Received Date: 1 August 2023 I Accepted Date: 24 October 2023

OPUS Journal of Society Research

RESEARCH ARTICLE

STEM Based Innovative Thinking Skills and Attitudes towards Digital Technology in Robotic Coding and 3D Printer Applications

Hasan Güleryüz

Dr. Instructor, Altinbas University,
Istanbul /Türkiye
ORCID: 0000-0002-0941-4969
E-Mail:
guleryuz_hasan@yahoo.com

October 2023
Volume:20
Issue: Special Issue-Human Behavior and Social Institutions

DOI: 10.26466//opusjsr.1336102

Citation:
Güleryüz, H. (2023). Stem based innovative thinking skills and attitudes towards digital technology in robotic coding and 3d printer applications. *OPUS– Journal of Society Research, 20*(Special Issue-Human Behavior and Social Institutions), 812-824.

Abstract

The aim of this study is to determine STEM-based innovative thinking skills and attitudes towards digital technology in robotic coding and 3D printer applications with 45 teacher candidates participating in the research. Quantitative research method was used. The research lasted 12 weeks. Innovative thinking skills scale and attitude scales towards digital technology were used. The research was conducted in the form of pretest and posttest. It is seen that there is a significant positive difference in the innovative thinking skills of the teacher candidates and their attitudes towards digital technology. In the STEM-based research, robotic coding and 3D printing training was given. In this context, three different applications were made regarding traffic lights. In robotic coding applications, Tinkercad, Arduino IDE and Fritzing programs for circuit diagrams, Tinkercad 3D in 3D printing applications and Zaxe PLA for slicing were taught. (SPSS-21.00) program was used to analyze the data and t test was applied for dependent samples. It was determined that the teacher candidates had innovative thinking skills attitudes (t=-23.33; p<0.05) and attitudes towards digital technology (t=-21.58; p<0.05). As a result of the research, it is seen that face-to-face workshop training activities in areas such as 3D design and smart devices are important to carry out robotics, coding and 3D design activities for teacher candidates in order to provide them with informatics production skills in STEM-based studies, and interdisciplinary applications for teacher candidates. It is seen that teacher candidates exhibit positive attitudes in the studies conducted.

Keywords: *STEM Education, Digital Technology, Robotic Coding, 3D Printer, Innovative Thinking skills,*

Öz

Bu çalışmanın amacı, araştırmaya katılan 45 öğretmen adayı ile Robotik kodlama ve 3B yazıcı uygulamalarında STEM temelli inovatif düşünme becerileri ve dijital teknolojiye yönelik tutumlarını belirlemektir. Nicel araştırma yöntemi kullanılmıştır. Araştırma 12 hafta sürmüştür. İnovatif düşünme becerileri ölçeği ve Dijital teknolojiye yönelik tutum ölçekleri kullanılmıştır. Araştırma öntest ve sontest şeklinde yapılmıştır. Öğretmen adayların inovatif düşünme becerileri ve dijital teknolojiye yönelik tutumlarında olumlu yönde anlamlı fark çıktığı görülmektedir. STEM temelli yapılan araştırmada robotik kodlama ve 3B yazıcı eğitimleri verilmiştir. Bu kapsamda trafik lambaları ile ilgili üç farklı uygulama yapılmıştır. Robotik kodlama uygulamalarında Tinkercad, Arduino İDE ve devre şeması için Fritzing programları, 3B yazıcı uygulamalarında Tinkercad 3B ve dilimleme için Zaxe PLA öğretilmiştir. Verilerin analizlerinde (SPSS-21.00) programı kullanılmış ve bağımlı örneklemler için t testi uygulanmıştır. Öğretmen adayların inovatif düşünme becerileri tutumlarının (t=-23,33; p<0,05) ve dijital teknolojiye yönelik tutumlarının (t=-21,58; p<0,05) olduğu belirlenmiştir. Araştırmanın neticesinde öğretmen adaylarına STEM temelli çalışmalarda bilişimle üretim becerileri kazandırmaya yönelik olarak robotik, kodlama ve 3B tasarım etkinliklerinin yürütülmesi ve öğretmen adaylarına disiplinler arası uygulamalar yapması, 3B tasarım ve akıllı cihaz gibi alanlarda yüz yüze atölye eğitim faaliyetlerin önem arz ettiği görülmektedir. Öğretmen adayların yapılan çalışmalarda olumlu tutum sergilediği görülmektedir.

Anahtar Kelimeler: *STEM Eğitimi, Dijital Teknoloji, Robotik Kodlama, 3B Yazıcı, İnovatif Düşünme becerileri,*

Introduction

The most distinctive feature of developed and developing societies is that they adapt to the scientific and technological changes experienced at the global level by updating their education systems. Countries that attach importance to the education system have moved away from the traditional understanding of education and searched for new understandings of education. The new approach known as STEM education has emerged with the concept of integration of disciplines, which is one of the concepts in the focus of countries (Akgündüz, 2018). Thanks to STEM education, it has now become possible to teach children programming, which develops systematic and innovative thinking skills and enables them to see the connection between events, as both entertaining and instructive.

