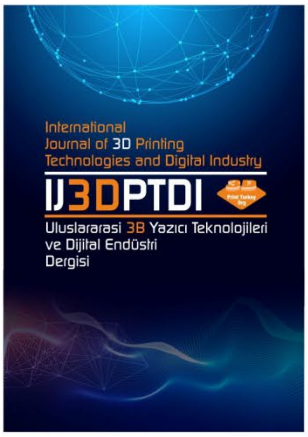

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INTERNATIONAL JOURNAL OF 3D PRINTING
TECHNOLOGIES AND DIGITAL INDUSTRY

ISSN:2602-3350 (Online)

URL: https://dergipark.org.tr/ij3dptdi

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Bu makaleye şu şekilde atıfta bulunabilirsiniz (To cite to this article): *Aslan A., "Integrating 3D Printing in Pre-School Education: Perceptions From Pre-School Teachers and Prospective Teachers" Int. J. of 3D Printing Tech. Dig. Ind., 7(3): 428-440, (2023).*

DOI: 10.46519/ij3dptdi.1331481

Araştırma Makale/ Research Article

Erişim Linki: (To link to this article): https://dergipark.org.tr/en/pub/ij3dptdi/archive

INTEGRATING 3D PRINTING IN PRE-SCHOOL EDUCATION: PERCEPTIONS FROM PRE-SCHOOL TEACHERS AND PROSPECTIVE TEACHERS

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(**Received:** 22.07.23; **Revised:** 04.10.23; **Accepted:** 01.11.23)

ABSTRACT

With the rapid advancements in technology, various educational technologies have been employed to facilitate the teaching process in the education system. One of the popular technologies is 3D printing, which finds applications from early childhood education to higher levels of instruction. This study aims to determine the perspectives of pre-school teachers and prospective teachers regarding the use of 3D printing technology in early childhood education. The study group consisted of 15 pre-school teachers and 17 prospective teachers. The research method employed was the case study approach. An online survey form with appropriate open-ended questions was utilized as the data collection tool. Data obtained from the study were analyzed through content analysis. The results revealed that pre-school teachers and prospective teachers have a superficial knowledge of 3D printing technology. Although the materials required for teaching varied based on the needs of children and teachers, certain common skills were emphasized in the instructional process. Some difficulties were encountered in acquiring these materials, which could be overcome by utilizing 3D printing technology. Furthermore, teachers and prospective teachers showed preferences for different features in the design of materials. In future studies, it is recommended to identify materials that captivate children's interests based on the perspectives of teachers and candidates. Providing necessary academic support to participants for material production and conducting similar studies in various disciplines are also suggested.

Keywords: 3D printing technology, 3D model, Pre-school Education, Pre-school Teacher, Prospective Teacher.

1. INTRODUCTION

Once deemed extravagant, technology has increasingly become prevalent in early childhood and primary education. Various technologies such as learning platforms (Learning Management Systems, Massive Open Online Courses, etc.) interactive videos, complex games, innovative tools, and electronic presentation devices are now integrated into classroom learning [1-2]. One of the latest technologies to enter the realm of education is three-dimensional (3D) printing technology [3].

3D Printing, a means of transforming imagination into physical objects, has become more accessible with the widespread availability of printing software [4-5]. It has attracted increasing interest in the education sector, including schools, libraries, and "maker spaces", as a technology with numerous applications for children [6-8]. As a tool, 3D printing serves the utilitarian needs of children, supports social interaction, and allows for quick interventions in their daily lives [6].

To fully harness the potential of 3D printing technology, previous research has emphasized its integration with content and classroom routines, alignment with developmentally appropriate practices, and provision of opportunities for play in early childhood and primary education [9-11]. As an exemplary technology for young children, 3D printing can fill a unique void in educational settings. While its most apparent impact lies in fields like manufacturing and engineering, it also possesses the potential to transform conventional situations in science, medicine, and even the food industry [3]. Currently, the most common use of 3D printing involves the creation of prototypes or models, which may not be readily associated with early childhood education. However, there is an increasing body of research on children's learning through "tangible tools" [12-13]. Simple tasks like printing a model allow young children to engage in collaborative learning, problem-solving, logical, and sequential thinking, and interactions with technology through simplified interfaces.

