# Opinions of Secondary School Students on 3D Modelling Programs and 3D Printers According To Using Experiences

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**ABSTRACT**
3D printers, it is possible to define these technologies as the tools that allow the production of 3D objects from different types of raw materials to be stacked in layers and to print out concrete 3D material. In this context, 3D modelling programs are very important software for 3D printers. In current research, it was aimed to determine the experiences and opinions of secondary school students on 3D modelling programs and 3D printers. In current research case study method was used. In the scope of this study, a total of 30 participants from 6th grade in the 2017-2018 academic year, who were student at a secondary school, were participated in this research. An implementation was carried out with the students. A semi-structured interview form has been developed by the researcher. In data analysis process, content analysis method was used. In current research, 3D modelling programs and 3D printers can be said to be appreciated by users. 3D modelling programs are effective in developing fast prototypes and making easy drawings. 3d printers has an important impact on developing effective learning environments and facilitating understanding. 3D printers' offering freedom in material development, and their success in embodying the imagination have been the most remarkable advantages. Especially long output time and high cost of output can be among the most important limitations of 3D printers. In particular, it is thought that these 3D printer technologies can be effective in Science and Mathematics teaching. It can be said that the superiority of 3D printers in material development is one of the most important factors in the use of the given courses. It can be said that 3D printers can be used in almost all areas of daily life.

**KEYWORDS:** 3D printers, 3D modelling programs, secondary education, students' opinions, case study

## INTRODUCTION

Today, the education area has a share of the technological developments, which has effects on many fields and gives direction to these areas at certain rates. Various technological innovations are being tested in educational environments day by day and the educational benefits it can provide to users are being examined in different ways. Especially today, with the adoption of STEM education, it can be said that the impact of technology on education will gradually increase. From this point of view, three-dimensional (3D) printers, which have been used effectively in different fields (engineering and health), have started to take their place in educational environments.

3D printers are basically analogous to traditional printers that are currently used (Lipson, 2013). That is, a computer-generated object is sent to the printer, and the printer presents the physical output of the object to the user. However, the main difference in 3D printers is that 3D objects prepared in a computer environment are presented to users in 3D outputs. In this context, Campbell, Williams, Ivanova and Garrett (2011) summarize the working logic of 3D printers as shown in Figure 1.


Figure 1. Additive Manufacturing (3D printing) Process (Campbell, Williams, Ivanova, and Garrett, 2011)

Considering the logic of 3D printers, it is possible to define these technologies as the tools that allow the

production of 3D objects from different types of raw materials to be stacked in layers and to print out concrete 3D material. Similar to this definition, there are many other definitions in the field literature. Lipson (2013) defines 3D printers as the production of objects shaped by the materials used in layers of layers. Fonda (2013) stated that 3D printers are the process of producing 3D solid objects from digital computer models. Berman (2012) defines 3D printers as tools where the materials used are melted and stacked on top of each other, and the 3D outputs of the products are obtained in a layered structure.

When historical development of 3D printers was examined, it is possible to find their basis in the mid-1980s, however, it has widely been used after the 2000s (Prince, 2014; Wohlers and Gornet, 2014). From this point of view, it can be seen as a young technology. However, it should not be ignored that it has developed and diversified too much in the process. Therefore, 3D printers offer different opportunities for users through different technologies. The most common printing technologies for 3D printers are summarized in Figure 2.

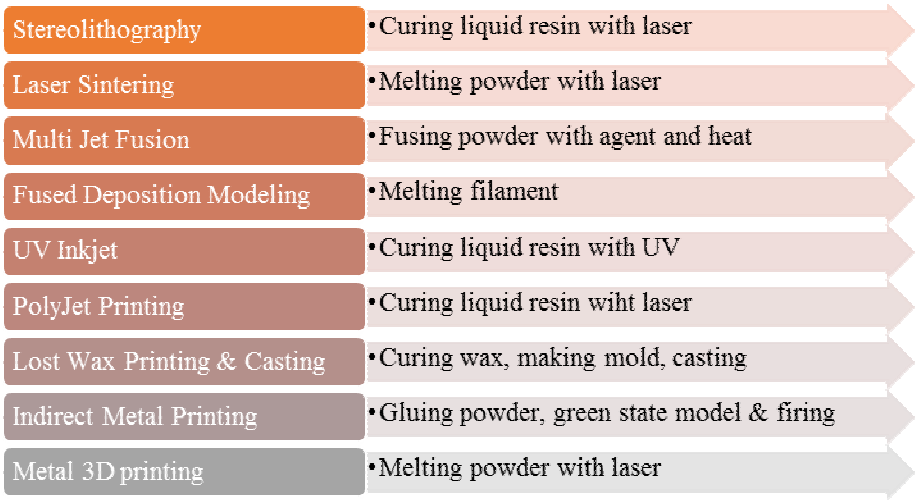


Figure 2. 3D printing technologies (https://i.materialise.com/en/3d-printing-technologies)

Studies have been carried out in many different fields, including health and engineering for 3D printers, which are used for different purposes (Lipson, 2013). In addition to these areas, 3D printers are utilized in areas such as fashion-clothing industry, food industry, astronomy and archaeology (Canessa, 2013; Demir et al., 2016). Similarly, studies on 3D printers in the field of education have been started with an increasing acceleration in recent years (Yıldırım, Yıldırım and Çelik, 2018). The current studies have been focusing on material development, in a similar way to other fields in general. However, it is a fact that studies focusing on the instructional effects of 3D printers, which is a developing technology, are also needed to a large extent.

