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XI International Eurasian Educational Research Congress

CONFERENCE PROCEEDINGS

KOCAELİ ÜNİVERSİTESİ 1992
ANI yayıncılık

XI INTERNATIONAL EURASIAN

EDUCATIONAL RESEARCH CONGRESS

EJERCONGRESS 2024

CONFERENCE PROCEEDINGS

May 21-24, 2024/ Kocaeli University - Türkiye

Editor

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INTERNATIONAL EJER CONGRESS

XI. INTERNATIONAL EURASIAN EDUCATIONAL RESEARCH CONGRESS

EJERCONGRESS 2024
CONFERENCE PROCEEDINGS
May 21-24, 2024/ Kocaeli University - Turkiye
by Anı Publishing
Kızılırmak Sokak 10/A Çankaya/ Ankara - Turkiye 06680
Tel : 90 312 425 81 50 pbx
Fax : 90 312 425 81 11
www.ejercongress.org
www.ejercongress@gmail.com
e-ISBN : 978-625-97716-6-3

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Main Theme

"Designing the Future: Changing Paradigms and Transhumanism with Artificial Intelligence in Education"

Sub-Themes

- Academic freedom, autonomy, and social responsibility in education
- Artificial intelligence and educational applications
- Augmented reality applications
- Barriers to learning
- Blended learning
- Computer-assisted measurement and evaluation
- Core skill sets for students and teachers
- Design of school buildings in the future
- Designing and delivering a digital strategy
- Digital competence
- Digital parenting
- Distance Education
- Earthquake Education
- Post Earthquake Trauma Training
- Earthquake and Effective Psychosocial Intervention Methods
- Earthquake and Trauma
- The Impact of Earthquakes on School Staff
- Education and society
- Education for healthy living and healthy communities
- Education for a sustainable life
- Education in the digital age: Primary, secondary, high school, higher education, and application examples
- Educational leadership in the digital age
- Effects of regional differences on education
- Equity, Diversity, and Inclusion Related to Marginalized Groups
- Emergency Management at Schools
- Evidence-Based School Counseling Services for Refugees and Marginalized Groups
- Globalisation and Education
- Higher education
- Innovative learning designs for student success
- Instructional technologies in the digital age
- Integration of immigrants into education
- K-12 education (preschool, primary, and secondary education)
- Learning management systems
- Lifelong learning
- Machine learning
- Management information system
- Managing schools
- Measurement and evaluation of students' learning outcomes
- Metaverse
- Migration and education
- Multicultural Classroom Concerns of Educators and Parents
- New educational system after COVID-19
- New skills to live and work in new times
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- New trends in learning and teaching methods
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- Politics, good governance, and leadership in the educational sector
- Program design and development
- Promoting equality, diversity, and inclusion
- Psychological counseling and guidance in education
- Quality assurance/standards and accreditation
- Research and innovations in education
- Research ethics
- Right to an education
- Sustainable Educational Goals Related to Refugees
- Teacher education in the digital age
- The Possibility of Fundamental Changes in the Curriculum
- The role of parents in education
- The skills we need to thrive in a post-COVID-19 world
- Vocational education
- Ways to overcome the digital divide

XI INTERNATIONAL EURASIAN EDUCATIONAL RESEARCH CONGRESS

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Author Information

This book has been compiled with contributions from 61 authors representing 35 different universities in Turkiye, the United States, and Iran, as well as Turkiye's Ministry of National Education. Among the contributors, there are 51 authors from 31 universities 6 authors from education institutions in Turkey, 3 authors from 2 universities in the United States, and 1 author from a university in Iran.

CONTENTS

The Prospective Mathematics Teachers' Opinions on the Use of Tinkercad

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Abstract

This study aimed to reveal the views of prospective mathematics teachers on the use of the Tinkercad program. This case study, utilizing a qualitative research method, was conducted with 18 prospective mathematics teachers currently enrolled in a fourth-grade education program at a state university in a province in western Turkey. The convenience sampling method was employed to select the participants. The data obtained via the questionnaire form created by the researchers were analyzed using the content analysis technique. The results of the research indicated that the majority of prospective teachers held a positive opinion of the Tinkercad program, with the majority of them believing that it could be applied to the subjects of solids and geometric shapes. Upon examination of the opinions regarding the positive aspects of the program, it was found that the opinions were generally positive, with the program being perceived as understandable, clear, diverse, easy to use, and providing concretization. In contrast, the negative aspects of the program were not widely discussed, with the majority of prospective teachers stating that they did not perceive any negative aspects. However, a few prospective teachers expressed difficulty using the mouse or buttons. Additionally, the majority of prospective teachers perceived the program to be time-consuming. With regard to the utilization of the Tinkercad in a professional context, the majority of prospective teachers indicated that they would use the program in their future professional roles.