By providing visual representations alongside concepts or skills, 3D printing technology enhances understanding and retention of knowledge [14-15]. Educational environments have been consistently equipped with contemporary technology to keep pace with rapid technological advancements. The evolution of education has seen a transition from blackboards to computers, tablet devices, smart boards, and mobile devices [16]. Considering 3D printing technology within this category, teachers should incorporate 21st-century teaching methods and techniques that are student-centered and technology-integrated to facilitate students' critical thinking, problem-solving, and active engagement in the learning process [2]. The use of 3D printing technology in the field of education has garnered interesting examples in developed countries. In Singapore, 3D printing technology is used as part of the education curriculum starting from primary school levels. Workshops and projects involving 3D printing are organized to impart design and engineering skills to students. In the United Kingdom, 3D printing technology is used as a part of design and engineering courses. Students have the opportunity to design their own projects, create prototypes, and explore the real-world applications of 3D printing. In our country, it is emphasized that within the framework of the 2023 Education Vision of the Ministry of National Education, the development of students' design skills with the innovative technology of 3D printing is important.

In conclusion, technology integration in education plays a vital role in preparing students for the demands of the modern workforce. Teachers can attract students' interest, enhance their understanding of complex concepts, and foster critical thinking skills by combining various technologies, including 3D printers and design software. It is crucial for educators to embrace 21st-century teaching methods and create technology-rich classrooms that empower students to learn technology as a tool for their learning and future success [1,17]. In early childhood education, there can be challenges in capturing children's attention and effectively conveying educational materials. To overcome these challenges, educational play tools should be designed to be relevant to scientific developments and compatible with the curriculum. Moreover, educational tools, especially those developed as teaching aids, serve as valuable resources for learning and contribute to the holistic development of children's abilities in various aspects.

Previous relevant studies suggest that 3D solid models can be effectively utilized in early childhood education. Martínez et al. [18] argue that guided interaction with 3D applications improves learning outcomes in pre-school children. Studies demonstrate that 3D solid models can be employed to enhance learning outcomes in early childhood education. Avanzini [19] proposes the use of 3D printing in early music education to create guided experiences and alternative musical notation forms. Baykara [20] has implemented an augmented reality-based mobile learning system in early childhood education, visualizing animals, and plants in 3D to expedite the learning process and evaluated its effectiveness.

While sight, hearing, and smell gather information from a distance, touch (and taste) involve direct contact between the body and other beings, objects, or substances. In early childhood, 3D materials can help children enhance their abstract thinking abilities. These materials contribute to a better understanding of abstract concepts through visual and tactile experiences and the development of relational thinking skills [21]. Especially problem-solving and critical thinking skills are highly important in today's complex world. Pre-school teachers and prospective teachers employ various methods and pedagogical approaches to enhance these skills. For example, game-based learning activities can assist children in improving their problem-solving abilities.

Based on the significance of utilizing 3D printing technology in education and the importance of identifying the awareness and perspectives of teachers and prospective teachers, this study aims to determine the views of pre-school teachers and prospective teachers on 3D printing technology, its use in pre-school education, their experiences with 3D printing, and their opinions on the need for 3D materials in the teaching process.

In pursuit of this goal, the following sub-problems were addressed:

- What are the views of pre-school teachers and prospective teachers on 3D printing technology?
- What are the experiences of pre-school teachers and prospective teachers with 3D printing?
- What are the views of pre-school teachers and prospective teachers on the necessity of using 3D materials in pre-school education?
- What are the opinions of pre-school teachers and prospective teachers regarding the characteristics of 3D materials required in the teaching process?

2. METHOD

2.1. Research Design

In this study, a qualitative research approach using the case study method was employed. The case study method facilitates an in-depth exploration of a specific phenomenon, event, or subject within its natural context, making it particularly suitable for investigating complex and context-dependent topics [22]. Researchers can use this method to obtain in-depth knowledge and place this information within a broader context. Given the focus on the perspectives and experiences of pre-school teachers and prospective teachers concerning 3D printing technology and 3D materials in early childhood education, the case study method was considered the most appropriate research design.

