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FIRST STEP TOWARDS BEING A LEARNER OF DIGITAL ERA: I AM LEARNING TO USE 3D
PRINTER ¹

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Abstract

Today's rapidly developing technology brings with it innovative applications in education. One of these innovations, 3D printing technology, makes significant contributions to learning processes thanks to its power to transform abstract concepts into concrete ones. It has been observed that, particularly in STEM (Science, Technology, Mathematics, Engineering) applications, students grasp subjects more easily, gain mastery of technology, and make the learning process more enjoyable. However, the earthquake disaster of 2023 severely disrupted the educational lives of students in Hatay and the surrounding area. This situation increased the need for distance education and digital learning tools. The primary objective of this study was to examine the perceptions, attitudes, and experiences of earthquake-affected middle school students toward 3D printing technology. The study was conducted with a group of 24 seventh-grade students selected through purposive sampling from a private middle school in the Defne district of Hatay province. A survey consisting of 5-point Likert-type scales and open-ended questions was used for data collection. Findings indicate that students more readily grasp abstract and challenging topics, particularly those related to cells and organelles, when they are embodied with a 3D printer. Furthermore, the study explored the differences between the education and research processes and the behaviors, attitudes, and observations of middle school students related to 3D printing technology, based on their earthquake-affected living spaces and demographic characteristics.

Key Words: Three-Dimensional Printer Technology, 3D Printer Experience, Cells and Organelles, The Effect of Earthquakes on Education

DİJİTAL ÇAĞIN ÖĞRENCİSİ OLMA YOLUNDA İLK ADIM: 3D YAZICI ÖĞRENİYORUM

Özet

Günümüzde hızla gelişen teknoloji, eğitim alanında yenilikçi uygulamaları beraberinde getirmektedir. Bu yeniliklerden biri olan 3D yazıcı teknolojisi, soyut kavramları somut hâle dönüştürme gücü sayesinde öğrenme süreçlerine önemli katkılar sağlamaktadır. Özellikle FeTeMM (Fen, Teknoloji, Matematik, Mühendislik) uygulamalarında öğrencilerin konuları daha kolay kavradığı, teknolojiye hâkimiyet kazandığı ve öğrenme sürecini eğlenceli hâle getirdiği gözlemlenmektedir. Ancak 2023 yılında yaşanan deprem felaketi, Hatay ve çevresindeki öğrencilerin eğitim hayatını ciddi şekilde sekteye uğratmıştır. Bu durum, uzaktan eğitim ve dijital öğrenme araçlarına olan ihtiyacı artırmıştır. Bu araştırmanın temel amacı, depremden etkilenen ortaokul öğrencilerinin 3D yazıcı teknolojisine yönelik algı, tutum ve deneyimlerini incelemektir. Araştırma, Hatay ili Defne ilçesinde bir özel ortaokulda 7. sınıf öğrencilerinden amaçlı örnekleme yöntemiyle seçilen 24 kişilik bir şube ile gerçekleştirilmiştir. Veri toplama sürecinde, 5'li Likert ölçeği ve açık uçlu sorulardan oluşan anket kullanılmıştır. Bulgular, özellikle hücre ve organel gibi soyut ve zorlayıcı konuların 3D yazıcı ile somutlaştırıldığında öğrenciler tarafından daha kolay anlaşıldığını göstermektedir. Ayrıca araştırma dâhilinde ortaokul öğrencilerinin depremden etkilenen yaşam alanlarına ve demografik özelliklerine göre 3D yazıcı teknolojisi ile alakalı davranışları, tutumları ve gözlemleri eğitim ile araştırma süreci boyunca meydana gelen farklılıklar ortaya konmuştur.

Anahtar Kelimeler: Üç Boyutlu Yazıcı Teknolojisi, 3D Yazıcı Deneyimi, Hücre ve Organeller, Depremin Eğitime Etkisi

¹ This study was produced from the first author's master's thesis.

Introduction

As the era progresses, many advances have also occurred in technology. In this regard, the development of digital media has helped elevate certain software technologies to new levels. The development of tools, devices, machines, and many electromechanical systems used as tools for perceiving and interacting with the world has revolutionized the way we work (Campbell et al., 2011). Three-dimensional (3D) printers, at the forefront of these revolutions, are used in a wide range of fields, from medical science to intricate jewelry design and the production of critical machine parts. Recently, it has become possible to print any object or object designed in a virtual environment in a solid, tangible form. Using technological tools like 3D printers, any solid object can be designed digitally and converted into a physical version.

The effective visualization of objects through 3D printing has contributed to many areas, particularly the education sector. 3D printing technology and design processes help middle school students learn subjects such as science, technology, mathematics, art, and engineering. They contribute to the development of skills related to these subjects, positively impacting cognitive abilities. Furthermore, the use of 3D printers in middle school facilitates students' preparation for high school and enables them to acquire professional design skills (MakerBot, 2017).

Students' ability to transform their thoughts and ideas into concrete forms using 3D printers enhances their imaginations and leads to the physical manifestation of the abstract knowledge they envision. Therefore, the use of 3D printers is crucial for students in fields such as STEM (science, technology, engineering, and mathematics) to generate new ideas. This provides motivation and a unique learning experience where students can touch the designed objects. By creating physical models of abstract ideas, students can more easily see how these concepts apply in the real world. This allows them to strengthen their knowledge by establishing stronger connections between theory and practice during the learning process. This technology encourages students to engage more deeply in scientific discovery processes and contributes to the development of analytical thinking and problem-solving skills (Güven & Gürdal, 2011). This approach highlights the importance of helping students develop a deeper understanding of scientific concepts and processes, as well as contributing to their problem-solving and critical thinking skills (Önen Öztürk, 2016). Students' approach to scientific knowledge with a more holistic and analytical perspective supports the development of these skills. Furthermore, the use of 3D printing technology in mechanics and technical courses has an impact that increases creativity and innovation among students. The use of such technologies encourages students' creative thinking processes while also enabling them to develop innovative solutions. This not only improves students' ability to apply their theoretical knowledge in practice but also helps them become more equipped individuals in the fields of engineering and technology of the future (Karagöz & Şahin Çakır, 2020). In this context, students' ability to translate problems they see in their environment or objects within the context of the lesson into concrete versions through physical labor and fun allows them to be more memorable. This creates significant advantages in education and facilitates learning (Brown, 2015). Thus, 3D printers have become an important tool for teachers and educators to help students better visualize and understand abstract concepts and make learning more engaging and interactive. The production of 3D objects has allowed students to use their imaginations to materialize abstract knowledge. This process enhances their scientific understanding, allowing them to create models of cells, organs, and even entire organisms. 3D printing technology is considered an extremely valuable tool that supports not only classroom learning but also scientific research outside the classroom. This technology provides students and researchers with deeper access to information, while also making the learning process more effective and creative (Karaduman, 2017).