Countries that will have a say in the world in the 21st century, are able to master programming languages, solve problems with their own methods, raise generations equipped with creative, 21st century skills, and develop skills such as robotics, coding and 3D design with STEM (Science, Technology, Engineering and Mathematics) education (Göksoy & Yılmaz, 2018; Güleryüz, 2023; Karataş, 2021). They are those who have succeeded in making the education that requires education a part of their education system by starting from early childhood.

In the 21st century, it is seen that students are trying to raise them as individuals who ask questions, define problems, encourage innovative thinking, have an entrepreneurial spirit, have lifelong learning skills and are sensitive to society. In order for Türkiye to increase its scientific research and technological development capacity, social and economic development, and to compete with other countries, it should offer opportunities to students, especially at young ages, to develop these features. STEM education is important in this sense (Güleryüz & Dilber, 2022b). By integrating concepts and skills in STEM fields with each other and applying them to a real-life problem or event, it provides an opportunity for students to learn these concepts and skills more meaningfully. In our age, the way to be ahead in all international fields is to make new inventions, in other words, to innovate.

The premise of innovation is to think innovatively. Innovations and inventions found with innovative thinking can be used by finding application areas. Innovative thinking is an important element that forms the basis of all innovations and inventions and has direct effects on the development and competitiveness of countries. However, researches focus on creative thinking, which is included in innovative thinking. The rapid change and development in the field of technology manifests itself in all areas of socio-economic life, and the changes and developments experienced are also reflected in the belief and value systems of societies. The education system and educational institutions are also affected by this process. In line with the changes and developments experienced, it has become necessary to make innovations in the field of education. The necessities of the change in the social field together with the technological developments have enabled the innovation process to start in the education sector (Sevinç & Uyangör, 2021).

Innovative Thinking Skills

It means transforming knowledge usefully and economically for the benefit of society. For this reason, it is in a number of processes technically, socially and economically. In order to do this, we need to have a culture that is willing to change, open to innovations and has an entrepreneurial spirit. Generating new ideas, brainstorming, mind maps, learning, etc. It is necessary to know the theories well, and then it remains only to implement our innovations and ideas. In the current age, students are expected to continue their skills throughout their life and to be creative individuals. In order to raise such individuals, an understanding based on knowledge production has developed within the framework of developing educational understandings. In order to produce knowledge, individuals must have certain skills. For example, it is seen that people who do research, are creative, catch up with the age by using information technologies, are not problem-solving, but solve problems, produce

solutions, take responsibility, are determined, have personal values, have strong communication, and have leadership qualities are more beneficial for themselves and their country known.

STEM education, which was created as a result of long studies in order to catch up with the era, it was predicted that it would be more accurate and more meaningful to provide students with some basic skills in the direction described in the paragraph above, as well as learning areas and achievements. With these basic skills, students can gain a love and habit of reading, develop their vocabulary, thus use Turkish correctly, effectively and beautifully, make inquiries, think critically, analyze and synthesize, think creatively, establish a healthy communication with their environment, do research when necessary, and do research while doing research. It is aimed to use scientific methods, to use information technologies such as the internet and mass media, to be entrepreneurs, to solve problems, to make decisions when necessary, to establish meaning between texts, and to attach importance to personal and social values. Thus, it is thought that students will be modern individuals who have knowledge and have the capacity to produce knowledge, away from memorization (Özatalay, 2007: 72). In this context, in this part of the research, thinking and thinking skills are explained first, and the importance of the teacher in effective thinking and the teaching of thinking skills are included in the transition to innovative thinking skills.

Innovative Thinking Process

Innovative thinking is a process that emerges as a result of certain stages. The healthy realization of each stage can ensure that the product to be produced has the desired properties. In this direction, Wallas (1926) examined the innovative thinking process in four stages as preparation, incubation, enlightenment and validation (Starko, 2001). Although the four-stage process in question seems to be systematic, the individual can wander between the stages during the application (Yıldırım, 2003).

Preparation: In this step, the elements of the problem are tried to be determined, and the information that individuals will acquire in order to find a solution is revealed (Baki, 2004: 156). In this step, the thoughts on the problem are revived and the relations between the theory and hypotheses are examined (Rıza, 2001:10-14; as cited in Özden 1997, Demirci, 2007: 66). It is stated that the more information about the existing material and the new subject, the easier it will be to develop creative thinking (Yıldırım, 2003). Here the problem is identified, explained, relevant data is collected and the material is checked. Requirements for the solution of the problem are examined, different dimensions of the problem and previous solution proposals are discussed. (Ozden, 2005).

Incubation: In the incubation phase, the individual does not think consciously about the problem. Meanwhile, the individual's mind continues to think about the problem, while the individual is caught up in other activities. This stage is considered as the stage in which the individual does nothing to solve the problem (Demirci, 2007: 66-67; Sünbül, 2011). This stage is considered as the stage in which the individual does nothing to solve the problem (Özden, 2005; Demirci, 2007: 66-67).

