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Attitudes of Pre-Service Teachers on the Use of 3D Printing with Tinkercad in Science Education

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Abstract: 3D printer technology and 3D design are used in many fields and are gaining various uses day by day. It is seen that the quality of education and training has increased with the effective use of 3D technology in the education and training environment. This study aims to investigate the attitudes of Pre-Service Teachers about the use of 3D printer activities made with Tinkercad in science education. 43 science pre-service teachers participated in the study, which lasted 8 weeks. A mixed research method was used in this study. The problem-solving scale and the attitude scale towards the use of 3D printers in science education were applied to the pre-service teachers. To collect the research data, the attitude scale was applied as a pre-test and post-test. For Paired samples, a t-test was applied and analyses were performed. In qualitative studies, semi-structured student interview questions were applied. According to the findings of the study, there was a significant increase in students' positive attitudes towards the use of 3D printers in science education. Tinkercad and 3D printer trainings have been given and applications have been made within the scope of these trainings. There have been 6 activities related to 3D printers. Thanks to 3D printers, students have the opportunity to present creative ideas and things they imagine to life by making designs in their minds. It seems that abstract concepts related to the sciences are embodied with a 3D printer and turned into tangible objects. Examining a physical object makes it easier for students to identify mistakes they have made in designs. It is seen that they do creative and solution-oriented work against the problems they encounter. Thus, it is predicted that learning will be more permanent and effective.

Keywords: *Tinkercad, 3D printer, science education, attitude.*

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Introduction

Today, there are many innovations in terms of technology. These innovations are taking place in our daily lives. 3D modeling and 3D printers are some of the most effective innovations. In some reports, it is stated that 3D printers and their technologies will start to progress more (Johnson et al., 2014; Ratto & Ree, 2012). A 3D printer is a device that converts three-dimensional computer data into tangible objects. 3D printer technology has been developing rapidly, especially in the last decade, and has become widely used. The reason why 3D printers have been leading the trend topics of recent years is that they provide many benefits to users. Most importantly, while it takes a certain degree of skill and fine workmanship to prepare a prototype using traditional methods, it is possible to produce your designs cheaply and in a shorter time with 3D technology. 3D printing technologies are becoming a key position in today's world. In this study, the studies of this technology used in industrial, textile, medical, manufacturing, health, aerospace, construction and architecture, textile, military applications, food, education, and many other fields in the field of education are examined. It is seen that 3D printing technology can bring significant advantages both in the educational process and in business life after education. Although it is not very common yet, there are now ways to use this technology more effectively in the field of education (Campbell et al., 2011; Güleryüz, 2020; Güleryüz & Dilber, 2022). 3D printers ensuring that technologies are developed, especially for children, are fully functional and, it is a feasible idea. The introduction of 3D printers the main purpose is to increase children's imagination and their three-dimensional imagination skills. It is designed to develop and enable them to produce new products. The most important achievement of the aim should be to make children producers of technology rather than consumers. With

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this together, creative ideas and interesting designs in children's world become concrete. It is to be put into practice and brought to life (Gürel Taşkıran, 2019).

Tinkercad is an online system that allows you to create a 3D model or create circuits on Arduino. Tinkercad is one of the most fun design programs to use. This program, designed especially for the use of people of all ages, also provides an advantage in meeting requests and needs (Güleryüz & Dilber, 2021).