As it can be understood from the definitions regarding 3D printers, 3D printers (hardware) and 3D modelling programs (software) are actually two different technological tools that are related to each other and fully supporting each other. Therefore, a 3D modelling program can be defined as software that allows users to draw and edit 3D objects. Today, 3D modelling programs have become more accessible. Different software types have been produced by various companies according to the needs of the users. This enables the service to be provided to wide range of users who make professional drawings and also who are beginners. There are also paid or free software available on the requests of the users. From this point of view, it is possible to talk about many different options for the development of 3D models that are essential for 3D printers (Slavkovsky, 2012).

As shown in Figure 1, the models need to be produced using a computer software before they are printed (Campbell, Williams, Ivanova and Garrett, 2011). Fonda (2013) stated the necessity of producing objects through various software in the computer environment as the first stage of the 3D printing process. Considering that objects prepared from this software are sent to a 3D printer, it can be shown as an indispensable support in preparing materials for a 3D printer. With this software, individuals can freely and easily develop any object they want, which can be very effective in developing free and original designs, which is one of the most important advantages of 3D printers (Schelly, Anzalone, Wijnen and Pearce, 2015).

Today, 3D printing technologies are being used in different areas, together with STEM trainings. One of the most important of these areas can be education. However, it is difficult to say that there is too much studies in the field of education when compared to other fields. Many of the studies in the field of education focus on material development rather than on the students' experience of using the current technology. In this context, it is

important to determine the usage conditions of the students who will be the implementer and user of the technology and to examine their views on 3D printers and modelling programs with a new technology in depth. In the upcoming years, especially considering the dissemination of 3D printers, the application of these studies on the students can be seen as a great opportunity for obtaining accurate data and detailed examination of user ideas. Thus, within the scope of the current research, it was aimed to determine the experiences and opinions of secondary school students on 3D modelling programs and 3D printers. For this purpose, the following research questions were researched:

1. **What are the general opinions of students about 3D modelling programs?**
   - 1.1. What are the students' satisfaction with the use of 3D modelling programs?
   - 1.2. What are the advantages and disadvantages of 3D modelling programs according to students?
   - 1.3. What are the opinions of students on the use of 3D modelling programs in daily life?
2. **What are the general opinions of students about 3D printers and its use?**
   - 2.1. What are the students' satisfaction with the use of 3D printer?
   - 2.2. What are the opinions of students on the use of 3D printer in learning environments?
   - 2.3. What are the advantages and disadvantages of 3D printer according to students?
   - 2.4. What are the views of students for course of instructional usage of 3D printer?
   - 2.5. What are the opinions of students on the use of 3D printer in daily life?

## METHOD

In current research case study method was used as one of the qualitative research methods. 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 students' perceptions on the use of 3D modelling programs and 3D printers as instructional tools in all aspects, a case study design was preferred.

### Participants

In the scope of this study, a total of 30 participants from 6th grade in the 2017-2018 academic year, who were student at a secondary school, were participated in this research. Of these students, 10 are girls and 20 are boys. The average age of the students is 12. In this study purposive sampling method was used for sampling. This is the most important choice of the sampling method it is necessary to carry out the implementation process in a quick and practical way (Fraenkel & Wallen, 2000; Yıldırım & Şimşek, 2013). Within the scope of the present study, students with basic computer skills and ready to use 3D modeling programs were selected. This has enabled the implementation process to be implemented more quickly and effectively.

### Data Collection

In literature case studies often combine and use data collection methods such as archives, interviews, surveys or observations. (Eisenhardt, 1989). 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 interview form consists of two separate sections. In the first part, there are 5 questions on views of 3D modelling programs and in second part, there are 6 questions on views of 3D printers. The interview form consists of 11 questions in total. But at the process of development of the interview form, the semi-structured interview form was consisted of 15 questions.

While the interview form was being developed, opinions of two experts with a doctoral degree in the field, three students, a teacher and a Turkish language expert were taken. At the end of the interviews of experts, some of the expressions in the form have been changed to give the final form to the interview form. During this process, interviews were held with students and there was no time limit for expressing their views clearly. Interview times with each student are different. However, a student expressed his opinions within an average of 8 minutes.

### Data Analysis

In data analysis process, content analysis method was used. The content analysis method is 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 students' views within the scope of the research. The interviews were posted to the electronic environment by the researcher. While the data were being analyzed, the code and categories were verified by a different expert with a doctorate degree in the field other than the researcher. At this stage, coding dependability has been tried to be provided. Coding dependability ensures that different coders code the same text or message accordingly or reach the same results in different times (Miles & Huberman, 1994). In this context, the code dependability is calculated at about 88%. The points of difference have been re-analyzed and concluded.

**Implementation Process**

The implementation process consists of two phases: introduction and implementation. These two phases lasted for a total of four weeks. In the first stage, which is the introduction, the information about 3D printers and their fields of use were presented to the students by experts. In this presentation, the historical development stages of 3D printers, past to present usage areas, application examples and possible future use areas were informed. In addition, paid and free programs on the market to prepare 3D models were introduced. Thus, it was ensured that all students were aware of 3D printers and 3D modelling programs.