[This paper was published in: "EJER Congress 2024 International Eurasian Educational Research Congress Conference Proceedings," Ani Publishing, 2024, pp. 1-7]

Keywords*: Mathematics Education, Teacher Training, Opinion, Using Technology, 3D Design Technologies*

Introduction

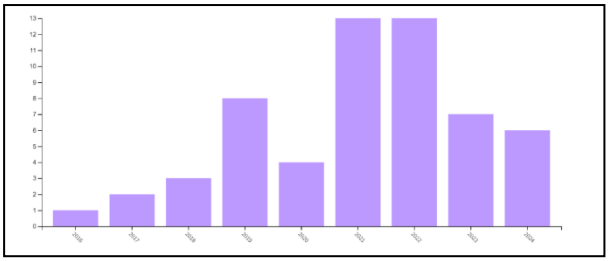
In the contemporary global context, it is challenging to envisage a society without technology. One of the most significant domains influenced by technology is undoubtedly education. As a result of the impact of technology on education, education, teaching, school environment, teachers and students; using technology as a tool to make the information learned permanent and to raise individuals who think critically and analytically are encountered as targeted situations in education.

Mathematics is a subject that is often approached with a degree of prejudice and perceived as difficult. However, the use of 3D technology design tools can help to break down these prejudices, increase students' interest in the subject, and facilitate the adoption of a constructivist approach to teaching that is currently in vogue. The technology design tools in question include programs such as Google Sketchup, Cabri, and Geogebra. Each of these programs has several different features. Google Sketchup facilitates the perception of the differences between three-dimensional and two-dimensional objects, employing the area and volume relations. This allows users to perceive spatial relationships, visualize, and use 3D objects more quickly and permanently. Cabri is the inaugural dynamic mathematics software. In addition to two-dimensional geometric shapes, it can create three-dimensional geometric shapes and demonstrate the expansions of these three-dimensional shapes in motion. The use of Geogebra, a 3D software, enables the creation of a variety of solid objects and the visualization of their expansions. The most significant advantage of Geogebra software is that it enables users to perform calculations related to area, volume, length, and angle. Additionally, it offers views from different directions and can create a rotational face for shapes feature.

In addition to the aforementioned programs, Tinkercad, which is included in the study, boasts a comprehensive interface. In addition to three-dimensional designs, it offers the possibility of creating circuits, code blocks, and Sim Lab with a moving workspace. The Projects tab allows users to examine works from across the globe, with the option to select the desired grade level, subject, and work area. Upon selecting the "Classes" button, educators can create a class with their students and offer them the option of working collaboratively on the same project or with the teacher. Furthermore, the Resources button provides access to a learning center for those who are utilizing Tinkercad for the inaugural time, lesson plans for educators to employ in the classroom, and challenges with a global reach. The distinguishing feature of Tinkercad is its capacity to interact with 3D printers, thereby enabling the tangible realization of the shapes created within the program. Tinkercad, which is accessible via a web extension without the need for download, is available at no cost and is suitable for use at both the basic and intermediate levels. Upon examination of the distribution of studies on Tinkercad in Web of Science, it becomes evident that the program continues to garner the attention of researchers and maintains its popularity (Figure 1).

Figure 1

Distribution of the Studies on Tinkercad by Year (WoS Database)



In comparison to other disciplines, mathematics education is an appropriate field for the utilization of technology design tools. The utilization of technology design tools in mathematics education facilitates the active participation of students, individualized learning, and collaborative work by providing tangible examples of the subject matter in the classroom. The General Directorate of Innovation and Educational Technologies (DGIET) (2019) posited that in order to develop digital skills and teacher training, integration of 3D design, coding, and similar IT production skills will be provided to teachers, students, and the public in and out of school at all education levels except higher education. Consequently, it is anticipated that prospective teachers will be able to utilize 3D technology design programs with students in their future professional lives, maintain students' engagement in the course, and comprehend the significance of the course. The utilization of Tinkercad or 3D printer programs is predominantly observed in science education (Doğan & Uluay, 2020; Karaismailoğlu, 2022; Güleryüz, 2023). Compared to science education, studies on Tinkercad conducted with pre-service mathematics teachers are limited to Taştı et al. (2015) and Guler et al. (2019). Whereas, Tinkercad is a program that enhances mathematical learning through 3D modeling within an interactive virtual environment (Sun, 2023). The rationale for utilizing Tinkercad in the study is that it is both free of charge and suitable for the initial stages of design. Thanks to the simple interface of the program, people of different age groups can design the shapes they target with the commands of select, drag, adjust the angle, and group the shapes. For this reason, the objective of the study was to ascertain the perspectives of prospective mathematics teachers on the utilization of the Tinkercad program.

