



Teachers' Opinions on Instructional Use of 3D Printers: A Case Study

Research Article

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ABSTRACT

Three-dimensional (3D) printers, can essentially be defined as tools that allow individuals to take physical outputs of objects as 3D that they previously designed through computer-aided support programs. In the study, it is aimed to determine teachers' views on the instructional use of 3D printers. In the research, case study method, which is one of the qualitative research methods, was used. A total of 29 participants, 10 males and 19 females, who were teacher at a middle school, were included in this research. The semi-structured interview form, which has been developed by the researcher, was applied on the teachers. The content analysis method was used in data analysis process. It was observed that the new 3D printers, which were introduced in learning environments, were appreciated by the teachers who will implement this technology and the teachers were influenced by the existing technology. It can be said that the use of 3D printers for teaching purposes is extremely beneficial. In the field of education, especially in the basic fields of Science and Mathematics, 3D printers are thought to have a significant impact.

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Keywords:

3D printer, teacher education, teacher opinion, case study

Introduction

The transfer of technological innovations to learning environments and the examination of their possible effects are among the most frequently addressed situations today. This has paved the way for the utilization of many innovations in learning environments and getting effective results. When it is considered that our era is the age of technology, it can be observed that the developments are very fast and that the number of types of technology transferred to learning environments is quite high. However, regarding the effects of these technologies in learning environments, it is particularly important to determine the views of stakeholders (teachers, students, managers and parents) on new technologies and to investigate the utilization status of these technologies by the stakeholders. Three-dimensional (3D) printers, which are among the technologies frequently discussed recently and whose instructional effects are attempted to be studied, are also among the leading innovations.

Although their initial development occurred in the mid-1980s, 3D printers, which have been commonly used after 2010, can essentially be defined as tools that allow individuals to take physical outputs of objects in

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3D that they previously designed through computer-aided support programs. Berman (2012) and Alan Kendrick (2013) describe 3D printing as a process of combining raw materials in layers and producing 3D materials as the products. 3D printers can be seen as much more sophisticated tools, since they allow printing in three dimensions, even though they are considered to be similar to two-dimensional printers in terms of operating logic.

3D printers, which have made a significant development in recent years, have been serving in different areas. As the number of studies on 3D-printers increases, the types of these areas have also been increasing day by day, and new applications are being developed as the potentials of 3D printers are discovered. With the development of this technology, 3D printers can be used effectively and innovatively in numerous areas such as the fashion-wear industry, the food industry, health and engineering (Shaikh, 2017). Particularly, the increase in the variety of 3D printers and the increase in the variety of raw materials used in these technologies is an important contribution to their use in such a large number of areas. Lately, many types raw of materials, as well as plastic and metal, have been used (Torres, et al, 2011). The change of the utilized raw material causes the development of the printers that produce with these raw materials. Thus, there are numerous types of 3D printers with different features (Berman, 2012). In Figure 1 the raw materials used in 3D printers are classified (3Dortgen.com, 2017; Olla, 2015; Ventola, 2014).

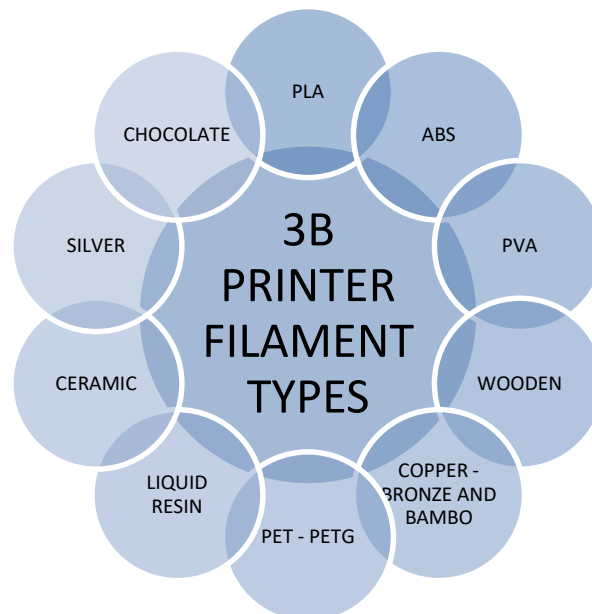


Figure 1. Filaments used in 3D printers

With the use of 3D printers in different ways in many areas, many advantages of these technologies are often mentioned in the literature. Considering these advantages, the fact that the recently developed 3D printers have a very wide production range in size, is one of the most important advantages for the development of this technology (Choi, et al., 2015). This advantage enables the development of products of a variety of sizes, from bridge and house construction to jewelry, using 3D printers. In addition, Shaikh (2017) stated that it is an important advantage that 3D printers are much faster than normal production processes. The fact that 3D printers allow production in one step, and the decrease in costs as a result of their expansion and freedom of design are among the advantages of existing technologies (Shaikh, 2017). In addition, other important advantages of this technology are having a very wide usage area and the increase in its potential by continuous development (Çallı and Taşkın, 2015).