After the introduction stage, the students were first presented with 3D modeling program and informed by the demonstrator. 3D modeling programs were used with the help of a smart board. During the course hours, all students were given the opportunity to use the program and draw. In addition, the students, who wanted 3D modeling program to be installed in their own personal computers to work in the environment they want independent from the school, were given the opportunity. At this stage, students were allowed to draw the drawings they desired and studies in this direction were carried out in extracurricular activities. Sample images from the implementation are presented in Figure 3.

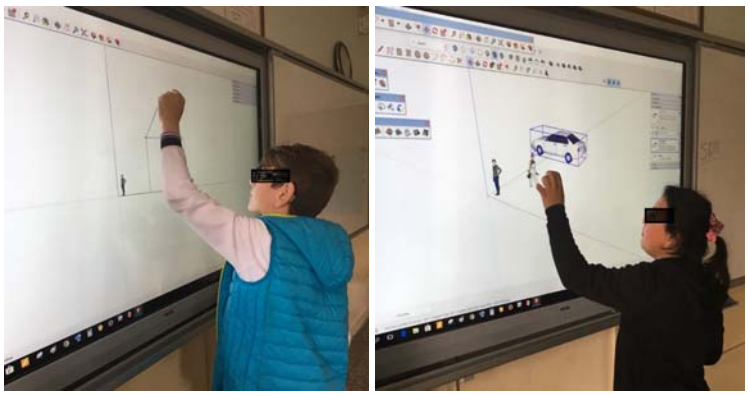

Figure 3. Use of 3D modeling program

After completing the drawings in 3D modelling program, a 3D printer was introduced to the classroom environment and students were given information about the printer. In the classroom environment, the process of printing from 3D printers was started by selecting a few of the projects that the students realized. At this stage, the participants were given the opportunity to examine the 3D printers in detail and all the points they were interested in at the output stage were answered. Sample images from the implementation are presented in Figure 4.

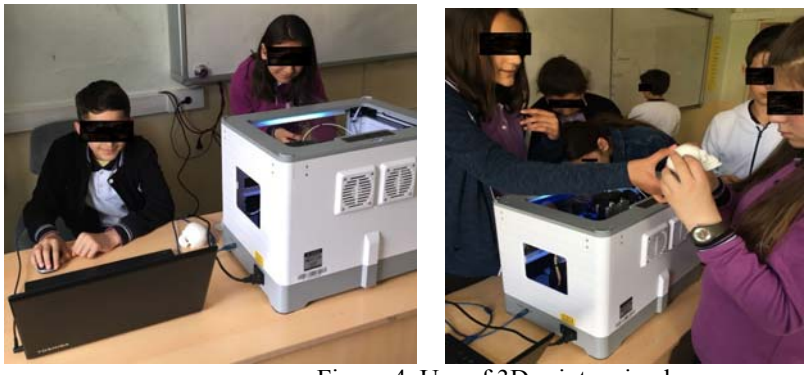

Figure 4. Use of 3D printers in classroom environment

In the final stage, the samples selected from the projects carried out by the students were presented to the students and the teachers with an exhibition. After this stage, the students' views on 3D modeling programs and 3D printers were taken. Sample images from the implementation are presented in Figure 5.

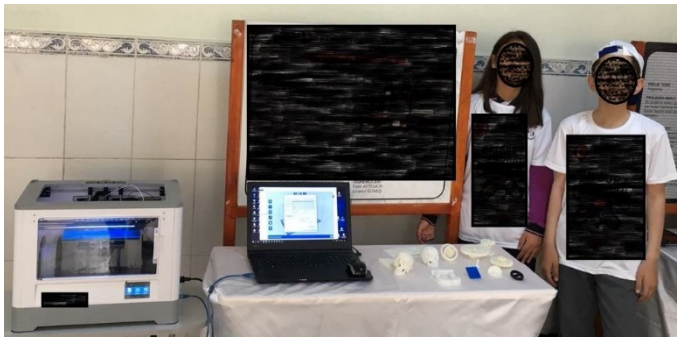

Figure 5. Exhibit of 3D printer outputs

**Limitations**

- The study was limited to 30 students.
- Students of secondary education were included in the study.
- Only case studies from qualitative research methods were preferred in the study.

## FINDINGS

The following findings were obtained from the data collected within the scope of the present research, which aimed to determine the experiences and views of secondary school students on 3D modelling programs and 3D printers, and are presented respectively according to the research questions.

### 1. General opinions of students about 3D modelling programs

Within the scope of the study, students' views on 3D modelling programs were investigated. In this context, first of all, the status of previous use of 3D modelling program was examined. While N=9 (30%) of the students who participated in the study stated that they used 3D modelling programs before, N= 21 (70%) said that they did not use the existing technology before. When the use of 3D modelling programs by gender was examined, it was determined that 20% of female students and 35% of male students stated that they used modelling programs at least once before.

#### 1.1. Students' satisfaction with the use of 3D modelling programs

As a result of the interviews with the students, the students' appreciation of the 3D modelling programs was examined. While N=21 (70%) stated that they liked the current technology, N=7 (23.3%) said that they did not like it because it was difficult to use, and N=2 (6.7%) said that they did not have any ideas. The interviews were analysed for finding out the general views of the students in depth, and the results were presented in Table 1.

