# STUDENTS' ATTITUDES TOWARDS APPLICATION OF 3D TECHNOLOGY IN THE FIELD OF VISUAL ARTS EDUCATION IN CROATIA

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**ABSTRACT**

*Theoretical starting points for this work are based on the knowledge about the importance of encouraging spatial abilities of young people and the need to modernize the teaching process. Based on these findings, we have designed research that aims to examine students' attitudes towards the application of the 3D technology in teaching various visual arts and art-historical courses. The research was conducted in 2022 using a random sample of 145 examinees. The measuring instrument consisted of two questionnaires used to examine students' attitudes towards the use of computer 3D models in the teaching process, using a Likert self-assessment scale. The results were processed using the IBM SPSS Statistics 23 software, and they indicate that students have a high interest in 3D models being used for teaching, since their use would modernize the teaching process and positively impact development of students' spatial abilities.*

**KEYWORDS:**

visual arts education, 3D technology, computer 3D models, spatial abilities, modern educational strategies

## INTRODUCTION

The time we live in is undoubtedly called the digital age. A significant part of our everyday life takes place on the Internet. We communicate, work, and learn using different applications on our computers, tablets, and mobile phones. The population of students is the most significant group of digital media users, because most of their free time they spend exposed to the influence of content from the Internet, television, videos,

animations, interactive media platforms, and computer and mobile games. We are witnessing the digitization of everyday life. Therefore, the pedagogue Milan Matijević emphasizes that "the effects of these media present a strong competition for school pedagogical efforts, so that we can talk about the presence of an alternative digital school in every home of today's children and young people."[1] Furthermore, Matijević states that "every adult, by the time they turn 18, spends more time exposed to the influences of various digital media than the influences of school teaching."[2]

Due to all the above and the fact that today's students are the so-called net-generation, it is necessary to modernize learning contents as well as learning and teaching strategies. One of the ways to modernize teaching is the inclusion of digital media in the teaching process. It is not only their educational content and their ability to arouse interest among students that are important, but the interactive component they provide to users also plays a role. Mila Nadrljanski, Đorđe Nadrljanski, and Mirko Bilić believe that "education using modern interactive media is of significantly higher quality than classical education. Digitized information can be more easily edited and is supported by images, animation, and sound, simultaneously affecting several senses, giving complete information."[3] In addition to encouraging the use of several senses, and thus arousing greater interest in the teaching topic, the use of digital media

1) Milan Matijević, "Novi mediji i razvijanje vrijednosti mladih" [New Media and the Development of Youth Values], in *Kultura i obrazovanje – determinante društvenog progresa (dostignuća, dometi, perspektive)*, ed. Drago Branković (Banja Luka: Filozofski fakultet, 2010), 303.
2) Ibid.
3) Mila Nadrljanski, Đorđe Nadrljanski and Mirko Bilić, "Digitalni mediji u obrazovanju" [Digital Media in Education], in *INFuture2007: Digital Information and Heritage*, eds. Hrvoje Stančić and Sanja Seljan (Zagreb: Zavod za informacijske studije Odsjeka za informacijske znanosti Filozofskog fakulteta Sveučilišta u Zagrebu, 2007), 528.

in the teaching process provides students with the experience which they are used to outside the educational institution. Interactive digital content is close, appealing, and stimulating to young people. Therefore, presenting selected teaching content through new media would modernize teaching, and motivate and activate students, providing them with more opportunities for independent learning.

The use of digital media in the field of visual arts education in the Republic of Croatia is promoted by the current *Curriculum for Visual Culture in Elementary Schools and Visual Arts in Grammar Schools in the Republic of Croatia* (2019),[4] which has been in effect since 2019. Within the Curriculum, educational outcomes are grouped into three domains: A. *Creativity and productivity*, B. *Experience and critical stance*, and C. *Art in context*. These domains make the structure of the subject curriculum and represent three key areas in which we want to develop students' competencies: "Students develop digital and computer skills by applying art/visual language when using different media technologies and computer programs in their own creative processes. They use them for the presentation of knowledge, activities, exploration, and evaluation of various data sources. By researching innovations in media technologies and their influence on art, values, cultures, and ideas, it is possible to understand the co-shaping of society and technology,"[5] the Curriculum states.

4) *Kurikulum nastavnog predmeta Likovna kultura za osnovne škole i Likovna umjetnost za gimnazije* [Curriculum for Visual Culture in Elementary Schools and Visual Arts in Grammar Schools in the Republic of Croatia] (Zagreb: Ministarstvo znanosti i obrazovanja, 2019), accessed August 25, 2023, https://mzom.gov.hr/UserDocsImages/dokumenti/Publikacije/Predmetni/Kurikulum%20nastavnog%20predmeta%20Likovna%20kultura%20za%20osnovne%20skole%20i%20Likovna%20umjetnost%20za%20gimnazije.pdf. The Curriculum was first published in: *Narodne novine: službeni list Republike Hrvatske*, no. 162 (2019), accessed August 25, 2023, https://narodnenovine.nn.hr/clanci/sluzbeni/2019_01_7_162.html.
5) *Kurikulum*, 56. All translations of the quotations are by the authors.