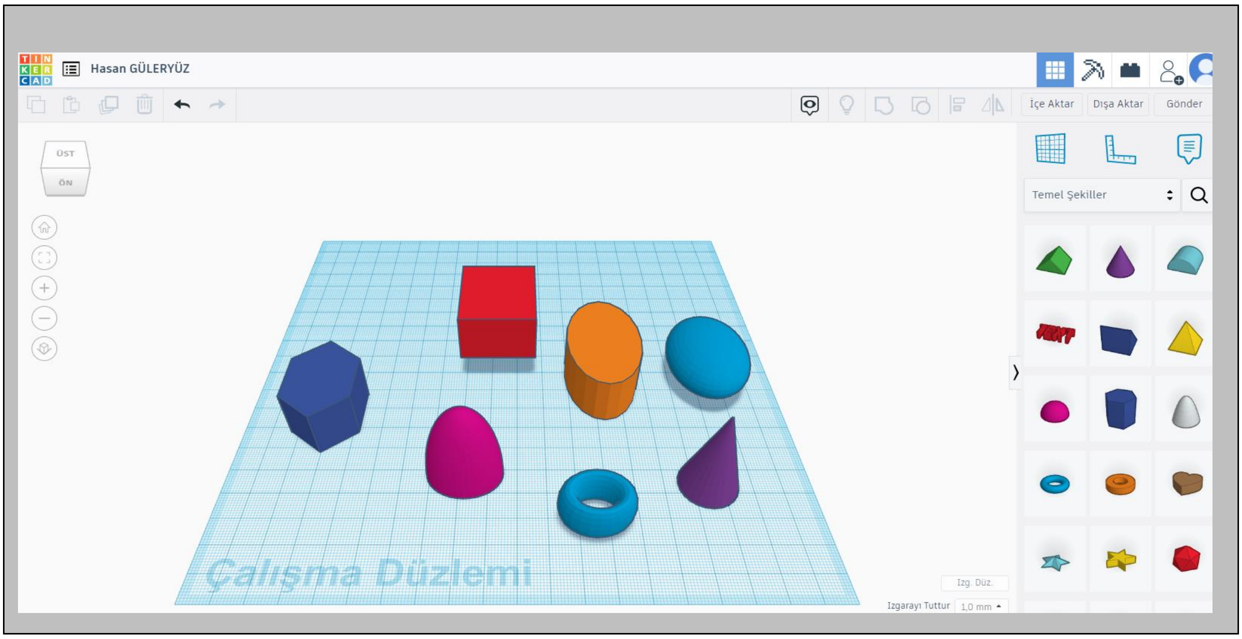


Figure 1. Tinkercad Program

One of the most important tasks of institutions and educators is to train individuals according to the requirements of the 21st century. For this purpose, the educational opportunities to be provided to the individuals who produce what they dream about are very important. For the imagination to be inversely proportional to age, and for the imagination to be lost as you get older, to be developed without being lost, training is very useful. For this reason, both easy-to-learn and (3D) three-dimensional design studies and production conducted using the Tinkercad program to develop children's imaginations show very positive results. While the design used to be very technical, very complex, and difficult, it is now very easy for students to design what they imagine. Thanks to the Tinkercad program, students who have developed thinking and imagination skills design and produce innovative products that will benefit in the future. Tinkercad is a program that develops and updates quite quickly. Tinkercad is a very useful tool that allows students to improve their creative thinking skills. It also helps students who find three-dimensional thinking difficult and have difficulty understanding abstract concepts (Güleryüz & Dilber, 2021; Güleryüz et al., 2019).

Science subjects present the facts in life, provide convenience, and contain abstract topics with intensity; therefore, the student sometimes has difficulty understanding. Unfortunately, science, which helps a person to know himself and his environment, is seen as a curriculum in schools. However, the science reflects the very essence of everyday life. Science and technology are complementary concepts. With the development of science, new technologies are also developed. Science and technology are also related to each other in this context (Gürel Taşkıran, 2019). For qualified and high-quality science education, it is important to transfer the concepts of science during the educational period. To gain this skill, learning ecosystems are needed in which students can apply and develop their knowledge. 3D printing was initially utilized in industries. Lately, it has been used in aerospace, automotive, robotics, education, and health (Güleryüz, 2020). In addition to providing the production of the necessary parts, these devices, which have started to enter our homes with the development of technology, have also been very effective in increasing the creativity and productivity of people (Carroll, 2015; Prince, 2014).

Problem-solving can be defined as finding new and different solutions beyond the application by following certain steps with the help of past experiences to solve a problem (Korkut, 2002). Although problem-solving skills are innate, these skills develop with the education and experiences gained in life (Çağlayan, 2007). In addition, in studies conducted with students whose problem-solving skills were determined to be high, it was observed that students' creative thinking skills and self-confidence were developed and they were motivated to solve a problem (Dow & Mayer, 2004). Curriculums to be prepared for this should include activities in which students can improve their problem-solving skills, taking into account the individual differences and developmental levels of the students. Science is part of daily life. The main aims of science education are to provide students with problem-solving skills, creative and scientific thinking, research skills, rational solutions to daily life problems, etc. skills (Güleryüz & Dilber, 2022).