2.2. Participants

The study group consisted of 32 participants, comprising 15 pre-school teachers working in pre-schools located in the city center and districts of Trabzon province, and 17 3rd and 4th-year pre-school prospective teachers enrolled in the Early Childhood Education program at Fatih Faculty of Education, Trabzon University. The participants were purposefully selected using purposive sampling, which allows for an in-depth investigation of situations with rich information. Including 3rd and 4th-year prospective teachers is beneficial, as they have taken courses related to early childhood education, such as "Development in Early Childhood Period," "Science Education in Early Childhood," "Mathematics Education in Early Childhood," and "Pre-school Education Programs." No specific criteria, other than being graduates of early childhood education programs, were set for the participation of pre-school teachers. All participants volunteered to take part in the study.

2.3. Data Collection Instrument

The data was collected using a researcher-developed questionnaire as the data collection instrument. The construction of the questionnaire considered the perspectives and experiences of pre-school teachers and prospective teachers regarding 3D printing technology, their usage experiences, the utilization of this technology in pre-school education, and its potential impacts. The online questionnaire consisted of eight open-ended questions and was shared with the participants through a communication platform. Participants were given approximately one month to complete the questionnaire.

2.4. Data Analysis

For data analysis, content analysis was utilized as it is a valuable method to obtain information describing situations or problems [23]. Content analysis involves organizing similar data under different concepts and themes, providing a clear structure, and presenting participants' thoughts and views through direct quotations [24].

The data obtained from this study were coded and analyzed by the researcher according to the sub-objectives of the research using content analysis. A deductive approach was employed to create primary codes, which were then combined under coherent themes. To enhance data reliability, direct quotations from participants were included in the findings. Pre-school prospective teachers were coded as PT1, PT2, ..., PT17, while pre-school teachers were coded as T1, T2, ..., T15.

3. FINDINGS

In this section, the findings obtained from the responses of pre-school teachers and prospective teachers to the online questionnaire are presented.

In the survey used within the scope of the study, the first question directed to the teachers and prospective teachers was about what they knew about 3D printing technology. In response to this question, 43.75% of the participants stated, "I do not have any knowledge," while 56.25% indicated that they were knowledgeable about the technology. The table below presents the themes and codes derived from the responses of the teachers and prospective teachers.

Table 1. Participants' views on 3D printing technology

Theme	Code	f_T
Having knowledge	Practical object production	10
	Being a technological tool	6
	Adding visual elements	2
Having no knowledge	-	14

According to Table 1, 3D printing technology is mostly described by most of the participants (10 individuals) as a practical way to produce objects. 6 participants characterized 3D printing technology as a technology that facilitates life. Participants with codes PT16 and T14 mentioned that this technology adds visual elements to two-dimensional images. The following are some exemplary quotes from the responses:

"I can produce the three-dimensional versions of images." (T10) "It is a technology that enables the production and presentation of products designed in three dimensions." (PT5) "It is incredibly enjoyable because it allows children to turn their drawings into three-dimensional forms." (T14)

The second question in the survey, directed to the participants, was whether they had obtained outputs from a 3D printer before. Only one teacher with code T14 and one prospective teacher with code PT16 responded "Yes" to this question. While the teacher with code T14 associated the 3D printing experience with a model produced for promotional purposes at a conference, the prospective teacher with code PT16 stated that she obtained 3D prints during the Forest Week activities. The following are some exemplary quotes from the responses:
"For the Forest Week activities." (PT16) "It was an event organized at a conference for promotional purposes." (T14)

Another question in the survey aimed to gather the participants' views on the necessity of using 3D models in the pre-school education process. The themes and codes derived from the responses of prospective teachers and teachers to this question are presented in the table below.