It is believed that models produced with 3D printers can make significant contributions to science education. Therefore, integrating 3D printing technology with the STEM approach in science education can create an effective and efficient learning path. This will enable students to acquire critical thinking skills in addition to theoretical knowledge in science courses, and to develop speed and creativity in problem-solving processes. Furthermore, 3D printers can create more engaging and dynamic educational experiences by offering new opportunities for the development of students' creative skills. This innovative educational approach will not only encourage more active student participation in the learning process but also prepare them for the technology-driven world of the future (Cano, 2015).

3D printing technology stands out as a significant tool for fostering creativity and innovation in science education. By providing students with the opportunity to design and build their own models, it instills a greater sense of ownership and pride in their research. This process allows students to showcase their creativity and increases their commitment to their projects. Students' ability to bring their own designs to life leads to greater engagement in their learning and increased motivation. Increased motivation and engagement have a positive impact on the learning environment, contributing to students' deeper learning and a better understanding of scientific concepts. Therefore, the use of 3D printing technology in education positively impacts students' overall educational experiences by increasing their academic success and self-confidence (Karamik, 2022).

3D printing technology significantly supports students in developing the design-focused thinking skills needed for innovation and problem-solving. This technology enhances students' creative thinking capacity, engages them more fully in design processes, and encourages them to develop innovative solutions to real-world problems. By integrating 3D printing technology into science education, teachers not only gain a deeper understanding of fundamental science concepts but also can make the learning process more dynamic and engaging. This provides students with a richer and more interactive learning experience, fostering their interest in scientific discovery and strengthening their motivation. This type of learning environment allows students to both reinforce their theoretical knowledge with practical applications and to be better prepared for future scientific and technological innovations (Güven & Gürdal, 2011).

When examining the use of 3D printers in educational settings, it appears that they are not among priority technology choices. The recent emergence of 3D printers for the end-user market and their widespread use for some time indicate that they have not yet become a top priority in education. However, it is undeniable that they will be used at much higher rates in the future. Schools must have the necessary infrastructure and facilities for the use of 3D printing technologies. Furthermore, ensuring local support from a team of experts on the subject is crucial. In particular, the availability of raw materials and the provision of multiple 3D devices are not available to all schools (Kuzu Demir et al., 2016). However, creating learning materials using these printers not only provides a significant advantage for teachers (Sarigöz, 2014; Saygıner & Laçın, 2024), but also encourages students to design and print their own models, contributing to the development of their skills in using technology effectively. The use of 3D printers in science teaching across various disciplines creates the opportunity to provide students with new and unique tools. In this context, the potential of 3D printers in science education allows teachers to both enrich their teaching and actively engage students in the learning process.

However, at this juncture where technology meets education, the socio-psychological impacts of natural disasters should not be overlooked. Particularly following the February 6, 2023, Kahramanmaraş-centered earthquake, the interruptions in education, housing problems, and psychological trauma experienced by students living in disaster areas like Hatay directly impact their learning motivation and access to technology. How variables such as home damage, place of residence, and economic hardship shape students' attitudes and perceptions toward

educational technologies after the earthquake has become an important research question. In this context, this research aims to reveal both the role of technology in post-disaster education and how students respond to this technology by examining the attitudes, perceptions, and observations of earthquake-affected middle school students toward 3D printing technology. By examining the transformative impact of 3D printers in education within the context of extraordinary events such as earthquakes, the research aims to make both a pedagogical and socio-technological contribution.

The aim of this study is to determine the relationships between the experiences, attitudes and perceptions of 7th grade middle school students who study at a private school in Defne district of Hatay province and who personally experienced the earthquake, regarding the 3D printing technology used in cell and cell division studies, and the observations made during product design and printing.

The research questions created to solve the main research problem are as follows:

1. What is the distribution of 3D printing technology experience, satisfaction, recommendation and request status of 7th grade middle school students studying at a private school in Defne district of Hatay province?

2. Do 7th-grade middle school students' perceptions of 3D printing technology differ according to:

- Gender,
- Home damage,
- Place of residence after the earthquake,
- Number of people staying in the place of residence,
- Economic hardship after the earthquake?

3. Do 7th-grade middle school students' attitudes toward 3D printing differ according to:

- Gender,
- Home damage,
- Place of residence after the earthquake,
- Number of people staying in the place of residence,
- Economic hardship after the earthquake?

4. What are the observational situations of 7th-grade middle school students during product design and printing?

This research is limited to the first semester of the 2024-2025 academic year, individuals in Antakya and Defne who were affected by the earthquake, 7th grade students studying in a private school in Defne District of Hatay Province, data collection tools, printing time with a single 3D printer, filament quality and the subject of Cell and Divisions.

Method

This research employed a case study method. The case study design is a widely used research method, particularly in fields such as social sciences, psychology, anthropology, and ecology (Yıldırım, 2010). The need for this method arose from the desire to understand complex social phenomena (Şimşek et al., 2008).

It is used to understand current situations that the researcher cannot control; it particularly seeks answers to questions of how and why (Yıldırım, 2010). A case study is defined as a method that allows for an in-depth examination of a phenomenon or event in which the researcher cannot intervene. This method is particularly preferred when the boundaries between the phenomenon and the context are unclear (Yıldırım & Şimşek, 2011). In a case study, it is

important to evaluate each case holistically, not only the event itself but also the environment in which the event occurred, the influencing factors, and the context. Researchers attempt to analyse the underlying reasons for these differences by examining the differences that emerge in this context in detail. This method offers a significant advantage in understanding events more deeply and assessing the impact of numerous variables (Akar, 2016).

A case study requires considering numerous variables when examining social structures and phenomena. Social structures are shaped by the interaction of numerous, often interconnected, factors. By revealing these complex interactions, a case study allows for a multifaceted examination of a phenomenon. Because it is based on real events, it bridges the gaps between theory and practice, providing a rich and holistic understanding. This allows readers to evaluate events from multiple perspectives, providing insight not only into the causes and consequences of events but also into the external factors that shape them (Ozan et al., 2017).

Participants

The participants consisted of 7th-grade middle school students attending a private school in Hatay, which was affected by the earthquake. Non-probability, purposive sampling methods are often preferred in qualitative research (Baltacı, 2018). Purposive sampling, a non-probability method, was used to determine the participants. Participants were used in a 7th-grade classroom located in the earthquake-affected Defne district of Hatay province. Demographic data regarding the students is presented below (Table 1).