Enlightenment: Ideas, thoughts and feelings suddenly fit together and the solution becomes clear. The stage in which the thought required for the solution suddenly emerges is called "enlightenment" or "comprehension". The stage in question is not one that occurs out of nowhere (Demirci, 2007: 67; Sünbül, 2000: 82; Üstündağ, 2009:10). At the moment in question, this formation is instantly recorded in the brain, rapid oscillations occur between the lower part of the left hemisphere of the brain and the upper part of the right hemisphere, and the result makes it possible to pass the verification stage (Üstündağ, 2009: 10).

Evaluation: It consists of a series of activities carried out in order to show whether the result that emerges during the enlightenment phase will meet the needs and whether it will comply with the criteria determined during the preparation phase (Sünbül, 2000). Sometimes, the ideas developed during the enlightenment phase, the solutions that are realized, may not include the solution of the problem. In this case, the individual returns to the incubation stage and participates in the process of developing new solutions (Bulut, 2014: 5). At this

stage, the solution of the problem is evaluated in terms of practicality, relevance and validity. Weaknesses in ideas are identified and some changes are made when necessary in order to implement the solution (Starko, 2001).

Digital technology is defined as applications that display, store and transmit information electronically on a screen. Digital technology plays an effective and active role in educational environments as well as in all areas of life. It is thought that determining students' attitudes towards digital technologies will have an impact on the design and organization of teaching environments (Gokhale, Brauchle & Machina, 2013).

STEM, which is based on technology, innovation and innovative thinking, aims to solve problems within this framework by providing students with the ability of experiential learning. With STEM, students can remove the boundaries of their concrete and abstract worlds, as well as have skills such as critical thinking and problem solving. It is seen that students who receive education with the STEM education model adapt much more easily to the change in the business world and new roles in the 21st century. The importance of these STEM-based studies is to develop innovative thinking, entrepreneurship and scientific thinking skills, to encourage technology learning and production, to increase the permanence of knowledge through learning by experience, to make students love 3D design, robotics and coding, and software technologies and science.

Importance of Research

The way to say that I am in all international fields can be realized by making new inventions and inventions, in other words, by innovating. The premise of innovation is to think innovatively and keep up with the digital age. Innovations and inventions found with innovative thinking can be used by finding application areas. Innovative thinking is an important element that forms the basis of all inventions and innovations. Rapid change and development takes place in the field of technology. These changes and developments are also affecting educational institutions and the education system. In line with the changes and developments experienced, it has become necessary to make innovations in the field of education. In this study, it was predicted that STEM-based robotic coding and 3D design applications and effective teaching strategies could be effective on prospective teachers' innovative thinking skills and attitudes towards digital technology.

Purpose of the research

The purpose of this research is to examine how pre-service teachers use their competencies and skills by coding and 3D design in the science curriculum, in robotic coding and 3D printing applications, and their STEM-based innovative thinking skills and their attitudes towards digital technology.

For these purposes, answers were sought for the following sub-problems:

1- What are STEM-based innovative thinking skills in robotic coding applications?

2- What are their attitudes towards STEM-based digital technology in robotic coding applications?

3- What are STEM-based innovative thinking skills in 3D Printer applications?

4- What are their attitudes towards STEM-based digital technology in 3D Printer applications?

Research Problem

What are STEM-based innovative thinking skills and attitudes towards digital technology in robotic coding and 3D Printer applications?

Method

Research Method

In this study, quantitative research method was applied. Quantitative research method, Quantitative research is defined as the systematic investigation of phenomena by collecting quantitative data and applying statistical, mathematical or computational techniques. By using sampling methods and sending online surveys to current and potential customers collecting quantitative research information,

survey results can be depicted in numerical form. After carefully understanding these numbers, it is predicting the future of a product or service and making changes accordingly. In the analysis of quantitative data, t-test was used for related samples. The related samples t test is used to test whether the difference between the two averages obtained from the related sample is statistically significant (Büyüköztürk, et al. 2013). The research conducted to measure STEM-based innovative thinking skills and attitudes towards digital technology, in which robotic coding and 3D printer applications are used, was conducted in the form of pre-test and post-test.

Sample

45 pre-service teachers participated in the research. Teacher candidates participated in the research on a voluntary basis.

Application

In this study, STEM-Based Innovative Thinking Skills and Attitude Scales towards Digital Technology, which are prepared for pre-service teachers and use robotic coding and 3D printer applications that make the education process simple and fun, were applied. This program was implemented for 12 weeks and for a total of 48 hours (2+2) hours per week. In STEM Based activities with robotic coding and 3D printer, Tinkercad-Arduino program for Robotic coding and circuit diagram was taught on Tinkercad portal. Zaxe (Desktop) PLA programs for Tinkercad-3D design and slicing were taught in 3D Printer activities on Tinkercad portal. A brief summary of the STEM Based Innovative Thinking application using robotic coding and 3D printer applications is given below and the work schedule is shown in Table 1.