Table 2. Necessity of using 3D models in the pre-school education process

Theme	Code	f_T
Use of 3D models	Concretizing abstract concepts	12
Insufficient response	Gaining experiences	5
	Making knowledge permanent	3
	Producing objects	2
	Developing creativity skills	2
	Becoming technologically literate	1
	-	7

According to Table 2, the prospective teachers and teachers attempted to explain the necessity of using 3D models in the teaching process from different perspectives. The most prominent view among the responses was that 3D models are highly effective in concretizing abstract concepts. Additionally, opinions highlighted that 3D models can provide students with different experiences, make learned information permanent, allow to produce objects according to needs, enhance the imaginative abilities of pre-school children, and help individuals become technologically literate. The following are some exemplary quotes from the responses:

"Children cannot think abstractly at this stage, so concrete modeling can be advantageous." (PT9) "I believe it can be beneficial for creating awareness, curiosity, interest, and conducting research." (T4) "Children who learn through concrete experiences will have more lasting knowledge through models." (PT9) "It is a field that stands out with creativity, and it would be very useful for us. Personally, I would like to use it in my classroom." (PT4) "In the technological age, I believe that various technological products should be used in children's development and education." (PT14).

The participants were asked about the materials their pre-school children needed during the teaching process within the scope of teaching activities/teacher practice. The themes and codes derived from the responses of the teachers and prospective teachers to this question are presented in the table below.

Table 3. Material/s needed by pre-school children during the teaching process

Theme	Code	f_T
Educational materials	Wooden blocks	6
	Educational toys	5
	Legos	4
	Science materials	1
Visual materials	Figures	4
	Models	1
Printed materials	Books	2
	Story cards	1
Stationery materials	Crayons	3
	Paper	2
	Scissors	1
	Glue	1
Other materials	Creativity-enhancing materials	6
	Real materials	6
	Recycled materials	2
Irrelevant response	-	2

According to Table 3, 9 prospective teachers and 5 teachers stated that the most needed materials in the pre-school education process are toys (educational toys, wooden blocks, Legos, puzzles, dollhouse toys, and attachable-detachable toys). Teachers with codes T6, T7, and T12 and prospective teacher with code PT6 expressed that children mainly need real objects in the teaching process. Animal figures were mentioned by both prospective teachers and teachers as materials that children needed. One prospective teacher with code PT9 and one teacher with code T2 responded with science center-related materials. One prospective teacher with code PT1 and one teacher with code T11 mentioned crayons and paper as necessary materials. Apart from these responses, 4 prospective teachers (PT3, PT4, PT5, PT8) and two teachers (T8, T14) stated that children need any material that enhances their creativity without any material restrictions. One prospective teacher with code PT2 and one teacher with code T2 provided irrelevant responses. The following are some exemplary quotes from the responses: "Educational materials, blocks, building materials." (PT10) "Scissors, paint, wooden toys or Legos, animal figures, etc." (T10) "To instill a love of reading in children, books are very necessary." (PT14) "Paints, colored pencils, and recycled materials." (T13) "Real materials, I am in favor of children experiencing in environments where they can reach reality as much as possible." (T7).

In the study, teachers and prospective teachers were asked about the materials they needed for instructional activities/teaching practices. The responses to this question were presented in Table 4, along with the corresponding themes and codes.

Table 4. Materials needed for teaching activities and teaching practices

Theme	Code	f_T
Educational materials	Models of numbers and letters	4
	Games with educational purposes	3
	Legos and building materials	2
	Science materials	1
Visual materials	Figures	3
	Models	1
Printed materials	Books	1
	Story cards	1
Stationery materials	Crayons	7
	Paper	4
	Scissors	2
	Glue	2
Other materials	Creativity-enhancing materials	1
	Real materials	3
	Recycled materials	2
Irrelevant response	-	2

According to Table 4, it can be observed that teachers and prospective teachers require various materials during the instructional process/teaching practices. The most needed materials by teachers and prospective teachers are activity cards, colored papers, cardboards, science education materials, game materials, and some technological devices. Two teachers (T2 and T6) mentioned that the materials needed vary depending on the type of activity. Some examples of responses to this question are presented below:

"Materials related to the life cycles of living beings." (T15) "Social life skills toys that can be diversified according to the age level, experiment materials that can support development areas by discovering through doing." (T4) "Cardboards, glue, printer, and laminator." (PT13) "I prefer recyclable and flexible materials." (PT5) "It varies depending on the activity; we need everything in pre-school." (T6)

The participants, including eight prospective teachers (PT1, PT3, PT5, PT7, PT8, PT9, PT11, and PT16), and four teachers (T2, T4, T7, and T13), responded with "No" to the question of whether they face difficulties in obtaining the materials required for teaching/teaching practices. The remaining teachers (n=11) and prospective teachers (n=8) stated that they face challenges in acquiring these materials.