Method

This section of the study outlines the design of the research, the composition of the study group, the research process, the data instruments, data analysis, validity, and reliability.

Research Design

The study employed a holistic single case study design, one of the qualitative research methods. A case study is an in-depth examination of how the factors related to the situation affect and are affected by this situation (Yıldırım & Şimşek, 2021).

Study Group

The study was conducted with 18 prospective mathematics teachers in their fourth year at a state university located on the western coast of Turkey. The participants were selected using a convenience sampling method. The names of the participants were coded as P1, P2, P3, ...P18 in order to keep their names confidential.

Research Process

Prior to soliciting the opinions of prospective teachers regarding the utilization of the Tinkercad program, two instructional hours were dedicated to training in the computer laboratory. In this training session, prospective teachers were provided with an overview of the Tinkercad interface. The initial information provided was on the process of becoming a member of the program and logging in. Once all prospective teachers had logged in, they were presented with the option of creating a class when logging in as a teacher. This option allows users to design three-dimensional objects, incorporating circuits and code blocks. Additionally, it provides guidance for those new to Tinkercad, showcasing the basic steps required to create designs. Furthermore, it displays examples of designs created by other users, as well as the challenges encountered when using the program. Furthermore, the lesson plans available in Tinkercad were discussed in detail. Subsequently, the prospective teachers were furnished with information regarding the design processes required to create three-dimensional designs. The prospective teachers were provided with information regarding the use of viewing angles of the working screen, the use of copy-paste-delete options, magnification, reduction, and backspace options, the view of the working plane from different perspectives, grouping, and ungrouping, rotation and alignment options, import and export options, working with collaboration, and printing options with the use of a three-dimensional printer. Furthermore, the prospective teachers were informed in detail about the various options for creating works on the work plane, including the use of shapes on the three-dimensional work plane, code blocks, Sim Lab, and bricks. Once the prospective teachers had been informed about how to use the program, the researchers proceeded to design the cup in stages with their assistance, utilizing the Tinkercad and a projector. For each step, the prospective teachers attempted to design with the researchers. The researchers proceeded to walk around the laboratory and complete the design, offering guidance to the prospective teachers who had encountered difficulties in making the design. Once the prospective teachers had acquired sufficient knowledge about cup design and Tinkercad, they were asked to create a sample study. The sample study was required to be designed based on the curriculum's achievements. Once the sample studies had been completed, the prospective teachers were invited to provide their opinions on the form provided.

Data Instrument

The questionnaire form prepared by the researchers was used to collect data in the study. Initially, a draft form with 6 questions was prepared, which was finalized as 5 questions in accordance with expert opinion.

The data for the study were collected during the 2023-2024 academic year at the university where the participants were enrolled. Prior to gathering their opinions, participants were informed about the purpose and content of the research. They were also briefed on the reliability and confidentiality of the study.

Data Analysis

The data collected in the study were analyzed using content analysis, which involves an in-depth examination to reveal implicit themes and dimensions (Yıldırım & Şimşek, 2021). The current study identified common or similar themes among participants, and the frequencies (f) of the themes were accompanied by direct quotations from the prospective teachers' opinions.

Validity and Reliability

In order to ensure the validity and reliability of the study, the 5-question questionnaire form was finalized by obtaining the necessary expert opinion for the questions in the 6-question questionnaire form administered to the prospective teachers at the end of the research process in order to increase credibility. In order to ensure transferability, the answers given directly by the prospective teachers to the questions on the questionnaire form were included without any changes. Inter-coder reliability was calculated using the Miles and Huberman (1994) reliability coefficient. The calculated reliability coefficient was 0.82.

Results

In this section, the results were interpreted under five themes: the applicability of the program, the positive aspects, the negative aspects, the difficulties encountered during the use of the Tinkercad, and the utilization of the Tinkercad in a professional context.