In addition to the existing advantages of 3D printers, there are certain disadvantages as in every new technology. It is observed that many studies have mentioned this situation in the field literature, when examining the disadvantages of 3D printers. Given the limitations of the current technology, Berman (2012) is

particularly focused on technical limitations such as price, low sensitivity, limited strength, color diversity, heat – moisture resistance. In addition, Shaikh (2017) focuses on issues such as 3D printer sizes, the aging of previous technology, limited raw material options and design challenges. When the technological developments of 3D printers is examined, it is foreseen that these limitations will be decreasing in the upcoming years. A review of developments in 3D printers shows that these technologies are being used effectively in many areas or they have the potential to be used in the coming years. The education field is seen as one of the important areas where 3D printers can demonstrate their potential. However, today, the existence of a very intensive development and progress in the field of education as in the field of engineering and health cannot be mentioned (Çallı and Taşkın, 2015). There are extremely serious studies for 3D printers particularly in the fields of health and engineering (Shaikh, 2017). With the expansion of this technology, 3D printers are predicted to become among the most frequently used technologies in the field of education. When the studies in the field of education are analyzed, it is seen that 3D printers are frequently used especially in medical and architectural education (Demir et al. ,2016). However, the technologies available in the classroom from primary school to university are not used frequently enough. Therefore, it is important to determine the potential of 3D printers in different groups. In this context, an implementation was carried out with the teachers. Teachers can be seen as one of the most important groups that can mediate the spread of technologies among schools and students. In addition, taking the views of teachers, who will use technology most intensely, can shed light on future studies. Besides, teachers' feedbacks have an important impact on the progress of the studies towards 3D printers to be used in the education field. Therefore, it is aimed to determine teachers' views on the instructional use of 3D printers within the scope of the present research. According to the purpose of the study, the answers of the below stated research questions were sought:

1. What are the teachers' satisfaction with the use of 3D printer?
2. What are the opinions of teachers on the use of 3D printer in teaching environments?
3. What are the instructional advantages and disadvantages of 3D printer according to teachers?
4. What are the opinions of teachers for area of instructional usage of 3D printer?
5. What are the opinions of teachers on the use of 3D printer in daily life?

Method

In the current research, case study method, which is one of the qualitative research methods, was used. Case study design is commonly adopted when a research aims to obtain detailed data from participants about an event or a situation to reveal and reach detailed conclusions (Eisenhardt, 1989). Since this study aimed to elaborate teacher perceptions on the use of 3D printers as educational tools in all aspects, a case study design was preferred.

Participants

In the scope of this study, a total of 29 participants, 10 male and 19 female, , who were teacher at a middle school, were participated in this research. Teachers were chosen not only from one branch, but from many branches. This situation has resulted in the emergence of different views and different suggestions. In this way, teachers' opinions in their branches and other branches for instructional use of 3D printer could be taken in detail. In this context, teachers' information is given in Table 1 according to their branch.

Table 1. Distribution of teachers participating in the study according to their branches

Branch	Teachers	N
Mathematics	T17, T18, T19, T20, T21, T22, T23	7
Turkish Language	T5, T6, T7, T8, T9, T29	6
Science and Technology	T12, T13, T14, T15, T16	5
Social Science	T1, T2, T3, T4	4
Foreign Language	T24, T27, T28	3
Information Technologies	T25, T26	2
Religion Cultures and Ethical Knowledge	T10, T11	2

Data Collection

Eisenhardt (1989) notes that case studies often combine and use data collection methods such as archives, interviews, surveys and observations. Interview was used in this research as a data collection technique. A semi-structured interview form has been developed by the researcher in order to get the opinions of the teachers in detail in the data collection process. The semi-structured interview form was consisted of 6 open-ended questions. While the interview questions were being prepared, literature on 3D printer were examined. In these studies, the most common points were determined and focused on the points where 3D printers can provide effective use in the future. During this process, individual interviews were held with the teachers and there was no time limit while expressing their views. Interviews were organized on voluntary basis and interviews were recorded with an audio recording device. While the interview form was being developed, opinions of two experts with a doctoral degree in the field, two teachers and a Turkish language expert were taken. At the end of the interviews of experts, some of the expressions in the form have been removed and some expressions have been changed to give the final form to the interview form.

Data Analysis

In data analysis process, content analysis method was used. The content analysis method is generally seen as a method used when the thematic results are obtained from written texts (Büyüköztürk et al, 2009). Thus, content analysis method is considered as the most suitable data analysis method since it is aimed to reach the stated results by analyzing the teachers' opinions within the scope of the current research. The interviews were posted to the electronic environment by the researcher. The data were categorized into codes and categories. In order to sustain coding dependability during these processes, researchers worked on the same interview records. Coding dependability ensures that different coders code the same text or message accordingly or reach the same results in different times (Miles and Huberman, 1994). When the code dependability is provided, the $\left(\frac{\text{agreed codes}}{\text{agreed codes} + \text{disagreed codes}} \times 100\right)$ formula developed by Miles and Huberman (1994) is used, and the code dependability is calculated at about 90%. The points of difference have been re-analyzed and concluded.

Implementation Process

The implementation process basically consists of two stages. At the first stage, a presentation was made by the experts to the teachers about the 3D printer and its usage areas. In the presentation, information on the historical development stages, usage areas, implementation examples and future points for 3D printers were made. In this way, all teachers were informed about the current technology. In the second stage, the use of 3D printers was shown to the teachers by the experts for two weeks.

During the two-week period, the abilities and working process of the 3D printers were shown to the teachers. Instead of doing classroom practice with teachers, technology recognition activities were made. Within these two weeks, the course materials for different branches were taken under control and supervision of the teachers. The printouts were checked and examined by the teachers. On this implementation, all the

printing processes of 3D printers are shown step by step to the teachers. After the study was completed, teachers' opinions were taken in one week.

Findings

Findings obtained from the interviews within the scope of the research aimed at determining teachers' views on the educational use of 3D printers are detailed under each research question.