Table 5. Difficulties encountered in obtaining materials

Theme	Code	f_T
Experiencing Difficulties	Financial Difficulties	13
	Lack of Suitable Materials	3
	Malfunction of Technological Devices	3
No Difficulties		12
Irrelevant Response		

Table 5 summarizes the difficulties encountered in obtaining materials. Among the prospective teachers, five participants (PT2, PT4, PT6, PT14, PT15) mentioned their limited financial means as they are still students, and eight teachers (T1, T3, T5, T6, T9, T11, T14, T15) mentioned the insufficient financial resources of the school as the reason for difficulties in obtaining materials. Two teachers (T10, T12) and one prospective teacher (PT13) experienced difficulties due to the lack of technological devices or technical issues in the school. Two prospective teachers (PT10, PT17) expressed difficulties in finding original models for the activities they wanted to implement, and one teacher (T8) mentioned the possibility of conceptual confusion among students if the sizes of their animal figures are the same. Some examples of responses to this question are as follows:
"I face difficulties due to the high cost of the models I need." (T15) "Sometimes it's not easy to find the desired models." (PT17) "We have difficulties in finding printers and laminators." (PT13).

The question posed to the teachers and prospective teachers through the survey form was as follows: "If you were asked to design and produce 3D models that you would use or need to implement the teaching process/teaching practice, which developmental area(s) would they be related to? (self-care, language development, cognitive development, social and emotional development, motor development)". The themes and codes generated from the responses to this question are summarized in Table 6.

Table 6. Developmental areas associated with 3D models

Theme	Code	f_T
Developmental Areas	Cognitive Development	16
	Language Development	12
	All Developmental Areas	9
	Motor Development	6
	Social and Emotional Development	4

According to Table 6, both teachers and prospective teachers expressed their intention to design 3D models considering all developmental areas. These developmental areas were sometimes mentioned individually, sometimes in combination (two developmental areas together), and sometimes all developmental areas were mentioned together. Cognitive development was the most frequently mentioned developmental area by both teachers and prospective teachers. Some example quotes from the participants regarding the developmental areas associated with 3D models are provided: "Language, cognitive." (T9) "Cognitive, psychomotor, language development." (T7) "It could be a material that covers all of them." (PT16)

The participants in the study, including both teachers and prospective teachers, were asked to express their opinions on the physical and design features of 3D model designs if they were to experience a 3D model design and production process. The following statements were given to them, and they were asked to choose the appropriate or applicable responses:
• I would prefer my 3D model to have a flexible structure, like a bouncing ball, because...
• I would prefer my 3D model to have a rigid structure, like LEGO, because...
• I would prefer my 3D model to consist of a single piece because...
• I would prefer my 3D model to consist of several pieces because...
• I would prefer my 3D model to be in a single color because...
• I would prefer my 3D model to be in several different colors because...
Regarding the statement "I would prefer my 3D model to have a flexible structure, like a bouncing ball, because...", 12 teachers and 6 prospective teachers responded. Table 7 presents the themes and codes generated from the responses to this statement.

Table 7. Views on 3D Model's Flexible Structure

Theme	Code	f_T
Flexibility	Long-lasting	5
	Attractive	5
	More suitable for the age group/Safety	3
	Easy to play	2
	Supports development/Functional	2
	Easy to design	2

According to Table 7, the participants who responded to this statement indicated that they would prefer their 3D model to have a flexible structure due to reasons such as longer durability and greater appeal to children. Additionally, they mentioned that flexibility in the model would make it more suitable for the age group, safer, easier to play with, and supportive of children's development. Some participants also highlighted that a flexible structure would make the model easier to design. Examples of responses include:

"It wouldn't get damaged in case of falling or impact." (PT1) "Flexible materials attract children's attention." (T7) "To prevent harm to children and ensure it's easier to use." (T5) "So that children can play with it comfortably." (PT14) "It involves attention, speed, and the use of gross motor skills." (T16) "I would prefer this to make the design process easier." (PT13)

Regarding the statement "I would prefer my 3D model to have a rigid structure, like LEGO, because...", 7 teachers and 9 prospective teachers responded. Table 8 presents the themes and codes generated from the responses to this statement.