Table 1. Demographic Characteristics of Students

Variable	n	%	Variable	n	%
<i>Gender</i>			<i>Post-Earthquake Accommodation</i>		
Male	10	41.7	House	10	41.7
Female	14	58.3	Relative	11	45.8
Total	24	100	Container	2	8.3
<i>House Damage</i>			Total	24	100
Non-Damaged	10	41.7	<i>People Staying in House</i>		
Moderate Damage	7	29.2	4 persons	8	33.3
Heavy Damage	4	16.7	5 persons	3	12.5
Destroyed	3	12.5	6 persons	6	25.0
Total	24	100.0	7 persons	2	8.3
			8 persons	2	8.3
			9 or more persons	3	12.6
			Total	24	100

The demographic information of 12-year-old students provides detailed data on their post-earthquake home damage, accommodation preferences, and the number of people they shared in their homes with (Table 1). All the students are private school students and 58.3% are male and 41.7% are female. An examination of home damage after the earthquake revealed that 41.7% of the students’ homes remained undamaged, 29.2% suffered moderate damage, 16.7% suffered severe damage, and 12.5% were destroyed. This suggests that a significant number of the students were forced to live in severely damaged housing. When their post-earthquake accommodation preferences were evaluated, the largest group (45.8%) stayed with relatives, 41.7% continued to live in their own homes, 8.3% lived in containers, and 4.2% lived in dormitories.

The most common group in terms of the number of people students share homes with is those living in households of four people, at 33.3%. However, the prevalence of individuals living in crowded households of nine or more people (12.6%) is noteworthy. This suggests that some families experienced overcrowded living conditions after the earthquake. Overall, this provides important insights into students' housing conditions, home damage, and family living arrangements after the earthquake. The high rate of those staying with relatives suggests that earthquake victims are turning to social support mechanisms. Furthermore, the fact that some families are forced to live with multiple people due to inadequate housing conditions highlights the importance of post-earthquake housing and social support.

Data Collection Tools

In this study, a survey method was used as a data collection method. Data obtained from students was collected using traditional survey techniques, analyzed, and interpreted. The survey form consists of five main sections. One section includes questions aimed at determining the students' demographic characteristics. These questions include basic personal information such as gender and earthquake status. The second section includes questions aimed at assessing students' knowledge and experience with 3D printing technology. This section aims to measure factors such as whether individuals have used a 3D printer before, their frequency of use, and the purposes for which they utilize this technology. The third section assessed students' perceptions of 3D printing technology. Scaled questions were posed to measure changes in perceptions before, during, and after the training. The fourth section included questions to evaluate students' observations during the product design and printing process. These questions aimed to reveal students' experiences with the design process, the challenges they encountered, and their overall impressions of the process. The final section contained questions designed to measure students' attitudes toward 3D printing technology. The questions in the second, third, fourth, and fifth sections of the survey were prepared by Küçüksolak (2019) and were used after obtaining the necessary permissions.

As a result of analyses conducted to determine the reliability of the survey, Cronbach's alpha reliability coefficient for the second section was calculated as 0.77. The Cronbach's alpha for the questions measuring perception in the third section was 0.93 before the education, 0.92 during the education, and 0.93 after the education. The Cronbach's alpha for the questions in the fourth section was calculated as 0.92. These high reliability values indicate that the survey has strong internal consistency.

3D Printing Treatment and Data Collection Procedure

The data collection process was conducted in accordance with the weekly lesson plans for the 2024-2025 academic year, where students were informed about what 3D printing is, what it can do, and what to do during the process. The diagram of the process is presented below (Figure 1).

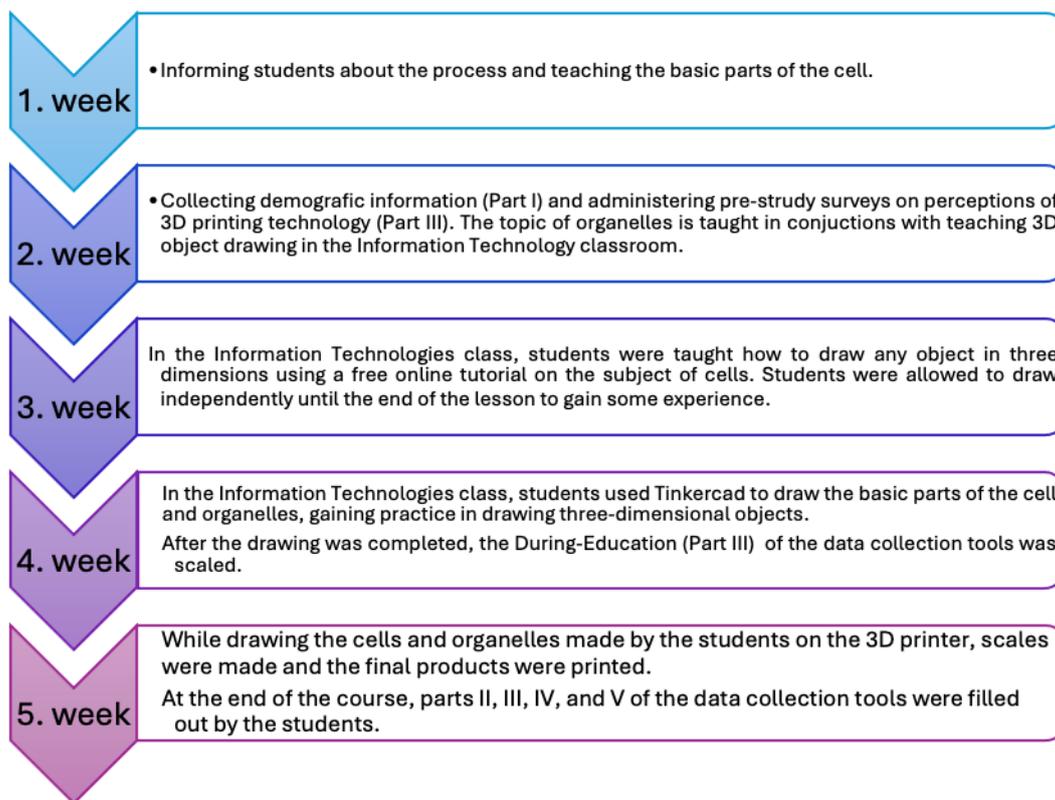


Figure 1. The Diagram of the Process

Students were asked questions about their sociodemographic characteristics (Part I). In the second week, they were asked about their experience with 3D printing technology. In the second week, their perceptions of 3D printing technology were asked prior to the lesson plan (Part III), in accordance with the specified lesson plan. Two participants drawings and product images, drawn in Tinkercad and printed according to the lesson plan, are presented below (Figure 2).

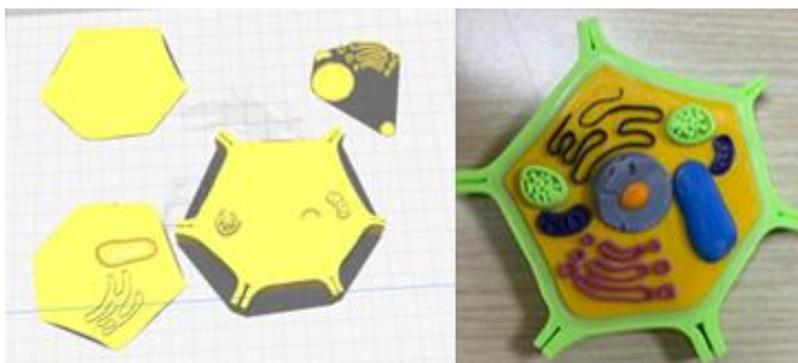


Figure 2. Sample Drawing and Product Image

As part of the fourth-week program, students were surveyed during and after the training on their perceptions of 3D printing technology (Part III). In the fifth-week program, they were subjected to observations of product design and printing (Part IV) and an Attitude Survey (Part V) to measure participation levels. They answered questions based on their previous experience (Part II). Participating students were selected and participated in the study on a voluntary basis.