The Applicability of the Program

The views of prospective teachers on the applicability of the program are given in Table 1.

Table 1

The Views on the Applicability of the Program

Themes	Codes	Prospective Teacher
Applicability (f=21)	Applicable	P2, P5, P8, P9, P10, P11, P12, P13, P14, P16, P17, P18
	Not applicable to every subject	P6, P7, P15
	Low applicability	P3, P4
	At the right time and place	P1
	Ease of use	P2
	Difficulty of use	P3
	The program is complicated	P17
Time (f=1)	Saves time	P1
Mathematics subjects (f=30)	Solid objects	P1, P2, P5, P7, P11, P12, P13, P16, P17
	Geometric figures	P3, P6, P8, P9, P14, P15, P18
	The appearance of three-dimensional objects	P3, P10, P17
	Analytic geometry	P1, P14
	Parabola	P9, P13
	Transformation geometry	P1, P4
	Trigonometry	P9
	Conics	P9
	Probability	P15
	Graphs of functions	P13
	Statistics	P15
Perception (f=10)	Abstract thinking	P6, P10
	Effective and enjoyable learning	P15, P17
	Facilitating concretization	P7, P9
	Instruction integrated with technology	P14
	Ease of conceptualization	P11
	A better grasp of the subjects	P8
	Sustainable learning	P1

As seen in Table 1, the responses of the prospective teachers regarding the applicability of the curriculum show that the participants mostly perceived the curriculum as applicable or not applicable to every subject. Only one prospective teacher emphasized the suitability of the program in terms of time. Under the mathematics topics theme of the program, it was generally stated that they were able to use solid objects and then geometric shapes. Under the theme of perception, it was stated that the program provided abstract thinking, effective and fun learning, and concretization.

P8 coded prospective teachers made the following explanation about the applicability of the program.

P8: This program can be applied in lessons. I think students can comprehend the subjects better with this program, especially when geometry is being taught.

When the theme of mathematics subjects of the program is examined, it is mostly stated that it can be applied to solids and geometric shapes. For this reason, the opinions of P7 on the subject of solids are given below.

P7: I think it can be useful in subjects that need concretization, especially in the explanation of solid objects.

The opinions of P6 for abstract thinking perception, P15 for effective and fun learning perception are given below.

P6: I do not think that Tinkercad can be suitable for every subject, but it can be important for students to think abstractly. It can be very useful in the field of geometry since it will be constantly interested in geometric shapes and the lengths of these shapes.

P15: It is suitable for use in the fields of Probability-Statistics-Geometry. It will make learning more effective and fun under adequate conditions.

The Positive Aspects of Tinkercad

The views of prospective teachers on the positive aspects of the Tinkercad program are given in Table 2.

Table 2

The Views on the Positive Aspects of the Program

Themes	Codes	Prospective Teacher
Function (f=14)	Understandable, clear, and diverse	P2, P4
	Ease of use	P2, P4
	Providing effective use of technology	P9, P14
	Interesting interface	P4, P10
	Use of three-dimensional printers	P12, P15
	Presence of studies from different courses	P5
	Variety of three-dimensional shapes	P5
	Supports imagination	P6
	Saving time and paper waste	P9
Perception (f=17)	The lesson is attention-grabbing and interesting	P1, P7, P11, P13, P16, P17, P18
	Enables concretization	P1, P7, P8, P18
	Provides effective and fun learning of the lesson	P14, P15
	Making learning sustainable	P17
	Facilitating learning	P18
	Enable multiple learning	P1
	Ensuring comprehension of the subject	P9
Usability (f=10)	Easy thinking and quick competence of three-dimensional objects	P6, P10, P11, P12, P13
	Enabling to see three-dimensional shapes	P3, P8, P16
	Using mathematics and geometry lessons with technology	P3
	Ability to create original designs	P5

As can be seen in Table 2, when the answers from the prospective teachers about the positive aspects of the program were coded, the function theme was mostly clear, clear diverse, easy to use, enabling effective use of technology, interesting interface, and the use of three-dimensional printers. In terms of the perception theme, it is thought that it provides the lesson to be attentive and interesting. When the theme of usability is examined, it is stated that it provides easy thinking and fast competence for three-dimensional objects.

The opinions related to P4 prospective teachers having an understandable, clear varied, easy to use, and interesting interface are given below.

P4: It is easy to use, that is, the commands used when creating a shape are open, clear, and simple. It has variety, and the interface is interesting. It can have many good aspects. I say that being easy to use is one of the good aspects.