Table 8. Views on 3D Model's Rigid Structure

Theme	Code	f_T
Rigidity	Durability	11
	Easier to use	5
	Close to reality	2

According to Table 8, the participants who responded to this statement indicated that they would prefer their 3D model to have a rigid structure because it would be more durable. Additionally, they mentioned that a rigid structure would make the model easier to use and bring it closer to reality. Examples of responses include:
"I would prefer this for the sake of durability and longevity." (PT15) "It should be easy to hold." (T5) "It should resemble the real thing." (T10)

Regarding the statement "I would prefer my 3D model to consist of a single piece because...", 7 teachers and 7 prospective teachers responded. Table 9 presents the themes and codes generated from the responses to this statement.

Table 9. Views on 3D Model's Single Piece Structure

Theme	Code	f_T
Single Piece Structure	Ease of use	10
	Clarity	2
	Time-saving	1
	Determining creativity	1

According to Table 9, the participants who responded to this statement indicated that they would prefer their 3D model to consist of a single piece due to reasons such as ease of use and less likelihood of losing pieces. They also mentioned that a single-piece structure would make the model more understandable, save time during production, and help determine children's creativity. Examples of responses include: "Preventing the loss of pieces, it should be in one piece." (PT10) "It should be clear and understandable." (T4) "It would save time." (PT1) "To see what children can do with it." (T3)

Regarding the statement "I would prefer my 3D model to consist of several pieces because...", 11 teachers and 11 prospective teachers responded. Table 10 presents the themes and codes generated from the responses to this statement.

Table 10. Views on 3D Model's Multiple Pieces Structure

Theme	Code	f_T
Consisting of multiple parts	Presenting different designs	8
	Supporting children's cognitive development	6
	Ease of use and design	4
	Creating a whole from parts	3
	Supporting the discovery process	3

Table 10 shows that the primary reasons for wanting the 3D model to consist of multiple parts are to present different designs and support children's cognitive development. Additionally, participants mentioned that the model's ease of use and design, creating a whole from parts, and supporting the discovery process are important factors. Some sample quotes from the responses are as follows:
"Playful parts would provide ease in creating different designs." (T15) "I would like it to develop children's visual intelligence." (PT2) "Replacing a missing part in any malfunction is easier than changing the whole model." (PT1) "For children to try to find the right solution on their own." (T10)

Six teachers and four prospective teachers responded to the statement "I would prefer my 3D model to be in a single color because...". The themes and codes generated from the responses to this statement are summarized in Table 11.

Table 11. Opinions on the 3D Model Being Monochromatic

Theme	Code	f_T
Being monochromatic	Not distracting attention	4
	Not straining the eyes	2
	Highlighting the concept	2
	Uniqueness of the model	2

Table 11 shows that the main reason for wanting the 3D model to be monochromatic is to avoid distracting children's attention. Apart from this reason, participants mentioned that the model should not strain the eyes, the focus should be on the concept rather than the color, and the model's uniqueness. Some sample quotes from the responses are as follows:
"To avoid distraction." (T12) "Color complexity may tire children's eyes." (PT14) "Because it will keep the achievement in front of the color and only in the area we want to achieve." (T8) "Because of its unique style and color." (T4)

Nine teachers and eleven prospective teachers responded to the statement "I would prefer my 3D model to be in several different colors because...". The themes and codes generated from the responses to this statement are presented in Table 12.