Data Analysis

The process of transferring data to the SPSS program is a crucial part of the research methods and data analysis process. This process requires considerable care and attention because it involves accurate data collection and analysis. For analyses to be performed correctly, the data obtained must possess certain characteristics. If the data are within the minimum range and have a normal distribution, and if all groups within the target population have equivalent variance values, and the margin of error is random, parametric analyses are applied. If these conditions are not met, nonparametric analyses are conducted (Altunışık et al., 2012). Statistical analyses for the study were conducted using the SPSS package program. The statistical data for the normality analysis of the data are presented below (Table 2).

Table 2. Shapiro-Wilk Analysis Values

Scale		Shapiro-Wilk			Skewness	Kurtosis
		Statistics	<i>sp</i>	<i>p</i>		
<i>Perception of 3D Printer Technology</i>	Before Training	.905	24	.03	.039	-.864
	During Training	.880	24	.02	-.737	.758
	At the end of Training	.717	24	.00	.090	-.408
<i>Attitude</i>			24	.06	-.622	-.918

When Table 2 is examined, it is seen that the Shapiro-Wilk values for 3D printer perception are not normally distributed, as the *p* value is less than .05. Since the *p* value for the attitude scale is greater than .05 and the skewness and kurtosis values lie between +1 and -1, it can be said that the distribution is normal (Kan & Ercan, 2004).

Findings and Discussion

In this section, the data analyses obtained from the survey were presented.

Findings and Discussion Regarding the First Research Question

Students were asked questions regarding their experience with 3D printing technology, as shown in Table 3. Thirteen students (*n*=13) responded “no” (54.4%), which was the dominant response. Ten responded “yes” (41.7%), and one student abstained. According to Küçüksolak (2019), the percentage of individuals with prior experience was 12.8%, while in this study, the percentage of individuals with prior experience was 41.7%, a high figure. This suggests that the students had previously experienced 3D printing in various interdisciplinary research projects at school.

Table 3. Students' 3D Printer Experiences

		<i>f</i>	%
<i>Have you experienced 3D printing technology before?</i>	Yes	10	41.7
	No	13	54.2
	Partially	1	4.2
	Total	24	100.0

Students were asked whether they were satisfied with the 3D printing training they received. Ten of the 24 students responded “partially” (41.7%), giving a dominant response. Nine responded “yes,” which was the second-highest response at 37.5%. Five students responded “no” (Table 4).

Table 4. Student Satisfaction with the 3D Printer Training

		<i>f</i>	%
<i>Were you satisfied with the 3D printer used in the lessons?</i>	Yes	9	37.5
	No	5	20.8
	Partially	10	41.7
	Total	24	100.0

Students were asked whether they would recommend a 3D printer to their friends or those around them after the 3D printing training. Of the 24 students, 14 responded “yes.” Seven (29.2%) responded “partly,” and three responded “no.” Similarly, a study by Küçükşolak (2019) found a high rate of recommending 3D printing training to their friends or those around them (Table 5).

Table 5. Students’ Recommendation Status for 3D Printers

		<i>f</i>	%
<i>Will you tell your friends and/or people around you about the 3D printing course?</i>	Yes	14	58.3
	No	3	12.5
	Partially	7	29.2
	Total	24	100.0

As seen in Table 6, students were asked whether they would like to take a course like this again in the future. Of the 24 students, 12 responded “yes” (50%), representing the majority. Ten students responded “partly” (41.7%), while two students responded “no” (8.3%). The percentage of those who would like to receive such training again in the future was even higher in Küçükşolak (2019) at 66.5%. This is thought to be due to their lack of prior experience with this technology.

Table 6. Students’ Desire to Use a 3D Printer in the Future

		<i>f</i>	%
<i>Would you like to take a course like this again in the future?</i>	Yes	12	50.0
	No	2	8.3
	Partially	10	41.7
	Total	24	100.0

Findings and Discussion Regarding the Second Research Question

Students’ perceptions of 3D printing technology were determined before the training session without any prior information transfer (Table 7). While students responded with “somewhat agree” to the question “I can design and visualize a 3D model”, they strongly disagreed regarding explaining and printing. While the students responded with “strongly disagree” to the question “I can explain to another person how to print a 3D model of someone else’s dreams”, they responded with “somewhat agree” to the question “I can explain to someone how to design a 3D model.”. According to Küçükşolak (2019), the reason they disagreed with the statements regarding their perception of 3D printing technology before the training session was due to their lack of prior experience.

Table 7. Students' Perceptions of 3D Printing Technology Before the Training Session

To what extent do you agree with the following statements?	Strongly Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat agree	Strongly Agree
I can design a 3D model.	8.3%	4.2%	16.7%	50%	20.8%
I can visualize a 3D model.	20.8%	8.3%	25%	37.6%	8.3%
I can explain to someone how to design a 3D model.	8.3%	16.7%	16.7%	45.8%	12.5%
I can explain to someone how to design and print a 3D model.	33.4%	20.8%	16.7%	20.8%	8.3%
I can explain to someone how to design a 3D model of someone else's dreams.	16.7%	29.2%	25%	29.2%	0%
I can explain to another person how to print a 3D model of someone else's dreams.	41.7%	20.8%	12.5%	16.7%	8.3%

Students were also asked about their perceptions of 3D printing technology during the training. Students were found to have gained more knowledge during the training compared to before (Table 8). While there was a significant decrease in the number of "strongly disagree" responses, many responses focused on "agree" were more prevalent. Comparing the pre- and post-training results, it appears that students' skills in designing and printing 3D models improved during the training process. While most students were uncertain about these topics before the training, they gained confidence during the training, particularly in designing models and explaining their design and printing to others. These results demonstrate that hands-on learning and practice are effective in developing students' technical skills.