This paper focuses on possibilities of implementing digital media in the teaching process, in the form of 3D technology within practical and theoretical classes in the field of art, and on examining students' opinions and attitudes towards the use of 3D technology in art teaching. The use of 3D technology in teaching modernises the teaching process in many ways. It helps present certain teaching content more vividly and interestingly, facilitates the development of students' digital and computer competences, motivates and activates their learning process, and it can also stimulate the development of their spatial abilities.

## SPATIAL INTELLIGENCE, TEACHING AND 3D TECHNOLOGY

The theory of multiple intelligences was created by Howard Gardner, American developmental psychologist, professor, and scientist.[6] His pluralistic understanding of intelligence contrasts with the traditional understanding of intelligence as a unique ability of an individual that is measurable using standardized intelligence tests and known as the intelligence quotient (IQ). According to Gardner's reflections and research, a certain type of intelligence prevails in each person and characterizes them. An individual's aptitude and success in a certain area will also depend on the predominant type of intelligence. Gardner's original categories of intelligence include musical, bodily-kinaesthetic, logical-mathematical, linguistic, spatial, interpersonal, and intrapersonal. Subsequently, he added naturalistic and existential intelligence to them. Gardner and his colleagues are aware that new research in psychology, neuroscience and genetics will influence, change, and reformulate the above classification.[7]

6) Howard Gardner, *Multiple Intelligences – New Horizons* (New York: Basic Books/A Member of the Perseus Books Group, 2006), 8–21.
7) Katie Davis, Joanna Christodoulou, Scott Seider and Howard Gardner, "The Theory of Multiple Intelligences," in *The Cambridge Handbook of Intelligence*,

In the broadest sense, spatial intelligence, as a special cognitive ability, refers to the successful and quick solving of various problems in space, from navigating in space to the ability to visualise, think through visual images, and manipulate these images in three dimensions. It manifests itself as a special ability for spatial thinking and spatial communication. Spatial abilities include "the manipulation of information presented visually, in the form of diagrams or symbols, as opposed to verbally." [8] In psychometric research conducted during the 20th century, most researchers cite two key factors that determine spatial intelligence. These are: the ability to understand spatial relations and the ability to visualise. Based on these two factors, a series of tasks have been designed that include solving problems in spatial relationships and spatial visualisation. The results achieved on these tests indicate to psychologists an individual's level of spatial abilities, that is, the person's spatial intelligence.[9] Developed spatial abilities are of crucial importance in many fields and professions, especially in mathematics, engineering, architecture, technology, chemistry, physics, geography, visual arts, medicine, dentistry, and modern technologies such as robotics. Therefore, Darko Suman emphasizes that "the development and improvement of spatial skills is in the interest of every individual in the environment of the 21st century."[10]

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eds. Robert J. Sternberg and Scott Barry Kaufman (Cambridge: Cambridge University Press, 2011), 485–503.

8) Carmel M. Diezmann and James J. Watters, "Identifying and Supporting Spatial Intelligence in Young Children," *Contemporary Issues in Early Childhood*, no. 3 (2000): 301, accessed August 25, 2023, https://journals.sagepub.com/doi/epdf/10.2304/ciec.2000.1.3.6.

9) James W. Pellegrino, David L. Alderton and Valerie J. Shute, "Understanding Spatial Ability," *Educational Psychologist*, no. 3 (1984): 239–253.

10) Darko Suman, "Tehničko crtanje, spacijalna inteligencija i CAD u osnovnoj školi – opravdanost, potreba, mogućnost, izazov" [Technical Drawing, Spatial Intelligence, and CAD in Elementary School – Justification, Need, Possibility, Challenge], *Polytechnica: Journal of Technology Education*, no. 1 (2018): 54.

Although every person is born with a genetically determined level of spatial intelligence, the results of many studies[11] indicate that it is possible to improve spatial abilities through targeted activities and tasks. Sherly A. Sorby lists activities that are stimulating for the development of spatial skills of individuals during childhood and youth, and before entering college, namely: playing with construction toys (Lego blocks, puzzles), encouraging drawing and sketching, playing 3D computer games, and involvement in sports activities that require well-developed mathematical skills.[12] Begoña Gros also mentions the positive impact of playing 3D computer games on the development of spatial abilities, primarily spatial rotation noticed among children and young people.[13] David H. Uttal, David I. Miller, and Nora S. Newcombe are among the researchers who concluded that spatial thinking can be improved through training, experience or educational interventions and that it has a positive impact on the choice of profession within, primarily, the STEM field.[14] Darko Suman points out that "experimental studies have shown that students' spatial abilities can be improved at all levels of education. This is most successfully achieved in the lower and upper grades of primary school, then in secondary education and at colleges, and with slightly less success in adults."[15] Carmel M. Diezmann and James J. Watters, in their long-term research on children's spatial abilities, conclude that these abilities are