A Brief Summary of the Study on Innovative Thinking Skills and Digital Technology of STEM Based Activities Made with Robotic Coding and 3D Printer:

- ✓ Pre-service teachers' readiness for STEM-based activities has been determined. Detailed information about STEM-based applications is given for the activities to be done.
- ✓ In the second week, pre-service teachers were informed about their innovative thinking skills.
- ✓ In the third week, pre-service teachers were informed about Digital Technology.
- ✓ In the fourth and fifth weeks, detailed information was given about the Tinkercad-3D design portal.
- ✓ In the sixth and seventh weeks, detailed information was given about the Tinkercad-Robotic coding portal.
- ✓ In the eighth week, Zaxe PLA program, which is one of the slicing programs, was taught to 3D print the designs made on the Tinkercad-3D design portal.
- ✓ In the ninth week, a Traffic Light was designed on the Tinkercad-3D design portal (Figure 4).
- ✓ In the tenth week, the designs made on the Tinkercad-3D design portal were printed with Zaxe PLA and 3D printers (Figure 6).
- ✓ In the eleventh week, Arduino codes and circuit diagram of Traffic light application were made in Tinkercad-Robotic coding portal (Figure 5, Figure7).
- ✓ Three different applications were made in the twelfth week. The first application with Arduino via Tinkercad, the second application of robotic coding with the traffic light module with Arduino, and then the third application was completed by providing the wireless connection between the traffic light application and the mobile phone, together with the traffic lamp printing made with 3D design (Figure 1, Figure 2, Figure 3, Figure,8), (Appendix-1).

Table 1. *STEM activity program with robotic coding and 3d printer*

Week	Subject
Week 1	STEM Education and STEM-Based Applications
Week 2	About Innovative Thinking Skills
Week 3	About Digital Technology

Week 4	Tinkercad-3D Design
Week 5	Tinkercad-3D Design
Week 6	Tinkercad-Robotic Coding
Week 7	Tinkercad-Robotic Coding
Week 8	Teaching the Slice Program; Zaxe (Desktop) PLA
Week 9	Tinkercad-3D Traffic Light Drawing
Week 10	3D Printing of Traffic Light from 3D Printer
Week 11	Arduino Circuit Construction of Tinkercad-Robotic Coding Traffic Lamp Application
Week 12	Robotic Coding; Three Different Applications about Traffic Lights

Robotic coding-1 traffic light application was made in Figure-1 by using Arduino Ide program on Tinkercad portal.

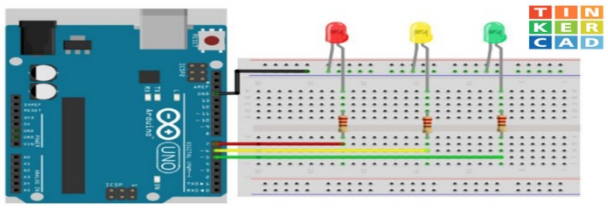

Figure 1. *Robotic Coding-1. Tinkercad Traffic Lamp Application*

The traffic light module to be used in the robotic coding-2 application is shown in figure 2.

Figure 2. *Traffic Light Module*

The Arduino circuit diagram in the Robotic coding-2 application made with the traffic light module is shown in figure 3.

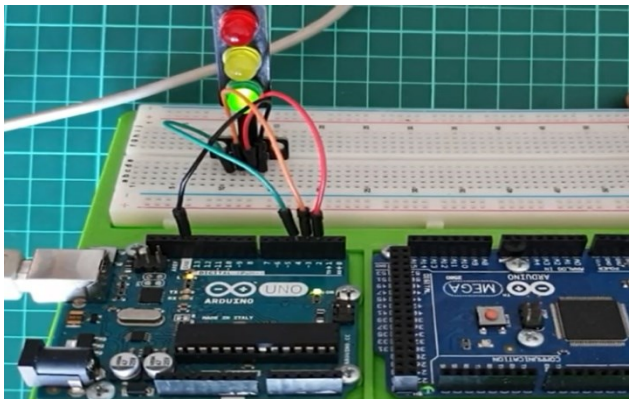

Figure 3. *Robotic Coding-2. Traffic Lamp Module Application*

The 3d design of the traffic lamp model over the Tinkercad portal is shown in figure 4.

Figure 4. *Tinkercad – 3D Design Application*

The traffic light circuit diagram of the robotic coding-3 application made over the Tinkercad portal is shown in figure 5.

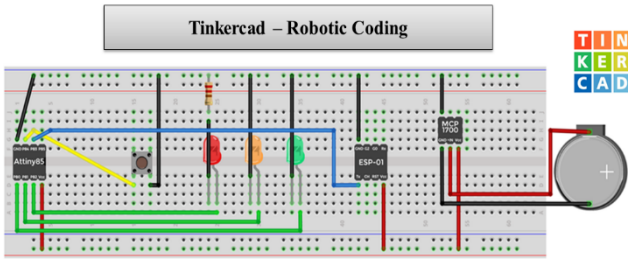

Figure 5. *Robotic Coding-3 Tinkercad Traffic Light Circuit Diagram*

The application of the traffic light was printed from the 3d printer and the assembly process was made. This application is shown in figure 6.

Figure 6. *Three-dimensional Printing and Combination of the Traffic Light*

The Arduino circuit diagram of the traffic light robotic coding-3 application is shown in figure 7.