The opinions of the prospective teachers coded P1 for the perception that the lesson is attentive and interesting and includes concretization. P14 for the perception that the lesson provides effective and fun learning.

P1: It attracts attention and interest. It helps to concretize. It is easy to use with the right guidance. Multiple learning can be realized at the same time.

P14: It helps students to use technology effectively. It increases interest in the lesson.

For this reason, the opinions of P6 for easy thinking and rapid competence of three-dimensional objects, P3 for enabling to see three-dimensional shapes, and for using mathematics and geometry lessons with technology are given below.

P6: It supports imagination and the student's ability to think in three dimensions.

P3: It allows students to easily see the appearance of objects from different directions. It enables geometry lessons to be learned in a digital environment.

The Negative Aspects of Tinkercad

The views of prospective teachers on the negative aspects of the Tinkercad program are given in Table 3.

Table 3

The Views on the Negative Aspects of the Program

Themes	Codes	Prospective Teacher
	Absence of negative aspects	P4, P7, P8
Function (f=9)	Difficult to use keys or mouse	P3, P5
	The program is in English	P1
	Connected to internet access	P2
	Difficult to create desired shapes	P13
	The program is complicated and long to get used to	P17

Time (f=5)	Time-consuming	P5, P11, P12, P16, P17
	Complicated or difficult to use	P9, P10, P11, P18
	The absence of adequate and appropriate conditions reduces the applicability	P14, P15
Usability (f=13)	Different levels of teaching	P6, P18
	Difficult to learn	P3
	Difficult to use without training	P5
	Difficult to apply to every subject for the lesson	P6
	Causing loss of classroom control	P10
	Difficulties during the construction phase reduce interest in the course	P14

As seen in Table 3, when the answers from the prospective teachers about the negative aspects of the program were coded, it was stated that there was mostly no negative aspect in the function theme, and then it was stated that the keys and the mouse were difficult to use. In terms of time, it is thought to be time-consuming under one code. In terms of usability, there are codes that it is mostly complicated and difficult to use, and the lack of adequate and appropriate conditions reduces the applicability and different levels of teaching.

The opinions of P8 about the lack of negative aspects, P3 about the difficulty of using the keys and mouse are given below.

P8: I didn't notice any negative aspects.

P3: It looks like a difficult software to learn. Some buttons aren't easy to use.

Considering the time theme of the program, it was stated that the program was time-consuming under a single code. Therefore, the opinions of P5 prospective teacher are given below.

P5: There may be different alternatives instead of the mouse when looking at the shape from different angles. Thus, it can be easier to use. For the program, especially if it is to be used in the lesson, students may need to be trained first, which is a disadvantage in terms of time.

Therefore, the opinions of the prospective teacher coded P18 that the program is complex and difficult to use, and it is difficult to apply the program to every subject for the course, the prospective teacher coded P14 that the lack of sufficient and appropriate conditions reduces the applicability are given below.

P18: It can be a little easier to use. It can have a different mode for primary school students.

P14: Not every school or student may have computer equipment. It may alienate students who have difficulty in the construction phase.

The Difficulties Encountered During the Use of the Program

The views of prospective teachers on the difficulties encountered during the use of the program are given in Table 4.

Table 4

The Views on the Difficulties Encountered During the Use of the Program

Themes	Codes	Prospective Teacher
Function (f=13)	No difficulties	P4, P14, P15
	Difficulty using shapes or arrows	P3, P13
	Difficulty in grouping or alignment	P17, P18
	Difficulty using a mouse	P5, P13
	Difficulty registering	P1
	Difficulty making reductions and enlargements	P2
	Difficulty in cutting shapes	P8
	Difficulty adjusting the length of shapes	P12
Usability (f=8)	Difficulty in following the steps in activity implementation	P3, P9, P13
	Difficulty in the learning phase of the application	P6, P10, P16
	Difficulty in the early learning phase	P7, P11

As can be seen in Table 4, when the answers from the prospective teachers regarding the difficulties experienced in the use phase of the program were coded, it was stated that there were mostly difficulties in the function theme, in the use of shapes and arrows, in grouping and alignment, and difficulty in using the mouse. In terms of usability, it is thought that there are mostly difficulties in following the stages of activity implementation and difficulties in the learning stage of the application. For this reason, prospective teacher P14 had no difficulty, prospective teacher P13 had difficulty in using shapes or arrows, and had difficulty in using the mouse, and in addition to these codes are given below.