1. Teachers' satisfaction with the use of 3D printer

Within the scope of the study, teachers' level of appreciation for 3D printers was examined. N=27 (%93.11) teachers who participated in the study said that they liked the current technology, while N=2 (6.89%) teacher stated that they were hesitant and that it would be more effective to use 3D printers after some deficiencies have been corrected.

In the present study, it was investigated how it felt for the teachers to use the prints from 3D printers in their classes. The code obtained as a result of content analysis performed to analyses teachers' opinions in depth is shown in Table 2.

Table 2. Teachers' opinions on the satisfaction of 3D printer

Codes	Teachers	f
3D printers, embody dreams.	T1, T2, T14, T15, T17, T18, T21, T22, T23, T25, T26	11
offer freedom to developing material.	T2, T4, T7, T10, T12, T16, T21, T25	8
provide interesting courses.	T1, T14, T18, T19, T22, T24	6
provide visualization of lessons.	T3, T13, T17	3
make a difference.	T5, T7, T29	3
increase retention.	T17, T25, T28	3
allow the student to be active.	T1, T25	2
increase productivity.	T11, T21	2
offer funny environments.	T15, T19	2
provide fast results.	T14	1
increase one's self-confidence.	T20	1
offer economic freedom.	T20	1
allow individuals to feel lucky.	T12	1

As shown in Table 2, when the teachers' appreciation level for 3D printers are evaluated, it was observed that they have stated this technology embodies their dreams and they may feel happy by designing effective materials. In addition, by means of 3D printers, interesting course environments can be created and an effective learning can be provided by using visual elements in the lessons. In addition, the views that the 3D printers increase the efficiency of the course and the teacher, that they ensure the individuals to be active, that they can entertain the individuals, that they increase the self-confidence levels of the individuals, and that they can comfort them economically. Sample participant opinions on these situations are given below.

T1: ... My class is a somewhat abstract class based on narration. I think it is very useful to concretize the course and make it interesting.

T12: ... (3D printers) I think it has very good advantages especially about my own department. It also makes me feel lucky to use these advantages.

T15: ... It will be more fun for students to touch and see the organelles they create in their imaginations when talking about 6th class. While they learn to enjoy themselves, we also will enjoy the class.

T20: ... I'm relieved to design and use the material I want. I'd be released of the search for material in the stationery.

2. Opinions of teachers on the use of 3D printer in teaching environments

In the study, it was examined whether teachers wanted to use 3D printers in learning environments, while N=28 (96.5%) stated that they wanted to make use of 3D printer technologies in lessons; N=1 (3.5%) teacher said that he/she could only use them in lessons, but he/she did not want them because he/she saw some shortcomings in their current form.

In this context, teachers were asked to specify the possible effects of the use of 3D printers in learning environments. The teachers' opinions were analyzed in depth and the obtained codes are shown in Table 3.

Table 3. Teachers' opinions on the effects of instructional use of 3D printer

Codes	Teachers	f
3D printers		
can embody learning experiences.	T7, T8, T9, T16, T17, T23, T28, T29	8
can increase interest in the course.	T2, T3, T7, T10, T23, T26, T28, T29	8
can improve the permanence of the course.	T2, T9, T10, T15, T17, T19	6
can develop effective learning experiences.	T5, T11, T14, T15, T19, T24	6
can provide active participation in the classroom.	T1, T4, T18, T25, T29	5
provide real like learning experiences.	T3, T4	2
can easily bring technological innovations into the classroom environment.	T12, T14	2
can be effective in attracting learner attention.	T1, T20	2
can developed real like models of impossible objects.	T25	1
can increase motivation.	T2	1

As shown in Table 3, when teachers' opinions are examined in depth, it is stated that the possible features such as the ability to embody their learning experiences and increase the interest in the course may have a significant effect on the use of these technologies for teaching purposes. It is also often emphasized by teachers that 3D printers can improve permanency, improve effective learning experiences, and provide active participation in the course. It is also mentioned by the teachers that 3D printers can be effective tools for bringing technological innovations into the classroom environment, creating real learning experiences and drawing the attention of learners. Sample participant opinions on these situations are given below.

T8: ... the courses provide materials that may be of interest to students. For example, maybe I could make a misspelled word wheel. I can embody each element while teaching the elements.

T9: Can be used to embody learned information. Especially in lessons such as social studies its use can provide the permanence of learning.

T12: ... I believe it is necessary to keep up with the evolving technology. We have to reflect the beauty that technology brings to the lessons.

T19: ... because my subject is abstract, I think increasing visualization will increase the efficiency of the lesson. In this way, it increases the percentage of permanent learning.

T22: I'd like to use it if the speed increases and the cost is reduced. However, it seems a little difficult to print out in the class and process the course by embodying the subject in 3D as it is now going to take a lot of time and be expensive.

T29: ... It can make the lessons more enjoyable. I think it would be interesting especially for students with advanced visual intelligence. Students are interested in technological developments.

Therefore, students are actively involved in the teaching process. It allows students to imagine what they can do and practice.

3. Instructional advantages and disadvantages of 3D printer according to teachers

In interviews with teachers, they were asked to indicate the advantages and disadvantages of 3D printer technologies in learning environments. At this stage, teachers have stated that there are many advantages of the current technology. The teachers' opinions were analyzed in depth and the obtained codes are shown in Table 4.