Use of 3D Printers in Science Education

Considering the use cases of 3D printers in science education, it is seen that they are not among the priority technology preferences. The fact that 3D printers emerged a short time ago in recent years is one of the most important reasons why they are not preferred in the field of education today. In addition to this, there are some important issues to be considered regarding the integration of technology into learning-teaching environments. The most important of these is the appropriateness of school infrastructure factors such as software, hardware, technical support, administrative support, and access so that 3D printer technologies can be used appropriately in learning-teaching environments. For example, it is very important that teachers and students have the opportunity to experience this technology, and that local support is provided by a team of experts in this field. In addition, because it is a current technology, the high costs of hardware, software, and raw materials for 3D printers cause these technologies not to be widely preferred in educational environments. Solving technological elements that may cause serious cost problems such as 3D printers in science teaching environments through open source technologies; has the potential to be considered a supportive factor in preventing the material dimensions of technological innovations and the costs of technological tools and equipment to be seen as a problem in educational environments. With a study revealing the potential use of open-source technologies in science teaching environments, course content was prepared for teachers and it was determined that teachers who produce 3D printers using open-source technologies immediately started to apply this experience in their classrooms (Schelly et al., 2015). It can be stated that students transforming their ideas and imaginative worlds into concrete models through 3D printers can develop students' imaginations.

With 3D printers, students can embody the soft information they dream of or learned in the course. Thus, it is thought that, especially in science, technology, engineering, and mathematics STEM activities, students' motivation to produce new ideas and work will increase, and the fact that students can touch the objects they design will provide a unique experience for students. In addition, science facilitates the learning of subjects and provides permanence in learning (Brown, 2015; Güleryüz, 2020; Güleryüz & Dilber, 2022). In addition, students are directed to mentally create new designs to identify the problems they see in their environment and produce solutions to them. 3D printers are used to make these solutions created by students' concrete. With the materials produced by using this technology, different sensory organs of the students can be addressed, thus helping the full and permanent learning from an educational point of view. When the literature is scanned, it is seen that most of the explanations about how 3D printer technologies are used in the field of education include suggestions for how this technology can be used only as hardware and software. However, the expectations for the use of 3D printer technologies for educational purposes are to specify how this technology will be supported by a comprehensive curriculum and to reveal relational structures (Brown, 2015).

Since this printing technology is used to create all or parts of a physical object from a digital model, it will not be possible to benefit from the opportunities offered by 3D printers without designing a 3D model in the digital environment (Lipson & Kurman, 2013). 3D models that can be used in science education environments can be obtained from different sources. For example, ready-made object stores can be used, unique models can be designed for various needs or a physical object can be digitized using 3D scanners (O'Neill & Williams, 2013). When models obtained in such ways are printed in 3D, geometric shapes and designs that are difficult to grasp with traditional drawings can be transferred to the educational environment (Segerman, 2012), and it will also make it possible to share copies of rare educational objects with people in different locations (Johnson et al., 2014). In addition to facilitating the production of learning objects, 3D printers can also be used to support knowledge and skill development by enriching student-based activities. For example, 3D printers can be used as an enabling technology in the implementation of designed solutions in project-based and problem-based educational activities and add a new dimension to the learning experience.

Project and problem-based learning environments contribute to the development of various 21st-century skills with a student-centered approach (Bell, 2010; Ravitz et al., 2012). Students working to solve a problem determined within the scope of project-based activities examine the current situation and make a situation determination before proposing a possible solution. While making this determination, students' skills such as observation, data collection, and analytical thinking can be developed (Lehrer & Romberg, 1996). Although individual projects or group projects are possible, group projects offer a more efficient structure to contribute to the development of various 21st-century skills, especially working together (Bell, 2010). With the transition to the design phase, 3D printers can also be included in the process. While creating their designs, students can develop in areas such as data synthesis, creative thinking, analytical thinking, and productivity, while at the same time, they can improve their collaborative working and communication skills by supporting each other. In a science education learning environment enriched with 3D printers, the development of students' visual media literacy can be supported, as computer-aided design knowledge will also be employed (Verner & Merksamer, 2015). Since 3D printers also enable the transition from virtual objects to physical objects, a more effective learning experience can be achieved by verifying theoretical knowledge with practice and recognizing and eliminating possible misconceptions. Physical objects printed with 3D printers provide students with the opportunity to examine the success level of their designs and to improve their existing designs with various arrangements (Kostakis & Papachristou, 2014). Thus, the processes consisting of design and update cycles from the creation of the first design to the completion of the project can be completed more quickly with the help of 3D printers (Demir et al., 2016).