Table 8. Student Perceptions of 3D Printing Technology During the Training

To what extent do you agree with the following statements?	Strongly Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat agree	Strongly Agree
I can design a 3D model.	4.2%	0	20.8%	33.3%	41.7%
I can visualize a 3D model.	8.3%	4.2%	16.7%	54.2%	16.7%
I can explain to someone how to design a 3D model.	12.5%	4.2%	25%	45.8%	12.5%
I can explain to someone how to design and print a 3D model.	12.5%	25%	8.3%	25%	29.2%
I can explain to someone how to design a 3D model of someone else's dreams.	4.2%	16.7%	25%	20.8%	33.3%
I can explain to another person how to print a 3D model of someone else's dreams.	12.5%	25%	25%	16.7%	20.8%

Students were asked about their perceptions of 3D printing technology after the training. Students were found to have gained more knowledge during the training compared to both before and during the training. While there were significant decreases in the "I completely disagree" response, the "I completely agree" response was quite dominant (Table 9). Therefore, the perception that students had mastered the use of this technology after the 3D printing training is clear from the dominance of the "I completely agree" response. According to Küçüksoğak (2019), the training showed a positive increase in students' perceptions of 3D printing

technology. However, while “I completely agree” responses were more dominant in the study group, Küçüksolak (2019) observed a more balanced distribution. While the percentage of those who strongly agreed with the statements “I can design a 3D model” and “I can print a 3D model” in Table 9 was 75%, this percentage was lower in Küçüksolak (2019) at 56.2% and 44.2%. The high rate of these figures can be attributed to students’ familiarity with the use of digital tools.

Table 9. Students’ Perception of 3D Printing Technology After Training

To what extent do you agree with the following statements?	Strongly Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat agree	Strongly Agree
I can design a 3D model.	0	0	4.2%	20.8%	75%
I can visualize a 3D model.	0	4.2%	0	20.8%	75%
I can explain to someone how to design a 3D model.	0	0	16.7%	37.5%	45.8%
I can explain to someone how to design and print a 3D model.	0	0	29.2%	37.5%	33.3%
I can explain to someone how to design a 3D model of someone else’s dreams.	0	0	33.3%	29.2%	37.5%
I can explain to another person how to print a 3D model of someone else’s dreams.	0	0	12.5%	41.7%	45.8%

Table 10 shows a Mann-Whitney U test analysis of perceptions of 3D printing technology by gender before, during, and after the training.

Table 10. Mann-Whitney U Test by Gender

	Gender	n	Mean	Rank	Z	U	p
Pre-Education	Female	10	13.90	139.0	-.853	56.0	0.39
	Male	14	11.50	161.0			
During Education	Female	10	13.65	136.5	-.719	58.5	0.47
	Male	14	11.68	163.5			
Post-Education	Female	10	12.45	124.5	-.035	69.5	0.97
	Male	14	12.54	175.5			

When Table 10 was examined, it was seen that the students’ perceptions of 3D printing technology before, during, and after the training did not contain any statistically significant difference ($p > .05$). When the pre-training satisfaction average was examined, the average for males was 11.50 and 13.90 for females. The Mann Whitney U value was determined as 56.00 and the significance level was .39. When the average for females’ satisfaction during the training was observed as 13.65 and 11.68 for males. The Mann Whitney U value was determined as 58.500 and the significance level was .47. When the average for females’ satisfaction after the training was observed as 12.45 and 12.54 for males. The Mann Whitney U value was determined as 69.500 and the significance level was .978.

Table 11 shows the Kruskal Wallis-H Test analyses conducted to determine students’ perceptions of 3D printing technology based on home damage, place of residence after the earthquake, and economic hardship after the earthquake.

Table 11. Kruskal Wallis-H Test Analysis Results

			<i>n</i>	<i>Mean</i>	<i>sd</i>	χ^2	<i>p</i>	
Pre-Education	Earthquake Damage Status	Mild Damage	10	10.60		3	3.096	0.38
		Moderate Damage	7	13.07				
		Heavily Damaged	4	17.63				
		Destroyed	3	10.67				
	Post- Earthquake Residence	House	10	13.45		3	4.107	0.25
		Dorm	1	21.50				
		With Family/Relatives	11	12.18				
		Container	2	5.00				
	Economic Hardship After the Earthquake	We Are Not Living at All	14	13.75		3	2.876	0.41
		We Are Living Very Little	6	13.17				
		We Are Living Moderately	3	6.67				
		We Are Living Very Much	1	8.50				
During- Education	Earthquake Damage Status	Mild Damage	10	10.45		3	2.639	0.45
		Moderate Damage	7	15.36				
		Heavily Damaged	4	14.38				
		Destroyed	3	10.17				
	Post- Earthquake Residence	House	10	13.60		3	4.514	0.21
		Dorm	1	20.00				
		With Family/Relatives	11	12.41				
		Container	2	3.75				
	Economic Hardship After the Earthquake	We Are Not Living at All	14	13.29		3	2.545	0.47
		We Are Living Very Little	6	13.92				
		We Are Living Moderately	3	8.50				
		We Are Living Very Much	1	5.00				
Post-Education	Earthquake Damage Status	Mild Damage	10	12.00		3	1.546	0.67
		Moderate Damage	7	14.64				
		Heavily Damaged	4	12.75				
		Destroyed	3	8.83				
	Post- Earthquake Residence	House	10	14.10		3	4.979	0.17
		Dorm	1	23.00				
		With Family/Relatives	11	11.32				
		Container	2	5.75				
	Economic Hardship After the Earthquake	We Are Not Living at All	14	13.29		3	1.852	0.60
		We Are Living Very Little	6	12.33				
		We Are Living Moderately	3	7.83				
		We Are Living Very Much	1	10.50				

According to the Kruskal-Wallis H test results, no significant differences were found between the groups before, during, and after the training in terms of post-earthquake house damage, place of residence, and economic hardship variables. In terms of house damage, the highest mean rank before the training belonged to owners of severely damaged houses (17.63), while the lowest mean rank for collapsed houses (10.67) was calculated. During the training, the highest mean rank for owners of moderately damaged houses (15.36) and the lowest for collapsed houses (10.17). A similar distribution was observed after the training, with the highest mean rank for owners of moderately damaged houses (14.64), while the lowest mean rank for

collapsed houses (8.83) remained. However, statistical analyses conducted across all three periods revealed no significant difference between the groups based on home damage. When the mean ranks were examined, individuals living in severely damaged homes had higher mean scores in some measurements. This may be since those living in severely damaged or collapsed homes experienced greater post-earthquake difficulties, which may be reflected in psychological or social factors.

When examining the post-earthquake residence variable, the mean rank of individuals living in dormitories (21.50) was found to be the highest before the training, while the mean rank of those living in containers (5.00) was found to be the lowest. Similarly, during the training, the mean rank of individuals living in dormitories (20.00) was the highest, and the mean rank of those living in containers (3.75) was the lowest. After the training, the mean rank of individuals living in dormitories reached its highest level (23.00), while the mean rank of those living in containers (5.75) remained low. Because no individuals lived in tents, this category was not included in the analysis. Statistical tests revealed no significant difference between the groups based on post-earthquake residence. When examining post-earthquake residence, it is noteworthy that individuals living in dormitories generally had higher mean ranks, while those living in containers had the lowest. The fact that individuals living in dormitories generally experienced less uncertainty about housing, had greater access to social support systems, and had their basic needs met may have led to higher mean ranks on some variables. Conversely, individuals living in containers might be expected to have lower mean ranks due to social isolation, uncertainty, and inadequate living conditions.

