislik, Matematik ve Sanat (J-STEAM) Eğitim Dergisi, 2*(1), 1-20.

Scaradozzi, D., Cesaretti, L., Screpanti, L., Costa, D., Zingaretti, S., & Valzano, M. (2019). Innovative tools for teaching marine robotics, IoT and control strategies since the primary school. In L. Daniela (Ed.) *Smart learning with educational robotics.* (pp. 199-227). Springer.

Secer, M. (2020). *Bilişim teknolojileri̇ ve yazılım dersinde arduino kodlama ile kâğıt-kalem kodlama uygulamalarının öğrencilerin bilgi işlemsel düşünme becerileri̇, problem çözme becerileri̇ ve STEM tutumları üzerine etkisi.* [Doktora Tezi]. Mersin Üniversitesi.

Sencer, M. ve Sencer, Y. (1978). *Toplumsal araştırmalarda yöntembilim.* Türkiye ve Orta Doğu Amme İdaresi Enstitüsü.

Smith, J., & Karr-Kidwell, P. J. (2000). *The interdisciplinary curriculum: A literary review and a manual for administrators and teachers.* [Master Thesis]. Texas Woman's University.

Soros, P., Ponkham, K., & Ekkapim, S. (2018, January). The results of STEM education methods for enhancing critical thinking and problem solving skill in physics the 10th grade level. *In AIP Conference Proceedings*. AIP Publishing LLC.

Şahiner, A. ve Kert, S. B. (2016). Komputasyonel düşünme kavramı ile ilgili 2006-2015 yılları arasındaki çalışmaların incelenmesi. *Avrupa Bilim ve Teknoloji Dergisi, 5*(9), 38-43.

Şendurur, E. (2018). The pedagogical beliefs and instructional design practices: Pre- service IT teachers' case. *Eurasian Journal of Educational Research, 18*(75), 59-80.

Şimşek, E. (2018). *Programlama öğretiminde robotik ve scratch uygulamalarının öğrencilerin bilgi işlemsel düşünme becerileri ve akademik başarılarına etkisi.* [Yüksek lisans tezi]. Ondokuz Mayıs Üniversitesi.

Taş, N. (2018). *Farklılaştırılmış bilgisayar destekli matematik etkinliklerinin üstün yeteneklilerin bilgi işlemsel düşünme özyeterlikleri ve matematiğe yönelik tutumlarına etkisi.* [Doktora Tezi]. Atatürk Üniversitesi.

Turan, B. (2019). *Ortaokul öğrencilerinin geliştirdiği oyun ve robot projelerinde probleme dayalı öğrenmenin problem çözme ve bilgi işlemsel düşünme becerilerine etkisi.* [Yüksek Lisans Tezi]. Van Yüzüncü Yıl Üniversitesi.

Uluyol, Ç. ve Eryılmaz, S. (2015). 21. yüzyıl becerileri ışığında FATİH projesi değerlendirmesi. *Gazi Üniversitesi Gazi Eğitim Fakültesi Dergisi*, *3*5(2), 209-229.

Wang, H. H. (2012). *A new era of science education: Science teachers' perceptions and classroom practices of science, technology, engineering, and mathematics (STEM) integration.* [Doctorate Dissertion]. University of Minnesota.

Wang, M. T., Ye, F., & Degol, J. L. (2017). Who chooses STEM careers? Using a relative cognitive strength and interest model to predict careers in science, technology, engineering, and mathematics. *Journal of Youth and Adolescence, 46*(8), 1805-1820.

WEF. (2016). *The future of jobs, report by the World Economic Forum, Davos.* January 2016. https://www.weforum.org/reports/the-future-of-jobs/ adresinden 12 Eylül 2021 tarihinde erişilmiştir.

Wing, J. M. (2006). Computational thinking. *Communications of the ACM*, *49*(3), 33-35.

Yamak, H., Bulut, N., & Dündar, S. (2014). 5. sınıf öğrencilerinin bilimsel süreç becerileri ile fene karşı tutumlarına FeTeMM etkinliklerinin etkisi. *Gazi Üniversitesi Gazi Eğitim Fakültesi Dergisi, 34*(2), 249-265.

YEĞİTEK (2015). Sınırsız öğretime açılan kapı. *T.C. Millî Eğitim Bakanlığı Yenilik ve Eğitim Teknolojileri Genel Müdürlüğü Dergisi,* 12, 14-15.

Yıldırım, B. (2016). *7. sınıf fen bilimleri dersine entegre edilmiş fen teknoloji mühendislik matematik (STEM) uygulamaları ve tam öğrenmenin etkilerinin incelenmesi.* [Doktora Tezi]. Gazi Üniversitesi.

Yıldırım, Y. (2016). *Probleme dayalı öğretim yöntemi ile doğrusal denklemlerin grafiğinin öğretiminin ortaokul üçüncü sınıf öğrencilerinin akademik başarısına etkisi*. [Yüksek Lisans Tezi]. Atatürk Üniversitesi.

Yıldız, B. (2017). Disiplinlerarası öğretim yaklaşımı: Bilgi işlemsel düşünme ve FeTeMM. Y. Gülbahar (Ed). *Bilgi işlemsel düşünmeden programlamaya* (ss. 319-336). Pegem Akademi Yayıncılık.

Yolcu, V. (2018). *Programlama eğitiminde robotik kullanımının akademik başarı, bilgi- işlemsel düşünme becerisi ve öğrenme transferine etkisi.* [Yüksek Lisans Tezi]. Süleyman Demirel Üniversitesi.

Yüzbaşıoğlu, M. K., Doğanay, K. & Avan, Ç. (2020). Science, engineering and entrepreneurship practices: activity of designing a lighting tool to reduce light pollution and students views about this activity. *Online Science Education Journal*, 5 (2) , 60-72.