Importance of Research

It is very important that pre-service teachers brought up at this age follow technology, observe and interpret their environment understand natural sciences, use science to solve the problems they face, and have access to the ability to use the information they have obtained, most importantly, they must be scientific literacy. At this point; science and technology education is of great importance for the progress of societies. Therefore, it is aimed that individuals are scientifically literate individuals who understand living and inanimate beings and research abstract information through 3D printers to find solutions to problems that may arise by embodying concepts. It aims to make learning easier, permanent, and fun in science education thanks to 3D printer technology. Thus, it is aimed to easily learn some abstract concepts that are difficult to learn in science education and to obtain the needed materials easily by designing.

Research Problem

What are the attitudes of pre-service teachers about the use of 3D printer applications made with Tinkercad in science education? What is the awareness level of pre-service teachers about the use of 3D printer applications made with Tinkercad in science education? What are the opinions of pre-service teachers about the use of 3D printer applications made with Tinkercad in science education? Does the effect of science teacher candidates on problem-solving skills change?

Research Questions About the Study

1- What are the attitudes of pre-service teachers about the use of 3D printer applications made with Tinkercad in science education?

2- What is the awareness level of pre-service teachers about the use of 3D printer applications made with Tinkercad in science education?

3- What are the opinions of pre-service teachers about the use of 3D printer applications made with Tinkercad in science education?

4- What is the effect of science teacher candidates on problem-solving skills?

Methodology

In this research, the attitudes of 3rd-grade science teacher candidates towards the use of 3D printers in science education were investigated. A mixed method was used in the research. Mixed method research is defined as the researcher combining qualitative and quantitative methods, approaches, and concepts within a study or successive studies. The quantitative data of the study were obtained from the attitude scale towards the use of 3D printers in Science Education, which was applied in the form of pre-test and post-test. Qualitative data was obtained from semi-structured interviews with the teacher candidates in the study group. The research was implemented at a state university. In the research, the Attitude Scale towards the Use of 3D Printers in Science Education, the Problem-Solving Scale, and semi-structured student interview questions developed by the researcher based on the 3D printer activities carried out in the science course were used. The topics were chosen from the science course curriculum. During 8 weeks, the lessons were taught practically with a 3D printer. The data obtained at the end of the 8 weeks was analyzed with the SPSS (21.00) package program. For quantitative data, a paired samples t-test was applied. A paired sample t-test compares the means of a variable observed on two different occasions. Semi-structured student interview questions were applied for qualitative data (Büyüköztürk et al., 2013).

Sampling

A study on 3D printing in science education was conducted with pre-service teachers. The study group of the research consists of teacher candidates (N=43) studying at a state university. The teacher candidates who participated in the research participated voluntarily. The teacher candidates who participated in the research are shown in Table 1 below.

Table1. Descriptive Statistics

Gender	Number of Students
Female	17
Male	26
Total	43

When we look at the results given in Table 1; A study was conducted with prospective teachers about 3D printing in science education. It is seen that 17 of the science teacher candidates who participated in the research were female teacher candidates and 26 were male teacher candidates (N = 43).

Data Collection Tools

The attitude scale towards the use of 3D printers in Science Education was developed by Gürel Taşkıran (2019). The scale consists of 35 items. The purpose of the scale is to determine the attitudes of students toward the use of three-dimensional printers in science education. Responders specify their level of agreement to a statement in five points; 1-Strongly disagree; 2-Disagree; 3-Neutral; 4-Agree; 5-Strongly Agree.

Problem Solving Scale; The Problem Solving Scale, developed by Ge (2001) and later adapted into Turkish by Coşkun (2004), was used to measure the problem-solving skills of pre-service teachers. The scale is a five-point Likert-type scale and includes 4 problem steps and consists of a total of 20 questions, 5 questions for each problem step. It is scored as 1- Never, 2- Rarely, 3- Occasionally, 4- Often, 5- Always.

Pre-service teachers who participated voluntarily were asked semi-structured interview questions prepared beforehand After the literature review on the use of the Tinkercad program and three-dimensional printers in science education, the interview questions prepared by the researcher were examined by two scientists who are experts in their fields. Semi-structured student interview questions were prepared with the feedback received from them.

Semi-Structured Student Interview Form Questions

1- What are the advantages of 3D-printer applications with Tinkercad in science education?

2- What are the contributions of Tinkercad and 3D-printer applications in science education?

3- How has the use of Tinkercad and 3D-printer applications in science education made an impact on you/on you?

4- What are the disadvantages of using Tinkercad and 3D-printer applications in science education?