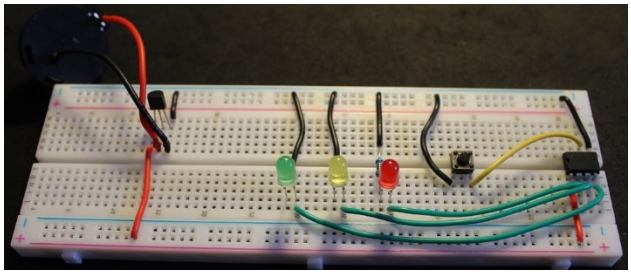

Figure 7. *Robotic Coding-3 Traffic Light Circuit Diagram*

The final stage of the traffic light robotic coding-3 application is shown in figure 8. At this stage, all the necessary parts were combined, codes were added and the traffic light application was made successfully with the mobile phone.

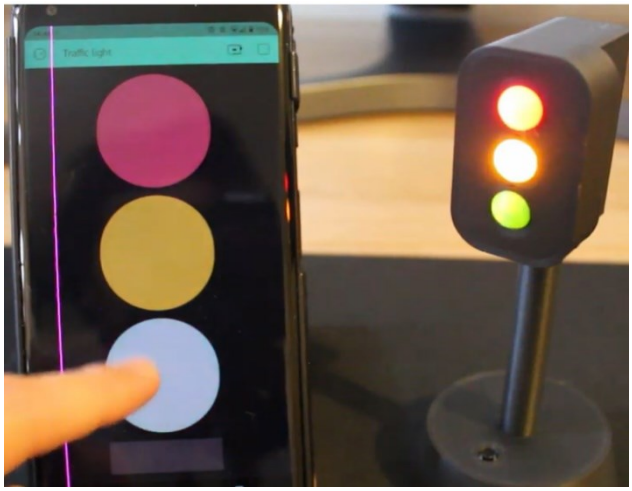

Figure 8. *Robotic Coding-3 Traffic Light Application*

Data Collection Tools

Innovative Thinking Skills Scale; Sevinç & Uyangör developed an Innovative Thinking Skills Scale in 2020. They developed a scale for vocational high school students. This scale consists of 13 three-dimensional items. The scale was prepared according to a 5-point likert type and was graded as "Strongly Agree (5), Agree (4), Undecided (3), Disagree (2) Strongly Disagree (1)". After these procedures, validity and reliability analysis were performed. As a result of the reliability analysis performed on the innovative thinking skills scale, the total reliability coefficient of the scale was found to be α = .916.

Attitude Scale Towards Digital Technology; Cabı 2015 has developed an attitude scale towards digital technology. This scale consists of 39 items. The scale was prepared according to the 5-point Likert type and was graded as "I totally agree (5), I agree (4), I am undecided (3), I do not agree (2), I do not agree (1)". After these procedures, validity and reliability analysis were performed. As a result of the reliability analysis on the attitude towards digital technology scale, the total reliability coefficient of the scale was determined as 0.90.

Data Analysis

For quantitative data; due to the homogeneous distribution of the results of the research, it showed a normal distribution in the analysis of the data obtained both before and after the application. To test the problem situation in research the standard

deviations of the scores and the significant difference between the averages of these scores. has been looked after. In the analyses, the skewness value was -.019; The kurtosis value is -.179. has been calculated. If these values are between -1 and +1, the data shows a normal distribution. (Büyüköztürk, 2020). It was observed that the scores showed a normal distribution. This due to this situation, t-test for dependent samples, one of the parametric tests, was applied. As a result of the reliability analysis performed on the innovative thinking skills scale, the total reliability coefficient of the scale was found to be α = .916. As a result of the reliability analysis on the attitude towards digital technology scale, the total reliability coefficient of the scale was determined as 0.90.

Findings

Findings of Quantitative Data

In order to examine whether there is an effect on STEM-based innovative thinking skills in robotic coding and 3D printing applications, the Innovative Thinking Skills Scale and the Attitude towards Digital Technology Scale were applied as a pre-test and post-test at the beginning and end of the application. Dependent samples t-test was performed on the data obtained from teacher candidates.

Innovative Thinking Skills Analysis

Table 2. *Statistical values of innovative thinking skills*

N	valid data	45
	Missing data	0
Skewness		.49
Std. HataSkewness		.41
Kurtosis		.22
Std. Hata Kurtosis		.77

When Table 2 is examined, the skewness and kurtosis values are between (+/-2) values (Büyüköztürk, 2020). The results of the Kolmogorow Smirnov test seem to support these data. These values give the result that the data show normal distribution. Therefore, it is envisaged to use parametric tests in tests performed on variables.

Table 3. *Innovative thinking skills t-test for dependent samples*

	$\bar{x}$	n	ss	s $h_{\bar{x}}$
PRETEST	60.28	45	3.11	.48
POSTTEST	74.43	45	2.91	.45

When Table 3 is examined, when the results of STEM-based innovative thinking skills in robotic coding and 3D printing applications are examined, it is seen that there is an increase in the averages of $\bar{X}$pretest = 60 and $\bar{X}$posttest = 74. In the results, numerical data show that there is a positive progress in favor of the post-test average scores. However, we need to see the T test results in order to obtain a definite and scientific result.