Table 4. Instructional advantages of 3D printers specified by teachers

Codes	Teachers	f
Embodying	T1, T2, T6, T7, T8, T11, T12, T14, T15, T19, T20, T22, T25	13
Material development	T1, T4, T10, T13, T14, T17, T18, T21, T22, T28	10
Provision of retention	T7, T9, T15, T16, T29	5
Facilitating learning	T12, T22, T27, T29	4
Attracting attention	T1, T3, T16	3
Increasing interest in the course	T5, T22, T25	3
Development of imagination	T14, T21, T26	3
Increasing participation in the course	T1, T2	2
Learning by doing	T15, T21	2
Ease of instruction	T16, T20	2
Produce inaccessible materials	T9, T24	2
Joyful learning environment	T11, T21	2
Time saving	T4, T7	2
Produce material that is close to the original	T23, T25	2
Increasing motivation	T14	1
Experiment - observation	T1	1
Providing digital thinking	T20	1
Easy access to technology	T28	1

As shown in Table 4, when asked about the possible advantages of 3D printers in learning environments, the majority of teachers stated that these technologies could be very effective in embodying and developing new materials. The advantages of 3D printers are demonstrated by the fact that they can perform permanent learning and make learning easier. It was also stated that 3D printers can have significant effects on students' attention to the course, increasing their interest in the course, and improving their imagination. In addition, it can be supportive in increasing attendance, bringing materials that are difficult to reach into the classroom, and developing learning activities by doing-experiencing. Sample participant opinions on these situations are given below.

T7: It saves time. In this course, when the oral samples are transformed into a material that students can see and that can be held by hand, the comprehension will be achieved more. It will also increase memorability.

T15: 3D printers can be used for the learning from abstracts to embodied. It is a suitable tool for the learning model by doing-experiencing. Those learned in this way can be more permanent in mind.

T21: It is especially useful for students with visual intelligence. Provides a variety of materials. There will also be a difference in visual aspects. It makes the lesson more fun. Provides student activity.

T25: Transforming abstract concepts into concrete objects. Keeping the interest level of the student high. Making a model of a work that is wanted to be done to create the visual that is closest to reality.

In addition to the stated advantages of 3D printers, there are certain disadvantages indicated by the teachers. Disadvantages are generally concentrated on two codes, which are high cost and printing time, while N=6 participants said that this technology has no limitations. The teachers' views regarding these disadvantages are stated in Table 5.

Table 5. Instructional disadvantages of 3D printers specified by teachers

Codes	Teachers	f
High cost	T1, T2, T4, T7, T8, T9, T15, T19, T22, T24, T25, T26, T29	13
Print time	T8, T9, T10, T11, T15, T18, T22, T23, T26	9
Need for technical use skills	T1, T17, T19, T25	4
Physical weight	T1, T29	2
Destroying human power	T4, T14	2
Technological access difficulties	T19, T25	2
Ordinariness	T5	1
Low margin of error	T15	1
Uncommon technology	T17	1
Unpredictable potential of technology	T17	1
Raw material cost	T1	1
Difficulty in using in crowded classrooms	T21	1
Limits of field use	T29	1
No disadvantage	T3, T6, T12, T13, T16, T20, T27, T28	8

As shown in Table 5, the cost of these technologies and the time of printing are the limitations that are the leading disadvantages that may arise in 3D printers indicated by teachers. Requiring a certain amount of technical skill and the physical weight of the printers are among the other mentioned disadvantages. Some of the teachers emphasized that these technologies could destroy the human power that could be needed in industry and production. In addition, the difficulty of access to technology, becoming ordinary over time, the cost of raw materials and the lack of technology's being spread are among the other limitations mentioned. Sample participant opinions on these situations are given below.

T1: Its physical weight makes it difficult to use. The high cost, cost of raw material to be used and insufficiency of users.

T14: Man becomes happy as he produce. People who do not have business, who have a lot of spare time, are suffering from psychological disorders because of unemployment. It could also cause that.

T17: The fact that its use is not very common. We don't have enough insight into how to use it and how far it can go. The number of people who know (technology) is very less. In short, to us right now, it is a foreign technology.

T25: It's difficult to procure. It's an expensive tool. The use is not yet known by many. 3D programming should also be known to be able to use the printer effectively.

T26: ... It's expensive and it takes a long time to create the object we want.

4. Opinions of teachers for area of instructional usage of 3D printer

Within the scope of the study, teachers were asked to express their views on the areas in which 3D printers can be used most. The teachers' views regarding its use in teaching are stated in Table 6.

Table 6. Teachers' opinions on the instructional use of 3D printer

Codes	Teachers	f
Science and Technology	T1, T2, T3, T4, T6, T7, T8, T10, T12, T13, T14, T15, T16, T17, T18, T19, T20, T21, T22, T23, T25, T26, T27, T29	24

Mathematics	T6, T7, T8, T10, T11, T12, T13, T15, T16, T18, T19, T20, T21, T22, T23, T25, T26	17
Social Studies	T1, T2, T3, T4, T6, T8, T9, T27, T29	9
Visual Arts	T2, T3, T6, T13, T15, T22, T25	7
Technology Design	T1, T3, T14, T19, T20, T29	6
Information Technologies and Software	T2, T13, T15, T25, T26	5
Foreign language	T7	1
Religion Culture and Ethics	T21	1
All Courses	T5, T24, T28	3

As shown in Table 6, most of the teachers stated that the use of the present technology especially in science and technology courses would be effective. Similarly, it is emphasized that 3D printers are effective tools that can be used in mathematics courses. Besides, it is thought that 3D printers can be used in social studies courses especially in geography. In addition, in the field of visual arts and information technologies, 3D printers can be used as effective tools. Sample participant opinions on these situations are given below.