Analysis of the Data

The SPSS (21.00) package program was used to analyze the quantitative data of the research. In the study, the significant difference between the means of the scores and the standard deviations of these scores was examined. It was observed that the scores showed a normal distribution. For this reason, a t-test was applied for paired samples. There was a significant difference within the group according to the pre-test and post-test results. For the qualitative data of the study, there are analyses of semi-structured student interview questions about the use of 3D printer applications made with Tinkercad in science education.

For qualitative data; The data obtained was first prepared by the researcher and then, it was evaluated by two researchers who are experts in the field. presented. As a result of evaluations made with experts, the necessary changes have been made. Then the categories were determined by the researcher. has been created. This time, the categories created were presented to expert opinions and questions were prepared on the agreed points as a result of the interviews with them.

Analysis programs are used to analyze the quantitative data of the research. SPSS (21.00) program was applied. 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 et al., 2013). It was observed that the scores showed a normal distribution. Due to this situation, a t-test for dependent samples, one of the parametric tests, was applied.

Application

In this research, an educational program using three-dimensional design and 3D printer activities made with Tinkercad, which was prepared for science Pre-Service teachers and made the educational process fun, simple and efficient, was applied. The content of this prepared program lasted for a total of 32 hours, including (2 +2) hours and 8 weeks each week. Tinkercad and Zxe PLA programs were taught. In this study, a pre-test, post-test single group (without a control group) experimental research design was used. The work schedule is shown in Table 2.

The implementation process was carried out by the steps given below.

- ✓ For the first two weeks, Pre-Service teachers were granted membership on the Tinkercad page. Later, the Tinkercad program and Zaxe PLA programs were taught (Figure 1 and Figure 2.).
- ✓ In the third week, the first Tinkercad activity was made. In the activity, the three-dimensional design of the atomic was constructed and the printout was taken from the three-dimensional printer.
- ✓ In the fourth week, a second Tinkercad activity was made. In the activity, a three-dimensional design showing the interatomic bonding of water (H2O) was made and it was printed out on a three-dimensional printer.

- ✓ In the fifth week, a third Tinkercad activity was made. In the activity, a three-dimensional design of the heart was made and the printout was taken from a three-dimensional printer.
- ✓ In the sixth week, the fourth Tinkercad activity was made. In the activity, the three-dimensional design of the kidney was made and the printout was taken from a three-dimensional printer.
- ✓ In the seventh week, the fifth Tinkercad activity was made. In the activity, the three-dimensional design of the screw used in machines was made and the printout was taken from a three-dimensional printer.
- ✓ In the eighth week, the sixth Tinkercad activity was made. In the activity, a three-dimensional design of a spinning wheel was made and the printout was taken from a three-dimensional printer (Figure 2).

Table 2. Weekly Schedule of 3D Printer Activities Made With Tinkercad

Week	Subject
1. Week	Introduction of the Tinkercad Program
2. Week	Introduction of the Tinkercad Program
3. Week	Tinkercad 1. Activity: Atomic Structure (Chemistry)
4. Week	Tinkercad 2. Activity: H_2O Bond Structure (Chemistry)
5. Week	Tinkercad 3. Activity: Heart (Biology)
6. Week	Tinkercad 4. Activity: Kidney (Biology)
7. Week	Tinkercad 5. Activity: Screw (Physics)
8. Week	Tinkercad 6. Activity: Spinning Wheel (Physics)