In the analyses conducted in terms of the economic hardship variable, the mean rank of individuals who had no economic hardship before the training was highest (13.75), while the mean rank of individuals experiencing moderate economic hardship was lowest (6.67). A similar trend was observed during the training, with the mean rank of individuals who had no economic hardship being highest (13.29), and the mean rank of individuals experiencing severe economic hardship being lowest (5.00). After the training, the mean rank of individuals who had no economic hardship remained highest (13.29), while the mean rank of individuals experiencing moderate economic hardship was lowest (7.83). However, the Kruskal-Wallis H test analyses revealed that there was no significant difference between the groups in terms of economic hardship. In terms of economic hardship, the mean ranks of individuals who had no economic hardship were generally higher, while those experiencing moderate or severe hardship were lower. This suggests that economic hardship may impact on individuals' quality of life, psychological resilience, and social relationships. However, the lack of a statistically significant difference here suggests that the impact of economic hardship may vary from individual to individual and should be examined with a larger sample.

According to the Kruskal-Wallis H test analyses, no statistically significant differences were found in terms of the variables of home damage, post-earthquake residence, and economic hardship. This suggests that the groups exhibited similar distributions or that the participants were insufficient to reveal statistically significant differences. In particular, the small number of individuals living in dormitories and containers may have limited the power of the test, preventing the emergence of significant differences. Future research with a larger sample size could contribute to more clearly identifying differences between the groups.

Findings and Discussion Regarding the Third Research Question

Student responses regarding their attitudes toward 3D printing are shown in Table 12. It was observed that very few students were inclined to choose "strongly disagree" or "somewhat disagree." Generally, the predominant responses were "somewhat agree" and "strongly agree." However, there were exceptions where "neither agree nor disagree" was a popular response for some questions. An examination of Table 12 and K  ksolak's (2019) study reveals that students

generally have a positive attitude toward 3D printing training. According to the data, many students found this training interesting and stated that they would like to receive such training in school. According to Küçükşolak (2019), the percentage of students who strongly agreed with the statement “I think 3D printing training is interesting” was measured at 69.9%, indicating that many students found the training engaging. Furthermore, 33.3% who strongly agreed with the statement, “This training was not boring at all,” suggests that students generally found the training enjoyable. When examining motivation levels related to the training, 37.5% of students expressed their eagerness to receive training on a new 3D printer. Similarly, the rate of strongly agreeing with the statement, “This training was exciting,” was 33.3%. This data demonstrates that the training was not only interesting but also motivating.

Table 12. Student Attitudes Toward 3D Printing Technology

To what extent do you agree with the following statements?	Strongly Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat agree	Strongly Agree
I think the 3D printing training was interesting.	0	0	25%	25%	50%
I’m looking forward to further training on this topic.	0	0	16.7%	50%	33.3%
This training was exciting.	0	0	20.8%	45.8%	33.3%
I would like to take 3D printing training at school.	0	16.7%	0	45.8%	37.5%
I liked 3D printing technology more than the other training I’ve taken.	12.5%	12.5%	29.2%	16.7%	29.2%
This training wasn’t boring at all.	0	0	25%	41.7%	33.3%
I don’t think this training was difficult.	20.8%	8.3%	16.7%	25%	29.2%
I consider myself successful in this training.	8.3%	4.2%	37.5%	25%	25%
This training helped me discover my talents.	12.5%	4.2%	29.2%	33.3%	20.8%
I easily learned what was explained in this training.	0	16.7%	29.2%	29.2%	25%
I consider myself most successful in this training.	12.5%	12.5%	12.5%	33.3%	29.2%
I felt I could be creative during the training.	0	0	20.8%	33.3%	45.8%
I understood everything explained in this training.	0	0	37.5%	29.2%	33.3%

Evaluations of the learning process indicate that many students found the training easy and learned the material easily. The rate of strongly agreeing with the statement, “I didn’t find this training difficult,” was 29.2%, and the rate of strongly agreeing with the statement, “I understood everything that was explained during this training,” was 33.3%. This data suggests that the training received a generally positive evaluation in terms of its understandability. However, 29.2% strongly agreed with the statement, “I see myself as the most successful in this training,” suggesting that students are more cautious in their assessment of their own success. The data also demonstrates that the training process allows students to explore their creative potential. 45.8% strongly agreed with the statement, “I felt I could be creative during the training,” demonstrating that the training not only imparts knowledge but also fosters students’ creativity. Furthermore, 45.8% strongly agreed with the statement, “This training enabled me to discover my talent,” suggesting a more cautious approach. This suggests that education isn’t equally effective for every student in discovering their talents, but a significant portion still

benefits from it. It can be said that attitudes toward 3D printing education are largely positive, with students finding it engaging, exciting, and motivating. Furthermore, the educational process supports students in creative thinking and exploring their talents, although individual differences influence their perception of success.

Tutak, Aydoğdu, and Akgül (2015) investigated the effect of 3D printing software on learning the areas and volumes of geometric objects. In this context, studies conducted with 8th-grade middle school students revealed that 3D software technology significantly facilitated learning geometry. Students expressed a much better understanding of the subject.

Table 13 shows a t-test analysis of 3D printer attitudes by gender.

Table 13. t-Test Results for 3D Printer Attitudes by Gender

Gender	n	Mean	ss	t	sd	p
Female	10	3.66	0.42	-.942	22	0.36
Male	14	3.93	0.81			

An examination of Table 13 reveals that there is no statistically significant difference in students' attitudes based on gender. While the mean for boys (3.93) is slightly higher than for girls (3.66), this difference may be a coincidence, and the effect of gender on this measurement is not significant.

Table 14 presents ANOVA analyses conducted on students' attitudes toward 3D printing based on home damage, location of residence after the earthquake, the number of people staying in the residence, and the degree of economic hardship experienced after the earthquake.

Table 14. ANOVA Analysis Results Based on Home Damage, Location of Residence After the Earthquake, and the Degree of Economic Hardship Experienced After the Earthquake

		n	\bar{X}	ss	KT	$\frac{s}{d}$	KO	F	p
Earthquake Damage	Mild Damage	10	4.01	.614	1.510	3	.503	1.091	.376
	Moderate Damage	7	3.91	.275					
	Heavily Damaged	4	3.33	.904					
	Destroyed	3	3.62	1.209					
	Total	24	3.82	.683					
Post-Earthquake	House	10	3.95	.613	1.283	3	.428	.905	.456
	Dorm	1	3.92	-					
	With Family/Relatives	11	3.59	.763					
	Container	2	4.35	.490					
	Total	24	3.82	.683					
Economic Hardship After	We Are Living	14	3.98	.536	2.792	3	.931	2.344	.104
	Moderately	6	3.29	.911					
	We Are Living Very Much	3	3.80	.178					
	Mild Damage	1	4.69	-					
	Total	24	3.82	.683					

In the analysis conducted on home damage status, a p-value of 0.376 was found, indicating that home damage did not significantly affect the means. Similarly, in the ANOVA analysis conducted for the post-earthquake residence variable, a p-value of 0.456 was found, indicating that different residence locations (home, dormitory, family/relatives' residence, container) did not significantly affect the measured parameters. Furthermore, post-earthquake economic hardship also did not significantly affect the results, with a p-value of 0.104. These findings indicate that post-earthquake living conditions did not significantly affect students' responses to the measured parameters. However, since these results are limited by the

participants of the study, more accurate results can be obtained with analyses conducted on a larger sample.