T4: Science and technology course and social studies can use it to study the human body and to have full details. In social studies, I would like to use it to show the form of our world, heights, earth forms, examples of prehistoric works and the works in the Museums in the class.

T7: Every word in English can be taught by experiencing. It could work on experiments in science classes. Geometric shapes can be shown in mathematics courses.

T9: For example, it can be used very effectively in geography class. Because in this course, the events of nature are explained through visuals. Learning will be more effective if it is embodied in 3D.

T15: First of all, of course, I would say that my own branch is a must (Science). Because there are many abstract concepts and we can concretize them. It can then be used in mathematics, visual arts and informatics courses.

T25: It can be used actively in mathematics, science, information technologies and visual arts courses because of the need for materials.

5. Opinions of teachers on the use of 3D printer in daily life

Within the scope of the study, it was aimed to determine the purpose, for which teachers will use 3D printers in the future. While some teachers expressed their views on the areas of daily use, some teachers also focused on instructional uses. The teachers' views on the future use of 3D printers are shown in Table 7.

Table 7. Teachers' opinions on the future use of 3D printer

Codes	Teachers	f
Instructional purposes	T3, T7, T12, T13, T15, T16, T20, T21, T22, T23, T24, T25	12
Toys construction	T4, T8, T19, T23, T26, T29	6
Developing original designs	T1, T2, T5, T6, T10, T29	6
Producing daily items	T1, T19, T22, T26, T29	5
Designing spaces- vehicles	T3, T5, T9, T15, T17	5
Replacement parts	T1	1
In every aspect of your life	T11	1
I don't want to use	T14	1
No idea	T18, T27, T28	3

As shown in Table 7, teachers have stated that they will use 3D printers especially for educational purposes also in their future lives. In addition to this, 3D printers can be used in producing toys, developing original designs, producing daily items and designing spaces- vehicles. One teacher stated that he/she does

not intend to use 3D printers in the future, while three teachers said that they do not have any ideas. The sample participant views regarding this situation are given below.

T1: Supply of spare parts, original designs and the production of daily use materials

T7: Again, I would like to use it in my classes for educational purposes. If it is produced from a healthy material, I can use it when teaching talking (colors, numbers) to three to four years old students.

T8: In my future life, I can use 3D printers to make toys for children.

T14: I don't have too much intention to use it. I can use it in my business life. But I think it's going to be negative for my social life. For example, if pie-making 3D printers came out, I don't think those printers will be able to give the same taste. It can cause people to become more robotic, feelings to decrease, relationships to end.

Discussion and Conclusion

Qualitative data were collected from the participants within the scope of the research aimed at determining teachers' views on the instructional use of 3D printers. In this section, the results obtained from the data are presented in an organized manner and the results obtained in the light of the results are presented.

3D printers, which were introduced in learning environments, were appreciated by the teachers who will implement this technology and the teachers were influenced by the existing technology. The facts that this technology is new and that the target audience meets the new technology are considered to be important. Rogers (2010, p. 38) expresses that: "*The innovation decision process is the process through which an individual passes from first knowledge of an innovation to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision.*" It is important for teachers to reach the highest level of appreciation in the following years to choose and accept this technology. This new technology is embodied in abstract issues and it can be said that the teachers are extremely pleased with its existence. In addition, the technology used will eliminate the material limitation, where teachers can handle the tools more effectively, and more comfortable courses will be among the results reached. When the literature is examined, it is observed that 3-D printers focus on developing materials for instructional use (Blauch & Carroll, 2014; Lu, Su, Wang, & Lu, 2017). In addition, the present potential of 3D printers will facilitate the teacher's job and make them more comfortable in teaching the lesson (Jo, 2016), in increasing the permanence of the subjects taught, in creating joyful learning environments, and in drawing students' attention, which is a big problem for teachers. Hudson, Alcock and Chilana (2016) says that 3D printing and modelling is receiving increased attention in the educational environment. In addition, the use of these technologies can be said to be effective in increasing teachers' confidence in themselves, providing economic freedom and make them feel lucky. In particular, it can be very important for teachers to design instructional materials as they desire, and to be relatively free from the search for material, to organize more efficient learning activities, and to reduce their external dependencies. Therefore, the development of implementations where teachers and students can see the potential of 3D printers can help to produce more effective results.

The use of 3D printers for teaching purposes is extremely beneficial. It is emphasized that the use of 3D technologies in learning environments can be very effective with their current situation (Krassenstein, 2014). Similarly, Szulżyk-Cieplak, Duda and Sidor (2014) reported that 3D printers could support the learning process. In particular, the 3D printers that will be used in the learning environment may be important in developing concrete learning experiences, in increasing the interest - motivation towards the course and in ensuring the permanence of the course. It is stated in many studies in the literature that 3D printers attract the attention of their users, increase motivation and ensure the continuity of the course (Szulżyk-Cieplak, Duda and Sidor, 2014). 3D printers can also be effective in increasing the active participation of learners, creating

effective learning environments and attracting the attention to the lesson. Szulżyk-Cieplak, Duda and Sidor (2014) stated that projects using 3D printers can offer learners significant opportunities to see their weaknesses. This can play an important role in the development of effective learning by preventing the lack of learning. In the era of technology, the integration of new technological tools into learning environments is thought to be important in developing modern learning environments. This situation is thought to be related to the positive coverage of technological innovation. Here, in particular, some of the mentioned vague points of 3D printers are thought to be important in the adoption and diffusion of innovation within that society (Kılıçer, 2008).