Table 1. The general opinions of students about 3D modelling programs usage

| | Codes | Students | F |
|---|---|---|---|
| + | Provides funny and easy environments | S2, S4, S5, S11, S13, S19, S22, S28, S29 | 9 |
| + | It allows you to make imagined drawings. | S1, S9, S15, S16, S23, S25, S26, S29 | 8 |
| + | It gives you the opportunity to do the drawings freely. | S2, S9, S12, S17, S20, S26, S30 | 7 |
| + | It fully understanding the concept of 3D. | S3, S5, S8, S14, S28 | 5 |
| + | It supports visibility. | S24, S27 | 2 |
| + | It gives a different perspective. | S4 | 1 |
| + | It increases the self confidence | S26 | 1 |
| - | Usage is difficult and time consuming. | S2, S3, S5, S6, S11, S15, S22 | 7 |

When the students' opinions were examined, most of them stated that 3D modelling programs were fun and easy to use. The students have stated that they can easily draw the works, especially which are the products of their imagination, through 3D modelling programs. In addition, the students were given the opportunity to do what they want by providing free working environments. It was also emphasized by the students that the modelling programs were effective in students' feeling themselves comfortable, their fully understanding the concept of 3D, and their acquiring a different perspective. However, some participants stated that 3D modelling programs were useful but also they were difficult to learn and practice. Sample participant opinions on these situations are given below.

*S14: I found it beautiful. Because when I looked at an object, we looked one-dimensionally. Now I was looking at a better multi-dimensional look…*
*S16: I think it has a very good use. Because you can do your dreams easily …*

*S23: I was able to draw three dimensions of the objects I had in my head.*
*S26: It is beautiful. Because people are happy to make three-dimensional things with imagination. I can be proud of my own project.*
*S2: It is nice and funny, but it can take some time because it is very hard to use.*
*S22: I found it a bit difficult. The reasons for reaching the program were a little difficult.*

1.2. Advantages and disadvantages of 3D modelling programs according to students

In the scope of the study, students were asked to specify the advantages and disadvantages of 3D modelling programs, which were appreciated by them. In this context, the results obtained from the interviews with the students regarding the advantages of 3D modelling programs are presented in Table 2 in detail.

Table 2. Student opinions on the advantages of 3D modelling programs

| Codes | Students | F |
|---|---|---|
| Rapid prototype production | S1, S2, S3, S5, S9, S15, S16, S17, S18, S25, S26, S30 | 12 |
| Easy drawing development | S1, S3, S10, S13, S17, S23, S29, S30 | 8 |
| Facilitate understanding | S14, S21, S24 | 3 |
| Notice the mistakes | S20, S27 | 2 |

When the views on the advantages of 3D modelling programs were examined, it was seen that students stated that the greatest advantages of these technologies were rapid prototype production and easy drawing development. In addition, the advantages of 3D modelling programs to facilitate understanding and their superiority in noticing the errors are stated as advantages by the students. Student opinions on the advantages of 3D modelling programs are given below.

*S5: We can see what our project looks like, colours, stones, etc.*
*S16: ... we can model in detail what we want to do.*
*S17: We can make fast and flawless drawing with program when we can not give three dimensional images by drawing our own.*
*S24: I gained knowledge. I learned what I didn't know.*
*S27: ... we can easily see our mistakes on the object we designed…*

The limitations encountered by the students during the use of 3D modelling programs were studied within the scope of the study. The results obtained from the students regarding the disadvantages of 3D modelling programs are presented in Table 3.

Table 3. Student opinions on the disadvantages of 3D modelling programs

| Codes | Students | F |
|---|---|---|
| Difficult and complicated usage | S2, S3, S6, S9, S12, S13, S16, S18, S21, S24, S25, S26, S28, S29, S30 | 15 |
| Effective using with 3D printers | S3, S15 | 2 |
| Difficulty in accessing programs | S5, | 1 |
| No disadvantages | S7, S14, S17 | 3 |

When the general views of the students were examined, it was observed that most of the students focus on the difficulty of using 3D modelling programs. In addition, students saw 3D modelling programs and 3D printers as a whole and stated that a software did not mean much without a 3D printer. Access to the program was also defined as a limitation. Certain students stated that there was no disadvantage. Student opinions on the disadvantages of 3D modelling programs are given below.

*S15: The program may not work because it can be difficult to reach expensive 3D printers.*
*S18: We have to make sure that he puts an object in his place. These applications are a little difficult. A single mistake will cause your work to be ruined.*
*S28: It is difficult to use. So you need to get enough information. It's a very complicated program.*

1.3. Opinions of students on the use of 3D modelling programs in daily life

Within the scope of the study, students' views on the use of 3D modelling programs in daily life were examined. In this context, the results obtained from the students are presented in detail in Table 4.