Figure 2. Three-Dimensional Design and Printing Steps

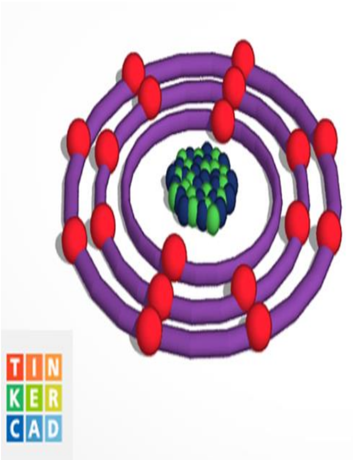
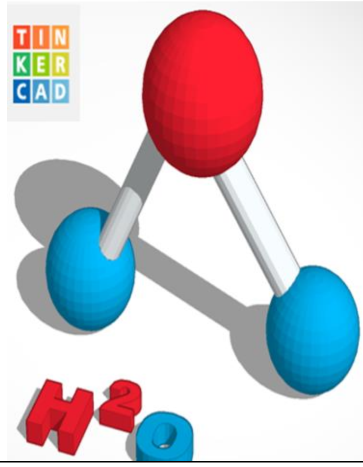
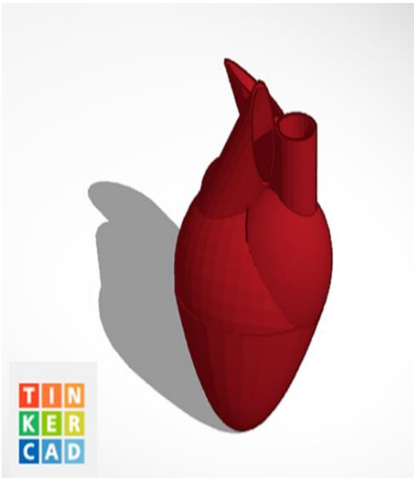
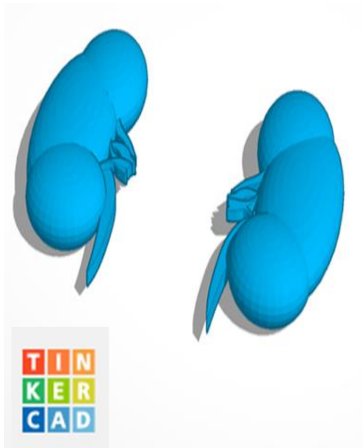
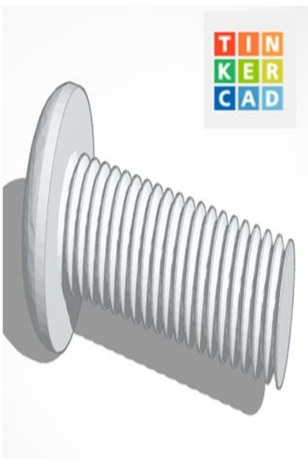
TİNKERCAD 1. ACTIVITY	**TİNKERCAD 2. ACTIVITY**
	
TİNKERCAD 3. ACTIVITY	**TİNKERCAD 4. ACTIVITY**
	
TİNKERCAD 5. ACTIVITY	**TİNKERCAD 6. ACTIVITY**
	

Figure 3. 3D Printing Activities

Findings

In this research, the attitudes of pre-service teachers about the use of 3D printer applications made with Tinkercad in science education and analyses of problem-solving skills are included. The data were analyzed by applying paired sample t-tests to the collected data.

Paired Samples T-Test

Table 3. Attitude towards the Use of Three-Dimensional Printers in Science Education

	$\bar{x}$	n	SD	s_{ex}
Pre-test	62.24	43	6.17	.91
Post-test	74.42	43	6.44	.95

When Table 3 is examined when the attitude towards the use of three-dimensional printers in science education paired samples t-test results are examined, there is an increase in the averages of $\bar{X}_{pretest}$ = 62.24 and $\bar{X}_{posttest}$ = 74.42. The results appear to support the post-test average scores.

Table 4. Attitude Towards the Use of Three-Dimensional Printers in Science Education Paired Samples Test

	$\bar{x}$	SD	s_{ex}	Lower	Upper	t	df	p
Pre-test post-test	-12.18	6.19	0.93	-9.77	-7.42	-9.21	42	.000

When we look at the results in Table 4, There is a statistically significant increase in students' attitudes ($t(42) = -9.21$, $p = .000$). According to the result, it can be said that the use of three-dimensional printer applications made with Tinkercad in science education positively affects the attitudes of pre-service teachers. The calculated Cohen's d effect size ($d = 0.39$) showed that the difference was large. Based on this finding, it can be concluded that the study had a positive impact on teacher candidates.

Analysis of the Problem-Solving Scale

Table 5. Problem-Solving Paired Samples T-Test

	$\bar{x}$	n	SD	sh_x
Pre-test	61.59	33	6.15	.90
Post-test	73.87	33	6.33	.94

When Table 5 is examined, when the results from the problem-solving scale of the teacher candidates are examined, it is seen that there is an increase in the averages of $\bar{X}_{pre\text{-}test}$ = 61.59 and $\bar{X}_{post\text{-}test}$ = 73.87. In the results, it is seen that there is progress in favor of the posttest average scores.

Table 6. Problem-Solving Paired Samples Test

	$\bar{x}$	SD	sh_x	Lower	Upper	t	df	p
Pre-test Post-test	-12.28	6.17	0.89	-8.62	-7.23	-9.12	42	.000

When Table 6 is examined, it is observed that there is a statistically significant increase in the students' pre-test and post-test results on the problem-solving scale of the pre-service teachers as a result of the paired samples t-test analysis; ($t(42) = -9.12$, $p = 0.00$). The calculated Cohen's d effect size ($d = 0.38$) showed that the difference was large. Based on this finding, it can be concluded that the study had a positive impact on teacher candidates.