Findings and Discussion Regarding the Fourth Research Question

In this section, a scale consisting of 14 questions was used to measure students' observations during product design and printing. Students predominantly answered yes to 13 of the 14 questions. No was the dominant response only for the question about dividing objects. All students (n=24) responded 100% yes to the question about changing perspective, and the same was true for the question about moving objects by zooming in and out. Therefore, it was observed that students had half the difficulty with dividing and measuring objects, while they had a high level of comprehension in all the remaining observations related to the 3D printer. The conclusion drawn from this is that 3D printing training had a positive learning effect on students (Table 15).

Table 15. Student Statistics Observed During Product Design and Printing

Expressions	Yes		No	
	<i>f</i>	%	<i>f</i>	%
Changing perspective	24	100	0	0
Zooming in/out	24	100	0	0
Resizing the object	22	91.7	2	8.3
Moving the object	24	100	0	0
Rotating the object	20	83.3	4	16.7
Measuring the object	14	58.3	10	41.7
Copied and pasted objects	17	70.8	7	29.2
Creating gaps/Removing the object	21	87.5	3	12.5
Combining the object	20	83.3	4	16.7
Dividing the object	11	45.8	13	54.2
Multiple objects selected at once	19	79.2	5	20.8
Importing the model to the 3D printer	18	75	6	25
Initializing the 3D printing model	17	70.8	7	29.2
Dominance of the object	16	66.7	8	33.3

Conclusion and Recommendations

Because the students participating in the study were in an earthquake-affected area, they were also asked demographic questions regarding their age, gender, home damage, the number of people living in their home, whether they experienced financial hardship, and where they lived. Since all the students were in 7th grade, the age ratio for the 12-year-old was 100%. The balanced ratio between males and females (58.3% male and 41.7%) is a significant demographic finding. The positive findings regarding the home damage question included a 41.7% undamaged rate. Another significant demographic finding was that the homes of three students (12.5%) were destroyed. This also permeated the question about their accommodation, with one student living in a dormitory and two in a container. Living in relatives' homes (45.8%) was seen as a significant demographic finding of 11 students. Similarly, one student responded that they experienced significant financial hardship, while three responded that they did not. 58.4% of students reported experiencing no financial hardship. However, it is assumed that the study focused on students attending private college. It is believed or estimated that this rate is much higher in public schools. When asked how many people lived in their homes or the number of people in their homes, three students responded with nine or more. It is inferred that these students also had a detrimental effect on the people living in the dormitories and containers mentioned above. While 2.3% of students responded with 8 and 7, the most popular response was 33.3%, with 4 students reporting a total of 4 people living at home. The most fundamental data emerging from the demographic results revealed that students were sadly and severely affected by the

earthquake, experiencing difficulties with accommodations, the number of people staying, and financial hardship.

The study aimed to determine the needs of STEM teachers and instructors regarding the use of solid model design, printing, or production using 3D printers in their teaching processes. The analysis and findings revealed that 3D printing technology has been helpful in many subjects within science that students struggle to grasp, such as chemistry, biology, and physics. Given the limited educational materials available in classrooms, 3D printing technology offers an innovative opportunity and has significantly improved students' comprehension. It's also been observed that it encourages teamwork, collaboration, and keeping up with technology and the times. It's been observed that students' understanding of topics is easier with the inclusion of visual and concrete memory.

One of the key data points obtained during the research relates to satisfaction with 3D printing training. 37.5% of students reported complete satisfaction, 41.7% reported partial satisfaction, and 20.8% were unsure. Therefore, the overall perception of students' satisfaction with the training was clear. The same pattern was also observed when asked whether they would recommend 3D printing technology to their family, friends, and loved ones. 58.3% of students responded with complete satisfaction. Half of the students indicated they would like to use a 3D printer in the future, 41.7% responded with partial satisfaction, and two participants were undecided. Therefore, it can be inferred that students may develop an interest in 3D printing in the future.

Among the findings obtained during the research, students' opinions on 3D printing technology are of paramount importance. One of the most significant findings is the striking change in students' responses to questions about their perceptions of 3D printing technology before the training, as well as during and after the training. Based on the data obtained from the survey conducted with a group of 24 7th-grade students, students' perceptions of 3D printing technology changed significantly after the training. In this context, it was observed that the students had learned and mastered many topics related to 3D printing. While the predominant responses on the 5-point Likert scale before the training were "strongly disagree" and "somewhat agree," the students were observed to shift to "strongly agree" and "somewhat agree" after the training.

Therefore, it was observed that the students were satisfied with the 3D printing training and learned a great deal of relevant information. Another important finding from the study was that when students were asked various questions about 3D printing, they were found to have mastered almost all of them. Only the question of dividing objects was answered "yes, I learned," with a minority of 45.8%. The other 13 questions also received a significant "yes, I learned." Therefore, it was observed that the students had made significant progress in 3D printing technology. The primary reason for choosing this topic was to facilitate 7th-grade students' understanding and comprehension of 3D technology while learning Science. It was observed that the students learned and retained many Science topics much more easily when they saw concrete objects during 3D printing. They also gained experience with 3D printing technology.

One of the most significant findings of the research is that students learn challenging topics related to STEM (Science, Technology, Mathematics, Engineering) much more easily thanks to 3D printing technology. A study conducted among a group of 24 7th-grade students at the first researcher's school found that students understood the concepts much more easily by touching and pressing. When students were asked relevant questions, they were found to learn science topics such as cells and organelles much faster. Therefore, the idea has emerged that 3D printing technology could be a primary option for curriculum subjects that can be integrated into STEM in secondary schools.

Consequently, in line with the dynamics of the digital age, the integration of highly interactive technological tools that capture students' attention into educational environments has become an inevitable necessity. In this context, the use of 3D printers in science courses is supported by various research findings that positively impact students' learning motivation by increasing them. The data obtained demonstrate that this technology enriches the educational process in a multifaceted way and makes the learning experience more meaningful by enabling the concretization of abstract concepts. In this context, the integration of 3D printers into educational processes in science courses not only supports current teaching practices but also has the potential to lay the groundwork for research using 3D printing in the future digital age. Each finding demonstrates the transformative impact of this technology in education and highlights the need to develop innovative, student-centred methods in teaching processes.