Table 12. Opinions on the 3D Model Consisting of Several Different Colors

Theme	Code	f_T
Consisting of several different colors	Attractive appearance	13
	Teaching colors	2
	Appealing to more children	2
	Detailed appearance	2
	Identifying children's emotions	1

Table 12 shows that the primary reason for wanting the 3D model to consist of several different colors is to have an attractive appearance. Two prospective teachers (PT2 and PT16) mentioned that a 3D model consisting of several different colors could help children learn colors. Additionally, participants mentioned that the model would appeal to more children, have a detailed appearance, and be used to identify children's emotions. Some sample quotes from the responses are as follows:
"For it to be eye-catching." (T7) "I would like children to recognize different colors." (PT2) "It

appeals to everyone." (T6) "To make the model detailed and visible." (PT15).

The final question directed to the participating teachers and prospective teachers was "Are there any other physical features that you think should be added to the material, apart from the characteristics mentioned in the previous questions?" Respondents with codes PT1, PT4, PT13, PT15, T6, T10, T12, T14, and T15 did not express any opinions other than the physical features mentioned in the design (color, flexibility, integrity, etc.). Prospective teacher PT8 evaluated the material based on its dimensions, while prospective teacher PT10 considered the material's weight, aesthetics, and cost. Prospective teacher PT16 focused on the material being visually appealing and contributing to cognitive development. Teacher T5 emphasized the importance of the 3D model being durable and practical, while teacher T8 highlighted the need for the model's color to be eye-catching. Some sample quotes from the responses are as follows:
"It should not take up much space, be light, look aesthetic, have low cost, but be of high quality." (PT10).
"Single bright color, with distinct angles." (T8).

4. CONCLUSION, DISCUSSION, AND RECOMMENDATIONS

In this study, the aim was to determine the opinions of teachers and prospective teachers regarding 3D printing technology and its relevance in early childhood education. The first question of the survey revealed that 43.75% of the participants stated they were not familiar with 3D printing technology, while the remaining 56.25% reported having knowledge about it. This finding suggests that 3D printing technology is not yet widely known. Considering the goals of the 2023 Education Vision and the objectives of the curriculum, teachers hold significant responsibilities in achieving these goals and managing the learning process. To attain these objectives and enrich the learning environment, it is expected that teachers integrate 3D printing technologies into the curriculum in alignment with the content and utilize instructional materials or models that cater to students' needs. Donohue and Schomberg [25] emphasized the need for prospective teachers to have learning opportunities with technology and practical experiences to gain expertise in using technology in early childhood classrooms.

Most participants defined 3D printing technology as a practical tool for object production, while some considered it as a facilitator in their daily lives. Conversely, a few participants described 3D printing technology as a means to add visual elements to two-dimensional images. These diverse definitions indicate that participants have varying perceptions of 3D printing technology.

The second question of the survey inquired whether the participants had previous experiences obtaining 3D prints. Only one teacher and one prospective teacher responded "Yes" to this question. One teacher associated the experience of obtaining a 3D model print with a promotional model production at a conference, while one prospective teacher mentioned obtaining a 3D print as part of Forest Week activities. These results suggest that most participants have not yet had any experience in obtaining 3D prints. Similar findings were reported by Aslan, Durukan, and Batman [26], who aimed to determine the needs of physics, chemistry, and biology teachers regarding the design of 3D solid models and their use in the teaching process. Their study revealed that 95% of the teachers had not used any models they developed with 3D printing in their classes, and 97% of them had no experience in designing 3D solid models. Only 6% of the teachers in their study reported using 3D printing for purposes such as producing teaching materials or competition materials. This study also indicates that both teachers and prospective teachers reported limited production experiences with 3D printing technology.

According to Table 2, teachers and prospective teachers highlighted various aspects of the importance of using 3D models in the teaching process. The most notable view was that using 3D models as concrete tools can enhance students' learning of concepts. Additionally, opinions emerged suggesting that 3D models can provide students with different experiences, enhance the permanence of learned knowledge, enable the production of objects tailored to students' needs, foster the imagination and creativity of pre-school children, and support individuals in becoming technologically literate. In a similar study by Karagöz and Şahin

Çakır [27], pre-service science teachers expressed reasons such as providing materials, visualizing abstract concepts, conducting experiments on difficult topics, and ensuring visuality when asked about their views on using 3D printing technology in the teaching process. These results align with the findings of this study.