In this research, there are opinions of pre-service teachers about the use of 3D-printer applications made with Tinkercad in science education. PST4 (Pre-Service Teachers) In the interviews with the pre-service teachers, the feedback received from the pre-service teachers is included.

PST1, PST19, and PST23 "…. *Now I can design the material I need in science education with the Tinkercad program and make my own with 3D printer*…"

PST5 and PST9 "… *I embody the abstract concepts I have in science education with Tinkercad and 3D printer…*"

PST19 and PST23 *"… I can now think solution-oriented towards the problems he faces*…"

PST17 and PST25 "…. *Thanks to finding solutions to the problems that arise, my creativity has improved*…".

PST2, PST11, PST29 and PST30 "…. *Now I embody my knowledge…"*

PST17 and PST24 "…. *I am aware that my creativity is developing…"*

PST26, PST27 and PST40 "*… Science lessons are very enjoyable and fun with Tinkercad and 3D printer applications …"*

PST28, PST31, and PST42 "*… It makes it easier for me to learn science lessons with Tinkercad and 3D printer…"*

PST7, PST9, PST19 and PST39"*… 3D printer and materials are very expensive…"*

PST13, PST17, PST24, PST28, and PST43 "*… It is difficult to find an expert trainer in the field of 3D printing…."*

Thanks to three-dimensional visuals, it becomes easier to explain topics that are difficult for students to understand. By printing small models of the topics to be taught in the course, students' interest and motivation in the course are maintained for a longer time. They can benefit from 3D printing to print models. Students are enabled to switch to project-based learning. In addition, students are enabled to turn their projects into products by doing them in a non-computer environment. The information that teachers share with their students does not only remain within the pages of books, teachers can create any example they want and share it with students. Students are enabled to export what they already have from their imagination. It enables abstract knowledge in science education to become concrete. Learning is provided effectively and efficiently. Students are provided with an efficient learning environment.

Discussion

The results of the analysis carried out to determine the changes in the attitudes of pre-service teachers about the use of 3D printer applications in science education and problem-solving, made with Tinkercad, showed that there was a positive significant change in their attitudes towards the use of 3D printers in science education and their problem-solving skills scores.

Güleryüz (2020), Güleryüz et al. (2019) and, Güleryüz and Dilber (2021, 2022) found similar results. Students experiencing the activities of 3D printing expressed that activities helped them to understand abstract concepts and learn effectively. In addition, they stated that the lessons were fun. When the literature related to the research is scanned. Thibaut et al. (2019) believe that the purposeful integration of 3D printing technology in formal science education can increase student interest in STEM and participation in STEM professions. To harness the educational power of this technology 3D printing and 3D printed parts should be incorporated into lesson plans that are aligned with national standards. Moreover, these lessons should utilize principles of active learning and real-world problem-solving connected to an engaging and motivating context. Novak and Wisdom's (2020) 3D printing lessons provide also opportunities for creative design and making processes. Finally, 3D printing technology can be used to promote interdisciplinary education by connecting STEM with literacy, arts, history, and other non-STEM subjects. Royalty et al. (2014) 3D printing science project introduced them to design-based learning and helped enhance their design thinking, defined as an ability to act with creative confidence, thus suggesting that creativity can be enhanced through a design process. Assante et al. (2020) Designing training courses on 3D printing for education must take into account the state of the art of technology and the real needs of trainers. Türnüklü and Yeşildere (2005) suggest that the steps of problem-solving are actively reading the problem, expressing the problem in their own words, understanding the problem, determining what is given and what is requested, making a plan for the solution, solving the problem, interpreting the result. It is defined as adapting the model to different problems and generating new problems based on the problem. Öztürk (2018) concluded that his study with pre-service science teachers had a positive and significant effect on problem-solving skills. It can be said that the answers given by Aksoy (2003) pre-service teachers act by the steps of the problem-solving process and the application steps of the lesson.