Table 4. Student views on the use of 3D modelling in daily life

| Codes | Students | F |
|---|---|---|
| For architectural purposes in home modelling | S1, S3, S4, S5, S8, S10, S11, S14, S16, S17, S24, S26, S27 | 13 |
| Developing new and original designs | S2, S7, S13, S18, | 4 |
| For instructional purposes | S22, S23, S28, S29 | 4 |
| In aircraft design | S3, S15, S20 | 3 |
| I don't want to use | S6, S25 | 2 |

When the general opinions of the students were examined, it was seen that they related the use of the 3D modelling program with the profession group they desire to be inside in the future. Especially those students who want to advance in the field of architecture have stated that they could use 3D modelling programs in the development of various models for architectural purposes. In addition, those who want to be teachers emphasized that they can use the 3D modelling program for educational purposes. There were also students who want to develop new and original designs using 3D modelling programs in the future. Some of the students stated that they would not use the 3D modelling program because they thought that it was not suitable for the professional group they want to be inside in the future. Student opinions on the use of 3D modelling programs in daily life are given below.

*S2: I can design new things or design models.*
*S14: When I am an architect, I make better bridges by looking at three dimensional bridges.*
*S27: If I were an architect, I wanted to visually see the houses I built. So I use this program.*
*S29: If I were a teacher, I could design geometric shapes and prisms with it.*
*S25: I do not use. Because doctors do not need a 3D modelling program.*

**2. General opinions of students about 3D printers and its use**

Within the scope of the study, students ' views on 3D printers were examined. Primarily, the students' being familiar with 3D printers was analysed. Students who participated in the study stated that N=20 (66.6%) were aware of 3D printers while N= 10 (33.3%) said that they did not know the current technology. Analysing the status of being aware of 3D printers by gender, 50% of female students and 75% of male students stated that they knew about the current technology.

2.1. Students' satisfaction with the use of 3D printer

As a result of the interviews with students, the status of appreciation for 3D printers was examined. While N=27 (90%) stated that they liked the current technology, N=3 (10%) said that they had no idea. In this context, the interviews, which were carried out to determine the general view of the students' perceptions of how they feel when they print out from a 3D printer in-depth, were analysed and presented in Table 5.

Table 5. Students' satisfaction with the use of 3D printer

| Codes | Students | F |
|---|---|---|
| Made happy | S5, S9, S13, S15, S17, S18, S20, S22, S24, S25, S26, S27 | 12 |
| Excited | S1, S5, S8, S23, S30 | 5 |
| Surprised | S2, S3, S19, S29 | 4 |
| Gained self-confidence | S4, S12, S21, S28 | 4 |
| Entertained | S11, S14, S16 | 3 |
| I did not feel anything | S6, S7, S10 | 3 |

A thorough examination of the students' views on the use of 3D printers revealed that these technologies make them happy. It was also expressed by the students that it was exciting to use 3D printers. In addition, it was also frequently emphasized that the output stage was very surprising, it was an entertaining technology, and it increased the students' self-confidence levels. Sample participant opinions on these situations are given below.

*S2: I never really thought I'd see it close. We got such good and beautiful printouts. 3D printers are great ...*
*S4: ...it became a bit more confident to become an architect.*
*S5: I was excited at that moment. I got 3D version of my project and I was happy.*
*S21: It's beautiful. Because I was proud myself when I made my own three-dimensional image.*

*S29: We printout the oxygen molecule from the printer and I'm surprised how it happened when I handled.*

2.2. Opinions of students on the use of 3D printer in learning environments

Within the scope of the study, students were asked if they wanted to use 3D printers in their learning environments. N=21 (70%) students wanted the use of 3D printers in learning activities while N=9 (30%) stated that they did not want to. The findings are presented in detail in Table 6.

Table 6. Positive and negative opinions of students for use of 3D printer in learning environments

| | Codes | Students | F |
|---|---|---|---|
| + | Provides effective and easy learning. | S5, S13, S24, S28 | 4 |
| + | Facilitates understanding. | S13, S14, S18, S21 | 4 |
| + | Easy to do homework | S1, S23, S28 | 3 |
| + | Improves visual intelligence. | S3, S13, S29 | 3 |
| + | Increases interest and attention to the lesson | S17, S20 | 2 |
| + | Eliminates instructional deficiencies | S4, | 1 |
| - | Technical difficulties can be experienced | S8 | 1 |
| - | Continuous use could distract | S9 | 1 |
| - | Hard to use. | S25 | 1 |
| - | It causes time loss. | S27 | 1 |
| - | It costs more. | S27 | 1 |

When the students' opinions were examined, the students stated that the use of 3D printers in educational environments could have different effects. Students who think they may have positive effects have stated that 3D printers can be important for effective and easy learning. It was also emphasized that these technologies could be effective in facilitating understanding and providing support to the lessons. In addition, it was expressed that 3D printers could be effective in developing visual intelligence and increasing the interest and attention to the class. However, students who did not want to use 3D printers for educational purposes have stated that they thought that these technologies would not be effective because of technical difficulties, because continuous use could distract them, and because they would lose time and it would be costly. Sample participant opinions on these situations are given below.

*S4: I want to use it because I can not draw cubes and shapes in math lessons.*
*S5: I'd like to. In Science, we can see what the living things look like, In Mathematics we can see what the square and the cylinder look like,*
*S13: I want. Our visual intelligence increases. We understand lessons better.*
*S17: It would be better to use it. ... catch students' attention.*
*S20: I'd like to. It attracts more attention.*
*S23: Yes, I would. Because it helps me a lot when doing research.*
*S29: Yes, I would. Because we give more importance to visuals.*
*S9: I do not want. Because we are constantly distracted and can not focus on the lessons.*
*S27: I do not want to use it. Because if we wait for hours it will be a waste of time and cost too expensive.*

2.3. Advantages and disadvantages of 3D printer according to students

Within the scope of the study, students' views on the advantages and disadvantages of 3D printers were determined. The results obtained from the students regarding the advantages of 3D printers are presented in Table 7.