Recommendations

Based on these research findings, the following detailed recommendations are made for the more effective use of 3D printers in science education:

Curriculum Integration and Innovative Educational Methods

- **Curriculum Revision:** Curriculum revisions can be made to more systematically integrate the use of 3D printers into the science curriculum. For example, core science topics can be supported with 3D modelling and printing. Topics and learning objectives can be rearranged to accommodate the use of 3D printers.

- **Modular Educational Content:** Modular educational content should be created to utilize 3D printers as educational technology. These modules can be easily adapted by teachers and integrated into various science subjects.

Teacher Training and Support Programs

- **Comprehensive Training Programs:** Comprehensive 3D printing training programs can be organized for teachers. These programs can include printer technical use, modelling software, project design, and teaching strategies.

- **Ongoing Support and Workshops:** Providing teachers with ongoing support and organizing hands-on workshops will enable them to use 3D printers more effectively. Online resources and support groups can also be created for teachers.

Providing Resources and Equipment

- **Adequate Equipment Provision:** Schools should be provided with enough high-quality 3D printers. Regular maintenance and repair of printers can also be ensured.

Student Projects and Competitions

- **Project-Based Learning:** Students should be encouraged to develop projects using 3D printers. These projects can address real-world problems related to science subjects.

- **Competitions and Exhibitions:** Competitions and exhibitions of 3D printer projects should be organized among students. These events encourage student creativity and provide an opportunity to share their achievements.

Collaboration and Sharing Networks

- **Inter-Educational Institutional Collaboration:** Collaborations can be established between schools to encourage the sharing of knowledge and experience in 3D printing. These collaborations can provide opportunities for collaboration on educational materials, projects, and teaching strategies.

References

- Akar, H. (2016). Durum çalışması (A. Saban ve A. Ersoy Ed.). *Eğitimde nitel araştırma desenleri*. Eğiten Kitap. (113-149).
- Altunışık, R., Coşkun R., Bayraktaroğlu, S., & Yıldırım, E. (2012). *Sosyal Bilimlerde Araştırma Yöntemleri*, Sakarya Kitabevi.
- Baltacı, A. (2018). Nitel araştırmalarda örnekleme yöntemleri ve örnek hacmi sorunsalı üzerine kavramsal bir inceleme. *BEÜ SBE Derg.*, 7(1), 231-274.
- Brown, A. (2015). 3D Printing in Instructional Settings: Identifying a Curricular Hierarchy of Activities. *TechTrends*. 59(5), 16-24.
- Campbell, T., Williams, C., Ivanova, O., & Garrett, B. (2011). Could 3D Printing Change the World. Technologies, Potential, and Implications of Additive Manufacturing. Atlantic Council, Washington, Strategic Foresight Report DC.: Atlantic Council.
- Cano, L. M. (2015). *3D printing: a powerful new curriculum tool for your school library*. California: ABC-CLIO, LLC.
- Güven, İ., & Gürdal, A., (2011). Türkiye ile Kanada Fen Eğitiminin Karşılaştırmalı olarak incelenmesi. *Türk Eğitim Dergisi*, 8, 89-110.
- Kan, İ., & Ercan, İ. (2004). Ölçeklerde Güvenirlik ve Geçerlik. *Uludağ Üniversitesi Tıp Fakültesi Dergisi*, 211-16.
- Karaduman, H. (2017). Sosyal Bilgiler Eğitiminde 3 Boyutlu Yazıcıların Kullanımı. *Anadolu Journal of Educational Sciences International*. 7(3), 590-625.
- Karagöz B., & Şahin Çakır Ç. (2020). Fen Bilgisi Öğretmen Adaylarının 3 Boyutlu Yazıcılar Hakkındaki Görüşlerin belirlenmesi, *Karaelmas Journal of Educational Sciences*, 8, 303-317.
- Karamık, G.A. (2022). 3 boyutlu yazıcı ile oyunumu tasarlıyorum, oynuyorum ve matematik öğreniyorum. *Int. J. of 3D Printing Tech. Dig. Ind.* 6(3), 566-577.
- Kuzu Demir, E. B., Çaka, C., Tuğtekin, U., Demir, K., İslamoğlu, H. & Kuzu, A. (2016). Üç boyutlu yazdırma teknolojilerinin eğitim alanında kullanımı: Türkiye'deki uygulamalar. *Ege Eğitim Dergisi*, 2(17), 481-503.
- Küçüksolak, S., (2019). *Üç boyutlu yazıcıların eğitimde kullanımı: Öğrenciler üzerine bir uygulama*. Yayınlanmamış Yüksek Lisans Tezi. Aksaray Üniversitesi, Aksaray.
- MakerBot, (2017). *MakerBot 3D Printing for Education*. Robotlab, New York.
- Ozan Leymun, Ş., Odabaşı, F., & Kabakçı Yurdakul, İ. (2017). Eğitim Ortamlarında Durum Çalışmasının Önemi. *Eğitimde Nitel Araştırmalar Dergisi*, 5(3), 367-385.
- Önen Öztürk, F. (2016). Bilim teknoloji toplum hakkındaki görüşler ile fen ve teknoloji okuryazarlığı özyeterlik algısı üzerine bir çalışma. *Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi*, 10, 1-31.
- Sarıgöz, O. (2014). Öğretim teknolojilerinin kullanımına yönelik öğretmen görüşlerinin değerlendirilmesi. *Uluslararası Beşerî ve Hakemli Akademik Bilimler Dergisi*, 5(10), 100-116.
- Saygıner, Ş., & Laçın, E. (2024). Teknoloji destekli eğitsel etkinliklerin özel eğitim öğretmenlerinin dijital yeterlik düzeylerine etkisinin incelenmesi. *Mustafa Kemal Üniversitesi Eğitim Fakültesi Dergisi*, 8(14), 26-39. <https://doi.org/10.56677/mkuefder.1532760>
- Şimşek, A., Özdamar, N., Becit, G., Kılıçer, K., Akbulut, Y. & Yıldırım, Y. (2008). Türkiye'deki eğitim teknolojisi araştırmalarında güncel eğilimler. *Selçuk Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, 19, 439.

Tutak, T., Aydođdu, M. & Akgül, A. (2015). Ortaokul 8. sınıflarda geometrik cisimlerin alan ve hacimlerinin öğretiminde Cabri 3D yazılımı kullanımının öğrenci başarısına ve tutumuna etkisi. *Turkish Journal of Educational Studies*, 2(1), 113-133.

Yıldırım, K. (2010). Nitel arařtırmalarda niteliđi artırma. *İlköğretim Online* 9(1), 79-92.

Yıldırım, A. & Şimşek, H. (2011). *Sosyal bilimlerde nitel arařtırma yöntemleri* (8. Baskı). Ankara: Seçkin Yayıncılık.