When the results of his study in Gürel Taşkıran (2019) were examined, it was seen that similar results were obtained. It is seen that the contribution of the 3D printer to science education has been achieved positively for students. Yıldırım et al. (2018) conducted a study to determine the focus of studies on the use of 3D printers for educational purposes. As a result of the study, they stated that there has been an increase in the number of studies on 3D printers in recent years. They have achieved the result that this technology is used more intensively, especially in the fields of health and engineering. They stated that the expected level of work was not done in the field of education. It is thought that it is not at the expected level because the current technology is new and the results are not fully revealed. At the same time, it is predicted that this technology will be used frequently in schools in the coming years. Schelly et al. (2015) A workshop was held in Michigan, USA with a group of educators to develop the curriculum and learn how 3D-printing can be applied, especially in the fields of science, engineering, technology, and mathematics. Karaduman (2018) examined the opinions of social studies teacher candidates about three-dimensional printers and the models obtained through these printers. It is desired to determine the importance of these models to the social studies course. In this context, pre-service teachers believe that three-dimensional printers are a qualified technology that transforms the abstract into concrete, can produce useful materials to support the learning-teaching process, adds the third dimension to the learning-teaching process, activates the sense of touch, and provides convenience. The effect of "transformation from abstract to concrete" was also emphasized in the evaluations of pre-service teachers regarding the importance of social studies courses. Accompanied by this information, they offered suggestions for pre-service teachers to gain knowledge and experience about 3D printers. Atalay et al. (2016) studied non-biological 3D printing models in their study. They looked at the impact of 3D-printed models on surgical planning, resident training, and patient information in the field of urology. They talked about the use and future importance of 3D printed models, especially in Percutaneous

Nephrolithotomy. Özsoy and Duman (2017) conducted research on the introduction of additive manufacturing (three-dimensional printing) technologies and their usability in education. It is thought that additive manufacturing technologies can be used in the fields of technical, health, and social sciences in education and other sectors, and as a result, students will become more skilled, technical, and equipped, and this will positively encourage the country to reach its future industrial strategy goals. Demir et al. (2016), in their study, introduced three-dimensional 3D-printing technologies, explained their relationship with education, and examined how these printing technologies are used in our country. In their studies, they included the use of 3D printers by which institutions, especially in our country, and for what purpose. They offered suggestions on how 3D printing technologies could be used in educational environments. Kostakis et al. (2015) conducted experiments on the applications of 3D printers in the field of education. When the studies conducted in this field are examined, other studies supporting this result are found (Aktaş & Yılmaz, 2017; Karaduman, 2018; Özgür, 2013).

Science and technology culture is one of the skills that every student should learn in their learning life. 3D printing helps students to improve their three-dimensional thinking, their creativity, and understand technological developments. Unusual designs and creative ideas in the minds of students come to life by taking shape. Applying 3D printing in science education prepares students for their future careers and teaches them valuable skills. It also serves as an extra revolutionary tool to help many areas of education and provides teachers with new ways to get their message across. It is thanks to the 3D printer that abstract concepts related to the sciences are embodied and transformed into tangible objects. Examining a physical object makes it easier for students to identify mistakes they have made in designs.

Conclusions

As a result, in this study, the attitudes of pre-service teachers about the use of 3D printer applications made with Tinkercad in science education were examined and it was seen that a positive perspective was formed in the attitudes of pre-service teachers towards 3D-printing applications in science education and their problem-solving skills. It was stated that the pre-service teachers embody the concepts and knowledge that are abstract in science and that learning is effective and permanent. Thanks to 3D printers, students have the opportunity to present their creative ideas and dreams to life by making designs. It was concluded that science lessons were fun. In addition, it is seen that educational efficiency will be increased by making education policies suitable for 3D printer technology and transforming educational content into a more integrated structure with these technologies. The interaction between the teacher and the students will increase, and the knowledge and concepts of the students will be transformed into tangible objects, and it will be easier for them to gain creativity and innovative thinking skills. It is seen that there are opportunities to first understand the problem, then define the problem, determine the desired ones, make a three-dimensional design suitable for it, or adapt the model to different problems, to produce solutions to the problems encountered in science education.

Recommendations

Three-dimensional designs and applications should be used in different educational programs as well as in science education. Training of 3D instructors should be provided to popularize 3D printing applications. Experts should be trained in this field. Different activities (STEM - 3D) should be prepared in the interdisciplinary curriculum. 3D instructors are trained among technology and design field teachers who are most prone to 3D applications as part of the course curriculum. Appropriate learning environments should be prepared for teacher candidates to adapt to this training by giving them lessons on 3D printing.

Limitations

The limitations of this research are as follows; the research is limited to the findings obtained from 3rd grade science teacher candidates at a state university. The implementation process of the research is limited to 8 weeks of training. The study group of the research is limited to 43 teacher candidates.

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