There are many studies on the advantages of 3D printers in the literature. These technologies have similar advantages in educational activities. In particular, it is thought to have great advantages in embodying abstract concepts (Eisenberg, 2013) and in developing materials that can be used in learning environments. It can also be said that these tools attract attention, keep the interest in the class alive and thus make learning easier. 3D printers are also effective in doing–experiencing learning environments and creating joyful learning environments for students. Krassenstein (2014) emphasizes that understanding and using 3D printers in their classrooms can be effective in the development of entertaining learning environments. In many studies, 3D printers are used in teaching activities and learners can develop their own designs. This is also important for learners to realize their own ideas (Szulżyk-Cieplak, Duda and Sidor, 2014). However, in these studies, students can be examined from different perspectives, in-class production and implementation activities can be examined in terms of students' achievements and teacher views. In addition, the advantages of 3D printers can be mentioned in the production of tools that are difficult or impossible to bring into the classroom environment. Yet, in such studies, long-term planning, which may be more effective in fully understanding the emerging views and implementations on teachers and students at different levels, can produce more generalized results. In addition to the educational advantages of 3D printers, there are also certain disadvantages. It is considered that printing time and cost, which are among the most important disadvantages mentioned in the field literature, will also be disadvantaged in learning environments (Howeidy and Arafat, 2017; Martelli et al., 2016). The facts that technology has not yet been spread at the desired level and the lack of access to technology can also be among the cost-related limitations. However, this limitation will possibly be eliminated after a certain period of time, considering that the 3D printers may be widespread in the following years (Berman, 2012; Ishengoma and Mtaho, 2014; Shaikh, 2017). Nevertheless, this situation can also be shown among the limitations that may arise as the spread of the existing technology reveals the possibility of being mediated. The users' inability to predict the potential of 3D printers can also be seen as another significant limitation. This situation may cause prejudice to technology and limited instructional planning when it prevents individuals from knowing what they can do. The 3D printers require technical skills and software knowledge in order to make 3D productions, which may also be regarded as a limitation. Shaikh (2017) considers this situation particularly among design challenges and illustrates this inside the significant limitations of 3D printers. However, Berman (2012) states that it is possible to make faster and easier-to-use designs than other technologies, while referring to the existence of many free or open source software for this business. Berman (2012) has shown that the fact that the production and design phases are separate as one of the most important advantages of 3D printers. This can also ensure that the requirement for technical use is excluded from the limitations.

Since 3D printers have been used in many different areas such as health, engineering, and clothing – fashion industry, it is reported in the literature that it can be used effectively in the field of education as well (Berman, 2012; Demir et al., 2016). In the field of education, especially in the basic fields of Science and Mathematics, 3D printers are thought to have a significant impact. Krassenstein (2014) stated that, in particular, 3D printers can have very important effects on mathematics teaching and that there are important tools to help learners. The 3D printers may also be used effectively in the field of social studies, especially in geography courses. Similarly, Krassenstein (2014) stated that 3D printers can provide a better understanding

in geography, history and geology classes. 3D printers are also thought to have effective areas of use in the courses such as visual arts, IT technologies and technology design, in which the visual elements are in the foreground. It is thought that the need to realize concrete learning experiences is effective in the formation of these situations, especially in terms of having the experience of permanent and effective learning (Szulzyk-Cieplak, Duda and Sidor, 2014). The intense presence of abstract concepts in the areas mentioned may have triggered such a need. However, according to the method applied and the purpose of the course, it can also be applied in the required areas of verbal skills such as foreign language.

It is stated that 3D printers can be used for many purposes. Teachers have more widely emphasized the educational use of 3D printers in accordance with their fields and professions. It is thought that especially their meeting with current technology in learning environments and not being able to predict its potential are also effective in this. In addition to its educational use, toy production, production of original designs and developing of everyday use products–ornaments can also be considered among the common uses of 3D printers. Shaikh (2017) stresses that new developments' enabling designers to freely and easily produce the products they want by offering free environments is one of the most important aspects of these technologies. Here, in particular, the needs and interests of individuals are thought to come to the fore. It can also be used in the production of spare parts (Shaikh, 2017). Berman (2012) stated the important areas of use of 3D printers, and emphasized the use of these technologies in a wide range of areas, such as spare parts production and the construction of medical/dental products. Szulzyk-Cieplak, Duda and Sidor (2014) also indicate that the potential of these printers will develop further in the coming years.

Limitations

- The study was limited to 29 teachers.
- Teachers of secondary education were included in the study.
- Only case studies from qualitative research methods were preferred in the study.

GENİŞLETİLMİŞ ÖZET

3B Yazıcıların Öğretimsel Kullanımına Yönelik Öğretmen Görüşleri: Bir Durum Çalışması

Problem Durumu ve Çalışmanın Amacı

Teknolojinin yaygınlaşması ile birlikte 3B yazıcıların eğitim alanında da sıklıkla kullanılan teknolojiler arasında olacağı düşünülmektedir. Bu nedenle 3B yazıcıların farklı gruplardaki potansiyellerinin belirlenmesinin önemli olduğu düşünülmektedir. Ayrıca teknolojileri en yakından kullanacak bireyler olan öğretmenlerin de görüşlerinin alınmasının gelecekte yapılan çalışmalara ışık tutabileceği söylenebilir. Ek olarak öğretmen görüşlerinin eğitim alanında kullanılacak 3B yazıcılara yönelik çalışmaların doğru yönde ilerlemesinde önemli etki oluşturabileceği düşünülmektedir. Bu bağlamda mevcut araştırma kapsamında öğretmenlerin 3B yazıcıların öğretimsel kullanımına yönelik görüşlerinin belirlenmesi amaçlanmaktadır.