Table 7. Student opinions on the advantages of 3D printer

| Codes | Students | F |
|---|---|---|
| Freedom of material development | S1, S2, S9, S13, S15, S17, S25, S30 | 8 |
| Embody dreams | S4, S16, S22, S23, S26 | 5 |
| Reduce the likelihood of making mistakes | S3, S5, S20 | 3 |
| Facilitate daily tasks | S7, S10, S29 | 3 |
| Provide examine in detail | S14, S28 | 2 |
| Provides visualization of lessons | S24, S27 | 2 |
| Making impressive designs | S19 | 1 |
| Offer joyful environments | S6 | 1 |

It was observed that the students' general view was expressed as the freedom to develop materials provided by 3D printers was a great advantage. I was also emphasized that it was an important advantage for them to realize their dreams by means of concrete objects. In addition, other important advantages expressed were the facts that 3D printers can be used to make prototypes to minimize the possible errors and provide an opportunity to examine the materials in detail. Providing convenience in everyday jobs and providing fun environments were among the other advantages of 3D printers. Sample participant opinions on these situations are given below.

*S3: Before we do anything, we can make mistakes by making a model.*
*S9: We can printout what we want and fix things.*
*S10: It makes our daily life easier.*
*S15: Some parts can be produced for some devices for the benefit of humanity.*
*S26: It would be nice to see the product we made when we printout from the printer.*
*S29: 3D printers are doing things that can not be done with cardboard and paper.*

The limitations determined by the students during the use of 3D printers were studied within the scope of the study. The results obtained from the students regarding the disadvantages of 3D modelling programs are presented in Table 8.

Table 8. Student opinions on the disadvantages of 3D printer

| | Codes | Students | F |
|---|---|---|---|
| - | Printing time is long | S1, S2, S3, S4, S5, S9, S11, S12, S13, S16, S17, S18, S20, S24, S25, S26, S27, S29, S30 | 19 |
| - | Expensive | S3, S4, S5, S11, S12, S13, S15, S17, S20, S22, S25, S27, S29 | 13 |
| - | Working at a very high temperature | S3, S8, S10, S18, S28 | 5 |
| - | Physical size | S10 | 1 |
| - | Aura | S28 | 1 |
| + | No disadvantages | S7, S14, S23 | 3 |

When the students ' opinions were examined, it was observed that the biggest disadvantages of 3D printers were the cost and duration of printing. It was also stated by the students that there were various disadvantages of working with high temperatures. The physical properties of printers were also considered as a limitation. Sample participant opinions on these situations are given below.

*S4: Printers are very expensive and printing time too much.*
*S8: Because it works at a high temperature, it can be burned when we touch it.*
*S10: It takes a lot of space. It warms when it work.*
*S28: The wires (filament) smell like plastic when heated. This is very disturbing.*

### 2.4. Views of students for course of instructional usage of 3D printer

Within the scope of the study, the students' opinions on the courses, in which 3D printers can be used, were taken. In this context, the results obtained from the students are presented in Table 9.

Table 9. Student opinions on classes where 3D printer can be used

| Codes | Students | F |
|---|---|---|
| Science and Technology | S1, S2, S3, S8, S12, S13, S14, S15, S17, S18, S20, S24, S26, S27, S28, S30 | 16 |
| Mathematics | S2, S4, S12, S13, S15, S17, S18, S20, S24, S25, S26, S27, S29, S30 | 14 |
| Information Technologies | S5, S6, S7, S12, S17, S18, S20, S21, S25, S26 | 10 |
| Social Sciences | S8, S10, S13, S14, S16, S17, S22, S23 | 8 |
| Visual Arts | S8, S17, S19, S20, S29 | 5 |
| Technology Design | S6, S17 | 2 |
| Physical Education | S12, S17 | 2 |
| Could not be used in any class | S9, S11 | 2 |

When the students' opinions were examined, it was observed that they stated that they could use 3D printers in almost all courses. However, it can be said that their use in Science and Mathematics courses would be more effective. It was also emphasized that 3D printers could be very useful in Information Technologies, Social Studies and visual arts courses. Additionally, in technology design and physical education courses, 3D printers might have areas of use. Some students stated that 3D printers could not be used in any class. The reasons underlying the students' views were examined in depth and the results are presented in Table 10.

Table 10. Students' opinions on the instructional usage of 3D printer

| Codes | Students | F |
|---|---|---|
| Developing the course materials | S1, S2, S3, S4, S10, S16, S19, S22, S23, S26, S28 | 11 |
| In facilitating learning | S2, S4, S25, S27, S29, S30 | 6 |
| Effective learning environments | S8, S28, S29 | 3 |
| In increasing the interest in the course | S21, S24 | 2 |

When the students' opinions were examined, it was observed that 3D printers could be effective in developing the course materials. It was also emphasized that 3D printers could be important in creating easy and effective learning environments. In addition, it was stated that 3D printers could be effective in increasing the interest in the course. Sample participant opinions on these situations are given below.