Table 4. *Innovative thinking skills dependent samples test*

	$\bar{x}$	ss	$sh_{\bar{x}}$	Lower	Upper	t	df	p
PRETEST-POSTTEST	-14.15	3.89	0.63	-16.69	-14.12	--23.33	45	0.000

As a result of the dependent samples t-test analysis in Table 4, when the Innovative Thinking Skills pre-test and post-test results of the pre-service teachers are compared, it is clearly seen that there is a statistically significant increase in the learner skills of the pre-service teachers. t(45) = -23.33; p = 0.00). With these numerical data, we can conclude that Robotic coding and 3D printer applications have a positive effect on the STEM-based innovative thinking skills of teacher candidates.

Attitude Analysis Towards Digital Technology

Table 5. *Statistical values of attitudes towards digital technology*

N	Valid data	45
	Nissing data	0
Skewness		.44
Std. HataSkewness		.37
Kurtosis		.17
Std. Hata Kurtosis		.72

When Table 5 is examined, the skewness and kurtosis values are between (+/-2) values

(Büyüköztürk, 2020). The results of the Kolmogorow Smirnov test seem to support these data. These values give the result that the data show normal distribution. Therefore, it is envisaged to use parametric tests in tests performed on variables.

Table 6. *T-test for attitude dependent samples towards digital technology*

	$\bar{x}$	n	ss	sh_x
PRETEST	61.43	45	3.17	.51
POSTTEST	75.81	45	2.94	.47

When Table 6 is examined, it is seen that there is an increase in the averages of $\bar{X}$pre-test = 61 and $\bar{X}$post-test = 75 when the results of their attitudes towards Digital Technology are examined. In the results, numerical data show that there is a positive progress in favor of the post-test average scores. However, we need to see the T test results in order to obtain a definite and scientific result.

Table 7. *Attitude dependent samples test towards digital technology*

	$\bar{x}$	ss	sh_x	Lower	Upper	t	df	p
PRETEST-POSTTEST	-14.38	3.77	0.61	-17.28	-13.62	-21.58	45	0.000

As a result of the dependent samples t-test analysis in Table 7, when the pre-test and post-test results of prospective teachers' attitudes towards Digital Technology are compared, it is clearly seen that there is a statistically significant increase in the learner skills of the pre-service teachers. t(45) = -21.58; p = 0.00). With these numerical data, we can conclude that robotic coding and 3D printer applications have a positive effect on prospective teachers' attitudes towards STEM-based digital technology.

Discussion

In the results of the analysis conducted to determine STEM-based innovative thinking skills and attitudes towards digital technology in robotic coding and 3D printer applications, it is seen that there is a positive significant change in both innovative thinking skills and attitudes towards digital technology. It is seen that pre-service teachers have positive attitudes towards STEM-based innovative thinking skills and attitudes towards digital technology in robotic coding and 3D printer applications.

Looking at the literature review; Dougherty and Clarke (2018: 360) determined in their study which features are necessary to be a successful innovation. Among them; cooperation, creativity, being observant, curiosity, willingness to experiment, taking risks, willingness to challenge the status quo, being action-oriented and visionary. In the light of the findings of the research, it can be said that the use of digital technology should be added to these features. Sevinç (2021) When the results of the research are evaluated holistically, it can be said that teachers' teaching-learning understanding and effective teaching strategies on students' innovative thinking skills are limited. It is thought that the reason for the limited results in the research is that two different sample groups, teacher and student, were studied. According to Vinichenko et al. (2021: 2) in his study, today, the most important condition for a company's competitiveness in any sector, both nationally and internationally, is the presence of educated employees who use modern information technologies well. Sevinç & Uyangör (2020) Innovative thinking skills scale is at a level that can be used to measure innovative thinking skills of vocational high school students. Although there are no studies in which students' innovative thinking skills are evaluated, studies on creative thinking skills related to innovative thinking are frequently encountered.

In her study, Dilek (2013) examined the effect of socio-cultural characteristics on creative thinking on university students who received mathematics teacher education, and determined that the creativity levels of the students did not differ according to the high school they graduated from. Erdoğan and Gök (2011) also found that the students had moderate creativity skills in their study in which they examined the creative thinking skills of prospective classroom teachers. (Güleryüz, 2020; Güleryüz & Dilber, 2022) He studied the effects of 3D printing and robotic coding applications on 21st century skills, STEM awareness and STEM self-efficacy (Özdamar,

2004). Reliability analysis of the innovative thinking skills scale was applied. Different from these studies, Adıgüzel (2016) conducted a study on classroom teachers working in primary schools and determined that classroom teachers have below-average creative thinking skills. They obtained positive feedback from teacher candidates. They stated that with the study, the information became concrete and provided permanent learning.