P14: Although it was an application I used for the first time, I didn't have any difficulties thanks to the guidance of our teacher.

P13: I had difficulty in creating the shapes because I used them for the first time. While following the steps and moving the mouse.

According to the theme of usability of the program, the opinions of P3 coded prospective teacher about having difficulty following the stages in the activity implementation, and P10 coded prospective teacher about having difficulty in the learning phase of the implementation are given below.

P3: I had difficulty in following the steps. I don't think that the shape to be chosen and the direction of the arrows are correct in cup making.

P10: I had difficulty in making a few moves during the application because it was the first time I realized the application.

5. The Utilization of the Tinkercad in a Professional Context

The views of prospective teachers on the utilization of the Tinkercad in a professional context program are given in Table 5.

Table 5

The Views on the Utilization of the Tinkercad in a Professional Context

Themes	Codes	Prospective Teacher
Positive (f=18)	I use	P1, P2, P4, P8, P10, P13, P14, P16, P18
	I use it for some subjects	P5, P6, P7, P9, P12, P17
	I use it when there is a suitable environment	P3, P15
	I use the program when I reach a sufficient level of its use	P11

As can be seen in Table 5, when the answers from the prospective teachers regarding the utilization of the Tinkercad in a professional context were coded, it was stated that the positive theme was mostly in the opinions of I will use it and I will use it in some subjects. For this reason, the opinions of P1, and P18 for the code "I will use it", P5 for the code "I will use it in some subjects" are given below.

P1: Yes. I want to prove to my students that I am an innovative teacher. Since it is easy and fun to use, I comply with the principle of economy by saving time and realizing efficient learning.

P18: I think it can be used not only in the profession but also in many other fields. It can make life easier.

P5: I would consider using the program in my future professional life in geometry in subjects that students have difficulty in thinking. At the same time, I think it will be useful when solving real-life problems.

Discussion

This study was conducted to examine the views of prospective mathematics teachers on the use of Tinkercad, and the results of the study were collected under 5 themes: applicability of the program, the positive aspects, the negative aspects, difficulties encountered during the use of Tinkercadand the utilization of Tinkercad in a professional context. The opinions of the prospective teachers regarding the applicability of Tinkercad are that it is applicable to mathematics subjects, especially solids and geometric objects, and that it provides abstract thinking, and effective and fun learning within the perception theme. Similarly; in Taştı et al. (2015) study, under the activity/efficiency theme, most prospective teachers think that the program concretizes abstract concepts. In the participants' opinions on the positive aspects of the use of Tinkercad; it is thought that it is understandable, clear and diverse, easy to use and its interface is interesting, and in the perception theme, it is thought that it provides the lesson to be attention and interesting and to concretize it. In the usability theme, they think that it provides easy thinking and fast competence in three-dimensional objects. In the study of Doğan and Uluay (2020), most of the prospective teachers were of the opinion that the program provided convenience and was fun.

In the opinions on the negative aspects of the use of Tinkercad; while they mentioned that there is no negative aspect in the function theme, the difficulties of using the keys or the mouse, most prospective teachers also think that the use of the program is time-consuming. In Taştı et al. (2015) study, prospective teachers had the opinion that time was sufficient for the applicability of the program, while in Karaismailoğlu (2022) study, it can be said that the opinions of prospective teachers support the study with the program being time-consuming. Regarding the usability theme, prospective mathematics teachers generally think that it is complicated or difficult.

As for the difficulties experienced during the use of Tinkercad, it was revealed that there were no difficulties with the function theme, but there were difficulties in the use of shapes and arrows. In the usability theme, it was stated that they had difficulties in following the stages for the activity and in the learning stages.

For the utilization of Tinkercad in a professional context, it was stated that they would mostly use it or that they would use it for some subjects. The prospective teachers think that the subject they will use is generally in the field of geometry because it will be beneficial in concretizing abstract thinking.

Recommendations

In addition, 3D printers are available in most public schools today. For this reason, in order to use 3D printers, teachers should include the use of 3D technology design programs more in their lessons. The results can be evaluated with different studies by conducting a longer study. By using different 3D technology design programs in the course, the opinions of the candidates on this subject can be examined. A different study can be carried out with mathematics teachers by organizing training on 3D technology design programs for teachers affiliated with the Ministry of National Education. Since Tinkercad allows interdisciplinary studies, studies can be

carried out with prospective teachers at different undergraduate programs.

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