*S2: Math because there are a lot of shapes. It might be useful to get them out of the printer or in science class because there are too many devices and scientific things. It may make it easier for us to learn.*
*S4: Math because I can not draw shapes. I can not measure the volume.*
*S8: I want to use it in social sciences, painting and science. Because we can learn better by seeing and examining a subject from 3D objects.*
*S21: I wanted to use it in a IT lesson. Because it attracts more attention in the IT course.*

2.5. Opinions of students on the use of 3D printer in daily life

Within the scope of the study, the purposes of the students for the use of 3D printers in daily life were investigated. The results obtained from the students are presented in Table 11.

Table 11. Student views on the use of 3D printer in daily life

| Codes | Students | F |
|---|---|---|
| Architectural purposes | S1, S4, S5, S8, S11, S16, S17, S18, S22, S24, S27, S28 | 12 |
| Production of daily goods and vehicles | S3, S14, S15, S19, S26, S30 | 6 |
| Educational purposes | S7, S17, S23, S29 | 4 |
| In all areas | S12, S21 | 2 |
| In the field of health | S20 | 1 |
| Commercial areas | S2 | 1 |
| I don't want to use | S6, S9, S10, S25 | 4 |

Examining the students' opinions, it was observed that they associate the use of 3D printers in their daily lives with the profession they would choose. They stated that they could use 3D printers mostly for the architectural purposes in the future. In addition, they stated that they would prefer 3D printers in the production of daily goods and vehicles. Education, health and commercial areas were also seen as areas in which they wanted to benefit from this technology in the future. However, some participants said that they did not think of the use of a 3D printer because they did not have any interest or because they thought it had nothing to do with their future professional plans. Sample participant opinions on these situations are given below.

*S1: I want it to be used on projects. Because an architect can benefit from writers when designing houses.*
*S2: I use it for commercial purposes. For example, toys, plastic bags, tools. It can be very profitable.*
*S9: I do not want to use it. Because I will not work in my profession.*
*S14: I want to use it to make life easier for people.*
*S21: I want to use 3D printers everywhere. For a better understanding*
*S29: If I could be a math teacher I calculated the volume of a cube with the output from the printer.*

## DISCUSSION AND CONCLUSION

The purpose of the study was to determine the experiences and views of secondary school students for 3D modelling programs and 3D printers and it was seen that the students substantially appreciated 3D modelling programs and 3D printers. The results of this study also showed that male students are more familiar with 3D modelling programs and 3D printers. Results are presented below according to the research questions.

3D modelling programs can be said to be appreciated by users. These programs' being fun and easy to use are among the reasons that affect the status of their being liked. Slavkovsky (2012) stated the existence of many 3D modelling programs that can meet the needs of each individual, according to their ability to use them. It can also be said that 3D modelling programs provide an important opportunity for users to realize their dreams and make the desired drawings freely. In addition, giving individuals a different point of view may have an important effect on increasing the level of appreciation for these programs. However, the popularity of these programs may vary depending on the usage situation. In this context, the use of 3D modelling programs by users can have a negative effect on the level of appreciation that is difficult and time consuming. Huleihil (2017) mentions the necessity for the individual to have a variety of skills (problem solving, imagination and innovation etc.), especially mathematics and geometry, in order to use 3D printing process and connected technologies. This could be effective in perceiving the process as difficult and troublesome.

Some of the advantages and disadvantages of 3D modelling programs can be mentioned. In this context, it is thought that these programs are effective in developing fast prototypes and making easy drawings. It is thought to be important to attract the attention of the users on these programs, to have paid or unpaid programs according to the needs of everyone, and to have user-friendly tools through their libraries (Slavkovsky, 2012). In addition, 3D modelling programs facilitate understanding (Huleihil, 2017) and possible errors can be avoided as an advantage to be mentioned. Especially in projects, it can be said that it is effective for users to see the situation in all aspects and examine it in detail. The advantages of 3D modelling programs as well as some disadvantages should not be ignored. Especially the difficult and troublesome use of it can be shown as the most important limitations. Although the literature mentions the diversity of these programs and the ease of use (Slavkovsky, 2012), it is thought that the selected program and the age groups of the students can be effective in this situation. In addition, given the experience of users in 3D modelling programs, it can be said that these new programs, which are newly recognised, are different from their previous habits. It can also be stated as a limitation that access to these programs is difficult. However, given that there are many options for 3D modelling programs according to the user's wishes and needs, the current limitation is thought to be related to the fact that 3D modelling programs are not known in detail. In addition, considering the need to concretize for the individuals, the need to print out the drawings using 3D printers instead of keeping them in the electronic environment can also be emphasized as a significant limitation. This can bring extra time and cost burden. Yet, when the literature is examined, 3D modelling programs and 3D printers are considered as complementary technologies and the end stage of one is the beginning process of the other (Campbell, Williams, Ivanova and Garrett, 2011).

It is thought that the daily use of 3D modelling programs is related by the users to the professional group in which they are present or want to be inside. It can be said that these technologies are generally preferred for architectural purposes. It is generally believed that 3D modelling programs are effective in developing a new drawing, planning living spaces, or preparing the environments created by imagination. In addition, it can be said that 3D modelling programs can be an effective tool in developing new and original designs or in educational activities. When Lacey (2010) stated the educational effects of 3D modelling programs, it was said that students gain the ability to think in 3D in design environments and were more efficient in other areas.