There are many studies on measuring students' attitudes towards technology. The most important of these studies is a scale developed within the scope of the project called "Students' Attitudes Towards Technology" carried out at Eindhoven University of Technology in the Netherlands in 1984. In his research, Cabı (2015) developed a scale to determine the attitudes of secondary school students towards digital technology. Yurdugül and Aşkar (2008) adapted the scale of "Students' Attitudes Towards Technology", adapted into Turkish, and the sub-dimensions of "negativeness of technology" and "interest in technology" defined in the US scale may overlap with the names of the sub-dimensions of the developed scale. However, no names such as "social networks" and "entertainment use" were found in the sub-dimensions of similar scales. According to Cabi (2016), digital technology can be defined as applications that display, store and transmit information electronically on a screen. In this context, a wide variety of applications including computer, internet, mobile phones, camera, video and web technologies are included in digital technology. Gokhale et al. (2013) conducted a study to determine the attitudes of university students towards information technologies. It is seen that students' work in the field of computer largely depends on their attitudes towards digital technology. Digital technology plays an effective and active role in educational environments as well as in all areas of life. It is thought that determining students' attitudes towards digital technologies will have an impact on the design and arrangement of teaching environments.

The digital world interaction of the students and the most important benefit of STEM education is to take an active role in the digitalizing world. In order not to be exploited by developed and strategy-developing countries in the digitalizing world, more productive individuals are needed than consumer individuals. With the development of the digital world, students continue their development as individuals with technology and innovative thinking skills. When it comes to STEM-based (robotics, coding and 3D design) construction, there are two main ways of thinking. First, as anyone can guess, "innovative thinking" The importance of innovative thinking is already understood when the questioning, researching and experiencing nature of STEM is taken into account. In other words, it is not enough to take what is offered and use it. It is necessary to develop different perspectives. Otherwise; It is not possible to advance in fields such as science and technology. It is necessary to criticize, think and question in order to discover a new way, to introduce a new product. Another way of thinking is “creative thinking”. Creative thinking is needed, especially when design comes into play. With creative thinking, it is possible to approach different problems differently. It is possible to produce more permanent solutions in a shorter time. In this sense, especially when engineering, technology and innovation are mentioned, it is seen that creative thinking plays one of the most important roles.

Conclusion

Pre-service teachers, who are expected to train individuals with STEM-based innovative thinking, are expected to adopt contemporary teaching approaches and be aware of the strategies they use. It is thought that students' innovative thinking skills may be affected by various variables. One of these variables is teachers' understanding of teaching and learning and the other is effective teaching strategies adopted by teachers. It is thought that determining students' attitudes towards digital technology, developing educational activities, and raising students who can effectively use rapidly advancing digital technologies. It is seen that face-to-face workshop training activities are important in areas such as robotics, coding and 3D design activities in order to provide students with informatics production skills within the scope of STEM education, and

preparing interdisciplinary activities for teacher candidates or project making, 3D design and smart devices. In this context, providing training for teachers in the fields of innovation, STEM, robotics, coding and 3D design supports the professional development of teacher candidates. It is seen that students are preparing the professions of the future with 3D design, robotics, coding and innovative thinking skills, innovative ideas development process and interdisciplinary studies. In addition, it is thought that detecting and developing innovative thinking skills in an earlier period will contribute to the innovation capacity of the country. In addition, it is seen that his attitude towards digital technology has a significant effect on individual innovation competencies.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Ethics statement

We assure that all subjects involved in the study could participate voluntarily, that par-ticipation or non-participation had no consequences, that all participants were informedabout the objectives and that no identifiable personal data were collected according todata protection standards. There were no ethical requirements at the time of our research.

References

Adıgüzel, D. Ç. (2016). *The relationship between the creative thinking skills of classroom teachers and the contribution of teacher behaviors to the development of students' creative thinking skills* (Master's thesis, Pamukkale University Institute of Educational Sciences).

Akgündüz, D. (2018). *The theoretical framework and historical development of STEM education.* In theory and practice STEM education from pre-school to university (pp. 19-49). Ankara: Memoir Publishing.

Baki, S. (2004). *To improve competitiveness in the global economic system Examination of creativity strategies.* Unpublished Master Thesis. Kocaeli: Kocaeli University Institute of Social Sciences.

Bulut, Y. (2014). *Vocational School students find themselves in terms of creativity. Examination of the relationship between the evaluations of the students and their creativity levels.* Unpublished Master Thesis. Gazi University Educational Sciences Institute, Ankara.

Büyüköztürk, E. (2020). Cover design criteria in archaeological sites. *International Journal of Social Humanities Sciences Research, 7*(51), 679-691.

Büyüköztürk, H., Çolak, S., Görgülü, F., Saraçoğlu, E., & Saracoğlu, İ. (2013). *Factors associated with eating attitude in a group of university students.* Baskent University, 15.

Cabı, E. (2015). Examination of digital native children's views on digital technology. *International Journal of Innovative Research in Education, 2(1),* 10-15.

Cabı, E., & Ergün, E. (2016). The effect of instructional technologies and material design course on teacher candidates' concerns about the use of technology in education. *Başkent University Journal of Education, 3*(1), 37-43.