Yöntem

Mevcut araştırma kapsamında bireylerin bir olay veya durum karşısındaki görüşlerinin derinlemesine incelenmesi için durum çalışması yöntemi kullanılmıştır. Veriler araştırmacı tarafından geliştirilen yarı yapılandırılmış görüşme formu ile toplanmıştır. Verilerin analizinde içerik analizi yöntemine başvurulmuştur.

Bulgular

3B yazıcılara yönelik beğeni durumları incelendiğinde bu teknolojilerin kullanıcıları tarafından beğenildiği görülmüştür. Buna ek olarak 3B yazıcıların özellikle öğrenme yaşantılarını somutlaştırabilmesi ve derse karşı olan ilgiyi artırabilmesi gibi muhtemel özelliklerin bu teknolojilerin öğretimsel amaçlı kullanımında önemli etkiye sahip olabileceği belirtilmiştir. Ayrıca 3B yazıcıların kalıcılığı artırabileceği, etkili öğrenme yaşantıları geliştirebileceği ve derse aktif katılım sağlayabileceği de öğretmenler tarafından vurgulanmıştır. Ayrıca teknolojik yeniliklerin sınıf ortamına getirilmesinde, gerçek öğrenme yaşantılarının oluşturulmasında ve öğrenenlerin dikkatlerini derse çekmede 3B yazıcıların etkili olabileceği de belirtilmiştir.

3B yazıcıların öğrenme ortamlarında oluşturabileceği muhtemel avantajlara yönelik öğretmenlerin büyük çoğunluğunun bu teknolojilerin somutlaştırma ve yeni materyal geliştirme aşamasında oldukça etkili olabileceklerini belirttikleri görülmüştür. Ayrıca kalıcı öğrenme gerçekleştirilmesi ve öğrenmeyi kolaylaştırabilmesi de 3B yazıcıların avantajları arasında gösterilmiştir. Buna ek olarak 3B yazıcıların öğrencilerin dikkatlerini derse çekmede, derse karşı olan ilgilerini artırmada ve hayal güçlerini geliştirmede de önemli etkilerinin olabileceği belirtilmiştir. Yine derse katılımın artırılmasında, ulaşılması zor materyallerin sınıf ortamına getirilmesinde ve yaparak – yaşayarak öğrenme aktivitelerinin geliştirilmesinde de destekleyici unsur olabileceği öğretmenler tarafından belirtilen muhtemel avantajlar arasında gösterilebilir. Belirtilen avantajlarının yanı sıra 3B yazıcılarda ortaya çıkabilecek dezavantajların başında bu teknolojilerin maliyetinin ve baskı sürelerinin sınırlayıcı olduğu belirtilmiştir. Bunun yanı sıra belirli bir oranda teknik kullanım becerisi gerektirmesi de belirtilen dezavantajlar arasındadır. Ayrıca bazı öğretmenler bu teknolojilerin sanayi ve üretimde ihtiyaç duyulabilecek insan gücünü yok edebileceğini vurgulamışlardır. Bunun yanı sıra teknolojiye erişim zorluğu, zamanla sıradanlaşabilmesi, hammadde maliyeti ve teknolojinin henüz çok yaygın olmaması da belirtilen sınırlılıklar arasında bulunmaktadır.

Öğretmenler 3B yazıcıların özellikle fen ve teknoloji ile matematik derslerinde kullanılmasının etkili olacağını belirttikleri görülmüştür. Bunun yanı sıra sosyal bilgiler derslerinde özellikle coğrafya ile ilgili konularda 3B yazıcıların kullanılabilmesi düşünülmektedir. Ayrıca görsel sanatlar alanında ve bilişim teknolojilerinde de 3B yazıcıların kullanılacak etkili araçlar olduğu belirtilmiştir.

Öğretmenler gelecek yaşantılarında 3B yazıcıları özellikle öğretimsel amaçlarla kullanacaklarını belirttikleri görülmüştür. Bunun yanı sıra oyuncak yapımında, özgün tasarımlar geliştirmede, günlük eşya üretiminde ve mekan – araç tasarımında da 3B yazıcıların kullanılabilceği vurgulanmıştır.

Sonuç ve Tartışma

Öğrenme ortamlarında kullanılmaya başlanan 3B yazıcıların öğretmenler tarafından beğenildiği görülmüştür. Bu yeni teknolojinin soyut konuların somutlaştırılması ve materyal sınırını ortadan kaldırması ile öğretmenlerin daha etkili ve rahat ders işleyebileceği de ulaşılan sonuçlar arasındadır. Ayrıca öğretmenler için büyük bir problem olan öğrencilerin ilgisini derse çekmede, öğretilen konuların kalıcılığını artırmada ve eğlenceli öğrenme ortamları oluşturmada 3B yazıcıların mevcut potansiyelinin öğretmenlerin işini kolaylaştırarak daha rahat ders işlemelerine etkisi olacağı düşünülmektedir. Özellikle öğretmenleri istedikleri materyalleri istedikleri gibi tasarlayabilmeleri ve materyal arayışından nispeten kurtulabilmeleri onların daha etkili ve verimli öğrenme etkinlikleri düzenlemelerinde ve dışa bağımlılıklarını azaltmada oldukça önemli olabilir.