As a result of the study, it can be said that the 3D printers have reached a high level of appreciation of the users. Especially the 3D printers' making users feel happy and excited is thought to have an important effect in this high level of appreciation for this technology. In addition, considering that individuals have never encountered such a technology before, 3D printers can be said to have a surprising effect on the users in the printing process and the output stage. This is thought to be due to the significant impact of the individual's not encountering the 3D printer technology. In addition, students' gaining self-confidence with the use of 3D printers and their being entertained are among the other results achieved (Lacey, 2010).

It can be said that the use of 3D printers for teaching purposes has many positive or negative effects. The current technology has an important impact on developing effective learning environments and facilitating understanding. In this situation, it is thought that 3D printers have important effects on motivating learners and enabling them to develop concrete learning experiences (Weinmann, 2014). In addition, it can be said that 3D printers are an important tool in the development of individuals' visual intelligence. It is also thought that this technology has important effects on the increase of interest in the class (Huleihil, 2017) and the elimination of learning deficiencies. Dougherty (2013) states that individuals can more easily identify deficiencies on these tools and learn better by developing a wide range of tools through 3D printers. In addition, it can be said that it can help students in extracurricular activities. However, in addition to these positive effects, the use of 3D printers in learning environments may also bring some limitations. In particular, the continuous use of these technologies in learning environments can negatively affect time management and distract the students. The technical difficulties that may be experienced may also prevent educational activities, which can be shown

among the negative situations that may arise.

Considering the general characteristics of 3D printers, many advantages are mentioned in field literature. 3D printers' offering freedom in material development, and their success in embodying the imagination have been the most remarkable advantages. Similarly, Shaikh (2017) stated their offering design freedom as one of the most important advantages of 3D printers. Huleihil (2017) stated that 3D printers were important for students' ideas' turning into reality. 3D printers can also be highlighted as a great advantage to reduce the margin of error and simplify daily tasks in accordance to models made before large projects. About this fact, Lipson (2013) stated that 3D printers were very effective in the production of prototype of a project, when they were first introduced. Naturally, this can minimize the margin of error by allowing detailed review before major projects. In his research, Shaikh (2017) stated that it could take days or weeks to develop a prototype in traditional processes before 3D printers, while stressing that this process could be completed within hours. In addition, it is stated that there is a superior aspect of 3D printers for detailed analysis of materials. It also provides entertaining environments and visualizations in the learning environment. Huleihil (2017) mentions that students who are physically studying their projects will increase their interest in the courses and that spatial Dreams can be effectively animated.

It should not be overlooked that 3D printers may have some limitations as well as the advantages. In this context, especially long output time and high cost of output can be among the most important limitations of 3D printers. This situation is noted in the field literature which has changed relatively today. Fonda (2013) and Blikstein (2013) indicate a significant decrease in the cost of 3D printers. In addition to this, the need for excessive heat while working is among the limitations of these technologies. In addition, it can be said that the smell emitted by filaments is not harmful to health while it is melted. It is thought that good ventilation of the environment can prevent this limitation.

The fact that 3D printers can be used in almost all courses have appeared as a result of the research. In particular, it is thought that these technologies can be effective in Science and Mathematics teaching. In consideration of the field literature, it can be said that the use of 3D printers in mathematics and Science courses can bring with it a number of advantages (Irwin, Pearce and Anzalone, 2014; Slavkovsky, 2012), especially when it comes to the application of 3D printers in STEM education (Slavkovsky, 2012). In addition, it technologies and Social Studies courses can be said to be among the application areas where 3D printers can be effective. Krassenstein (2014) noted that the production of abstract or hard-to-reach materials, especially in social areas (geography, history, geology, etc.), may have important implications for learners' realization of more effective learning experiences. In addition, visual elements such as visual arts and technology design in the foreground of the courses can be among the technologies that can provide the advantage of 3D printers. The geometric freedom presented to the users of 3D printers is thought to be effective in the formation of these views.

It can be said that the superiority of 3D printers in material development is one of the most important factors in the use of the given courses. In addition to this, it can be said that the use of 3D printers in classrooms can be effective especially in providing effective learning and facilitating learning. Similarly, the Canessa (2013) research suggests that 3D printers can develop faster and more efficient learning activities in teaching conceptual information or complex situations. In addition, 3D printers are thought to be important in increasing the interest in the class. In this context, Lütolf (2013) stated that the most striking point in his study was that the motivation of the students in the 3D project development stage was increasing and that they were fully interested in the project. In addition, it is stated that 3D printers gain practicality in their education as well as increasing their motivation, performance and knowledge retention (Blikstein, 2013; Weinmann, 2014).

It can be said that 3D printers can be used in almost all areas of daily life. It can be said that the needs of individuals are very important here. Especially in architectural areas or in the production of daily goods-vehicles are thought to attract users. Similarly, Kostakis, Niaros and Giotitsas (2015) stated that 3D printers can be effective in prototyping a house or drawing some parts of a car engine. In addition, it has been seen that it will have the opportunity to apply in many areas, from health to education. As with 3D modelling programs, it can be said that this situation has an effect on the opinions of the professional group in which individuals are or want to be in.

According to the results of the study, some suggestions can be presented for future studies. In this context students can be examined from different perspectives such as academic achievement and retention, in-class production and implementation activities can be examined and long-term studies and implementations on students at different levels, can produce more generalized results.

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