Demirci, C. (2007). The effect of creativity on achievement and attitude in science teaching. *Hacettepe University Faculty of Education Journal, 32,* 65-75.

Dilek, A. N. (2013). *The effect of socio-cultural characteristics on creative thinking* (Master's thesis, ESOGÜ, Institute of Educational Sciences).

Dougherty, I., & Clarke, A. (2018). Wired for innovation: Valuing the unique innovation abilities of emerging adults. *Emerging Adulthood, 6*(5), 358-365.

Erdoğan, T. & Gök, B., (2011). Investigation of Creative Thinking Levels and Critical Thinking Tendencies of Primary Teacher Candidates. *Journal of Faculty of Educational Sciences, 44*(2). 118-230.

Gokhale, A. A., Brauchle, P. E., & Machina, K. F. (2013). Scale to measure attitudes toward information technology. *International Journal of Information and Communication Technology Education (IJICTE), 9*(3), 13-26.

Göksoy, S., and Yılmaz, İ. (2018) Information technology teachers and students' views on robotics and coding course. *Düzce University*

Journal of Social Sciences Institute, 8(1), 178-196.

Güleryüz, (2020). *The effect of 3D printer and robotic coding applications on 21st century learner skills of prospective teachers, STEM awareness and STEM teacher self-efficacy.* Doctorate Thesis, Atatürk University, Institute of Educational Sciences. Erzurum.

Güleryüz, H., & Dilber, R. (2021b). STEM activities made with robotic coding; the effect on awareness of teacher candidates regarding its use in science lessons. *İnternational Journal of Engineering Teknologies and Management, 8*(11), 79–96.

Güleryüz, H., & Dilber, R. (2022b). The impact of robotics coding and 3d printıng STEM actıvıty on 21st century learner skills of teacher candidates. *International Journal of Engineering, 4*, 1–18.

Güleryüz, H., Dilber, R. (2021a). STEM Activities Made With 3D Printer The Effect On Awareness Of Pre-Service Teacherss Regarding Its Use In Science Lessons *International Journal of Engineering Technologies and ManagementResearch.2021.9(10).436-37*

Güleryüz, H. (2023). Attitudes of secondary school students towards robotics and coding in stem education with tinkercad. *Bayburt Faculty of Education Journal, 18*(38), 471-485.

Karataş, H. (2021). 21st century the place of robotics and coding education in turkey and the world. *Education and Society in the 21st Century Journal of Educational Sciences and Social Research, 10*(30), 693-729.

Riza, E. T. (2001). What to look for in creativity. *Education as You Live, 72,* 10-14.

Starko, A. J. (2001). Creativity in the classroom schools of curious delight. *Second Edicition, Lawrence Erlbaum Associates, London*, 25.

Sevinç, Y. S. & Uyangör, N. (2020). A scale development study for innovative thinking skills for vocational high school students. *Turkish Studies Education, 15*(5), 3669-3690.

Sünbül, A. M. (2000). Creativity and the development of creativity in the classroom. *SU Education Faculty Journal, 10*, 82-94.

Sünbül, A. M. (2011). Teaching principles and methods (5th revised edition). Konya: Education Academy Publications.

Özatalay, H. (2007). *Case study on the use of the basic skills aimed to be acquired by the students in the primary education Turkish curriculum in the textbooks* (Doctoral dissertation, Marmara University (Turkey).

Özden, Y. (2013). New values in education. Ankara: Pegem Academy.

Üstündag, T. (2009). Journey to creativity (6th ed.). Ankara: Pegem Academy.

Wallas, G. (1926). The Art of Thought. New York: Harcourt Brace.

Vinichenko, M. V., Rybakova, M. V., Chulanova, O. L., Barkov, S. A., Makushkin, S. A., & Karacsony, P. (2021). Views on working with information in a semi-digital society: Its possibility to develop as open innovation culture. *Journal of Open Innovation: Technology, Market, and Complexity*, *7*(2), 160.

Yıldırım, R. (2003). *Creativity and innovation.* Istanbul: System.

Yurdugül, H., & Aşkar, P. (2008). An investigation of the factorial structures of pupils' attitude towards technology (PATT): A Turkish sample. *Elementary Education Online*, *7*(2), 288-309.

Appendix-1
Arduino Codes of Traffic Light Application

```
void setup()
{ pinModeKirmizi(4,OUTPUT);
  pinModeSari(3,OUTPUT);
  pinModeYesil(2,OUTPUT); }

void loop()
{ digitalWrite(4 HIGH);
  digitalWrite(3, LOW);
  digitalWrite(2, LOW);
  delay(2000);// Kirmizi

  digitalWrite(4, HIGH);
  digitalWrite(3, HIGH);
  digitalWrite(2, LOW);
  delay(500);// Kirmizi-Sari

  digitalWrite(4, LOW);
  digitalWrite(3, LOW);
  digitalWrite(2, HIGH);
  delay(2000);// Yesil

  digitalWrite(4, LOW);
```

```
digitalWrite(3, HIGH);
digitalWrite(2, LOW);
delay(1000);// Sari }
```