Öğretimsel amaçlı olarak 3B yazıcıların kullanımının oldukça faydalı olabileceği söylenebilir. Özellikle öğrenme ortamında kullanılacak 3B yazıcıların somut öğrenme yaşantıları geliştirilmesinde, derse karşı olan ilgi - motivasyonu artırmasında ve dersin kalıcılığının sağlanmasında önemli olabileceği vurgulanmaktadır. Alanyazın incelendiğinde de 3B yazıcıların kullanıcılarının ilgisini derse çektiğini, motivasyonunu artırdığını ve dersin kalıcılığını sağladığını belirtilmektedir (Szulzyk-Cieplak, Duda ve Sidor, 2014). Ayrıca 3B yazıcıların öğrenenlerin derse aktif katılımını artıracığı, etkili öğrenme ortamları oluşturacağı ve dikkati derse çekmede etkili olacağı da söylenebilir. Benzer şekilde Szulzyk-Cieplak, Duda ve Sidor (2014) 3B yazıcıların kullanıldığı projelerin öğrenenlerin zayıflıklarını görmelerinde önemli fırsatlar ortaya çıkarabileceği belirtmektedir. Bu durum da eksik öğrenmelerin önüne geçerek etkili öğrenmelerin gelişmesinde önemli rol oynayabilir. Ayrıca teknoloji çağında yeni teknolojik araçların öğrenme ortamlarına entegre edilmesinin modern öğrenme ortamları geliştirmede önemli olduğu da düşünülmektedir.

3B yazıcıların avantajlarına yönelik alanyazında birçok çalışmanın varlığından bahsedilebilir. Bu teknolojilerin öğretimsel aktivitelerde de benzer şekilde avantajlarının olduğu görülmektedir. Özellikle soyut kavramların somutlaştırılmasında (Eisenberg, 2013) ve öğrenme ortamlarında kullanılacak materyallerin geliştirilmesinde – çeşitlenmesinde oldukça önemli avantajlarının olduğu düşünülmektedir. Ayrıca bu araçların dikkati çektiği, derse karşı olan ilgiyi canlı tuttuğu ve bu sayede öğrenmeyi kolaylaştırdığı da söylenebilir. Bunun yanı sıra 3B yazıcıların öğrencilerin yaparak – yaşayarak öğrenmelerinde ve eğlenceli öğrenme ortamları oluşturmada etkili olduğu düşünülmektedir. Krassenstein (2014) öğretmenlerin sınıflarında 3B yazıcıların potansiyeli anlayarak kullanmalarının eğlenceli öğrenme ortamlarının geliştirilmesinde etkili olabileceğini vurgulamaktadır. Ayrıca sınıf ortamına getirilmesi zor veya imkansız olan araçların üretilmesinde de 3B yazıcıların avantajlarından bahsedilebilir.

3B yazıcıların öğretimsel avantajlarının yanı sıra baskı süresi ve maliyetinin öğrenme ortamlarında dezavantaj oluşturabileceği düşünülmektedir (Howeidy ve Arafat, 2017; Martelli, ve diğ., 2016). Ayrıca teknolojinin henüz istenilen düzeyde yayılmamış olması ve teknolojiye erişim sıkıntısı da yine maliyetle alakalı sınırlılıklar arasında gösterilebilir. Ancak ilerleyen yıllarda 3B yazıcıların yaygınlaşabileceği düşünüldüğünde bu sınırlılığın belirli bir zaman sonra ortadan kalkabileceği düşünülmektedir (Berman, 2012; Ishengoma & Mtaho, 2014; Shaikh, 2017). Ayrıca 3B yazıcıların kullanıcıları tarafından potansiyellerinin kestirilememesi, 3B yazıcıların teknik beceri gerektirmesi ve 3B üretim yapmak için gerekli yazılım bilgisi de bazen sınırlılık olarak görülebilir.

3B yazıcıların eğitim alanında özellikle fen ve matematik temel alanlarında önemli etkiye sahip olabileceği düşünülmektedir. Krassenstein (2014) özellikle matematik öğretiminde 3B yazıcıların çok önemli

etkilerinin olabildiğini ve öğrenenlere yardımcı olmada önemli araçlar olduğunu belirtmiştir. Bunun yanı sıra sosyal bilgiler alanında özellikle coğrafya derslerinde 3B yazıcıların etkili bir şekilde kullanılabilmesi söylenebilir. Benzer şekilde Krassenstein (2014) coğrafya, tarih ve jeoloji derslerinde 3B yazıcıların daha iyi anlamayı sağlayabileceğini belirtmiştir. Ayrıca 3B yazıcıların görsel sanatlar, bilişim teknolojileri ve teknoloji tasarım gibi görsel öğelerin ön planda olduğu derslerde etkin kullanım alanlarına sahip olabileceği ve uygulanan yöneme ve dersin amacına göre yabancı dil gibi sözel becerilerin gerektiği alanlara da kullanılabilmesi düşünülmektedir.

3B yazıcıların gelecekte pek çok amaçla kullanılabilmesi belirtilmektedir. Öğretmenler alanları ve meslekleri itibarıyla eğitsel amaçlı kullanımını daha yaygın olarak vurgulamışlardır. Eğitsel amaçlı kullanımına ek olarak oyuncak üretimi, özgün tasarımlar gerçekleştirme ve günlük kullanım – süs eşyalarının geliştirilmesinin de 3B yazıcıların yaygın kullanım alanları arasında olabileceği söylenebilir.

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