Table 3 shows that toys, wooden blocks, Legos, intelligence games, pretend-play toys, attaching-detaching toys, and animal figures are among the most needed materials in the early childhood education process, according to teachers and prospective teachers. Additionally, some participants mentioned materials specific to science centers and basic materials such as pencils and paper as important. A group of participants also stated that they need any material that can enhance children's creativity without any limitations. In a study by Özyürek and Kılınç [28], they examined the effects of materials present in learning centers on children's free play behaviors. The results showed that different learning centers and materials were used in early childhood institutions, and sturdy and non-hazardous materials were preferred when selecting materials. Children engage in active, interesting, fun, repetitive, meaningful, and socially interactive experiences with people, objects, and representations in various activities to develop holistic skills [29].

When asked if they faced any difficulties in acquiring materials, some participants stated that they did not encounter any challenges. However, another group of participants expressed difficulties due to factors such as financial constraints, insufficient school resources, and technological device shortages or malfunctions. These challenges indicate that overcoming barriers in material acquisition is necessary.

Regarding the opinions of teachers and prospective teachers on the 3D model design process, the cognitive development domain was the most emphasized area. Participants preferred models with flexible or solid structures, consisting of one or multiple parts, and monochromatic or multi-colored designs for various reasons, including durability, attraction to children, ease of use, and portability.

This study aims to shed light on the perspectives of teachers and prospective teachers regarding 3D printing technology and the necessary materials for the teaching process. Participants believe that 3D printing technology has the potential to enrich students' learning experiences and can be beneficial when integrated into the instructional process. However, challenges related to material acquisition and financial limitations need to be addressed. Other research studies, such as Karagöz and Şahin Çakır [27] have noted that some prospective teachers lack detailed knowledge about 3D printing technology and sometimes confuse it with other applications like simulations and holograms. Awayda [30] explored the effects of 3D printing technology's implementation in four middle school social studies classrooms, revealing that creating, designing, and printing 3D models can provide a framework for active and relevant learning experiences in social studies. Literature also suggests that 3D design, and modeling activities contribute to the development of various skills, especially spatial skills, among students [31-34]. Although 3D printing technologies have become more accessible in the education sector in terms of technical efficiency, many 3D modeling software tools are still expensive and may be challenging for educators with limited experience in the field [35]. Thus, it is essential to further promote the widespread use of 3D printing technology in the education sector.

Ihmeideh and Al-Maadadi [36] examined the impact of integrating Information and Communication Technologies (ICT) into early childhood education programs, and the results indicated that such integration increased teachers' awareness and understanding of the value and applications of ICT tools in children's learning. Consequently, teachers' practices positively changed due to the use of ICT, leading to improved quality in their implementation of ICT tools. Therefore, increasing awareness and incorporating more applications related to 3D printing technologies within ICT should be encouraged among teachers and prospective teachers.

Considering the study's findings, it is recommended that universities collaborate with educators to organize training programs that enhance teachers' awareness of how 3D printing technology can effectively support classroom learning. Additionally, the Ministry of National Education should take concrete steps to implement 3D printing technology more widely in schools, starting from early childhood education levels. Providing sufficient financial support to schools will help overcome material acquisition challenges and ensure that necessary resources are available for effective learning experiences.

Furthermore, continuous professional development opportunities should be offered to teachers to improve their expertise in integrating 3D printing technology into the curriculum. This will enable them to create dynamic and interactive learning environments that foster the holistic development of young learners and prepare them for the challenges of the digital age.

On the other hand, among the potential risks of using 3D printing technology in early childhood education, first and foremost is the utilization of projects that are not developmentally appropriate for children. This can make it challenging for children with underdeveloped fine motor skills and hand-eye coordination to adapt to the technology. Additionally, the design of 3D printing projects on computers or tablets can lead to increased screen time and a lack of physical activity among children. Moreover, there is an increased risk of technology addiction among children exposed to technology at an early age. Furthermore, the printing of pre-made designs can limit children's ability to engage in creative thinking and design. Lastly, 3D printing technology and materials can be costly, potentially exacerbating inequalities among schools. Therefore, it is crucial to consider these potential risks when deciding to implement 3D printing technology in early childhood education.

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