11) Darko Suman synthesized a review of recent and significant research related to the development of spatial intelligence in his paper "Tehničko crtanje, spacijalna inteligencija i CAD u osnovnoj školi," 51–69.
12) Sherly A. Sorby, "Developing 3-D Spatial Visualization Skills," *The Engineering Design Graphics Journal*, no. 2 (1999): 21–32.
13) Begoña Gros, "Digital Games in Education: The Design of Games-Based Learning Environments," *Journal of Research on Technology in Education*, no. 1 (2007): 23–38.
14) David H. Uttal, David I. Miller and Nora S. Newcomb, "Exploring and Enhancing Spatial Thinking: Links to Achievement in Science, Technology, Engineering, and Mathematics?," *Current Directions in Psychological Science*, no. 5 (2013): 367–373.
15) Suman, "Tehničko crtanje, spacijalna inteligencija i CAD u osnovnoj školi," 54.

related to advanced drawing and painting abilities.[16] It implies that the spatial intelligence of children and young people can be encouraged through certain activities within the subject Visual Culture. In the context of this paper, the research conducted by Ali Ihsan Benzer and Bunyamin Yildiz is particularly interesting because they proved that computer-aided 3D modelling can improve the spatial abilities of students (future IT teachers) and positively influence their attitudes towards the implementation of 3D modelling in teaching. This can significantly help students develop their spatial abilities, which are key 21st-century skills needed for achieving success in the fields of STEM and STEAM.[17] Comparing different approaches to designing an art curriculum for primary schools, Jean Edwards, Helen Caldwell, and Rebecca Heaton advocate connecting traditional artistic expressions (drawing, painting, modelling) with digital technology, because today's students live in a time intertwining the digital and the virtual with reality.[18]

The current Curriculum requires the use of new media technologies to achieve certain educational outcomes within the domain of creativity and productivity, especially in the upper grades of primary school. Also, it provides an opportunity for secondary school students to present the results of their research tasks using appropriate digital media.[19] Therefore, we

16) Diezmann and Watters, "Identifying and Supporting Spatial Intelligence in Young Children," 299–313.
17) Ali Ihsan Benzer and Bunyamin Yildiz, "The Effect of Computer-Aided 3D Modeling Activities on Pre-Service Teachers' Spatial Abilities and Attitudes Towards 3D Modeling," *Journal of Baltic Science Education*, no. 3 (2019): 335–348, accessed August 27, 2023, https://files.eric.ed.gov/fulltext/EJ1309921.pdf.
18) Jean Edwards, Helen Caldwell and Rebecca Heaton, *Art in the Primary School – Creating Art in the Real and Digital World* (London and New York: Routledge, 2021), 28–31.
19) The current *Curriculum for Visual Culture and Visual Arts in the Republic of Croatia* enables interdisciplinary connections through the outcomes of interdisciplinary themes. The use of information and communication technology is one of the interdisciplinary themes that further emphasises the significance of learning, teaching, and communication with the support of new media technologies.

can conclude that the Curriculum, as a strategic document of educational policy in the field of visual arts education in the Republic of Croatia, allows for the use of 3D technology in teaching subjects of Visual Culture and Visual Arts.

## THE RESEARCH GOAL

Motivated by the results of recent scientific research emphasising the significance of developing students' spatial intelligence using 3D technology, as well as positive experiences with the use of computer 3D modelling and models in our teaching practices, we have decided to conduct research with the aim of exploring students' attitudes[20] towards the use of 3D technology in the field of visual arts education.[21] Our goal is to gain insights into the previous utilization of computer 3D models in the field of visual arts education, students' interest in and motivation for the use of 3D models, and their enhanced visualisation of spatial relationships through computer 3D models.

## PROBLEMS AND HYPOTHESES

Problem 1 – To examine to what extent, from students' point of view, teachers in the visual arts field use computer 3D models in their classes.

Hypothesis 1 (H1) – Based on existing findings, personal experience, and information collected during professional-pedagogical practice, it can be assumed that teachers of the

20) In this article, by the term "students" we refer to all students (in primary school, secondary school, and college – arts academy), who constituted three groups of our respondents.
21) Within this paper the term "field of visual arts education" or "visual arts field" refers to the subject of Visual Culture in primary school, the subject of Visual Arts in secondary school, as well as various art-historical and artistic subjects taught at the university level in the Republic of Croatia.

visual arts field do not use computer 3D models in class or use them rarely.

Problem 2 – To examine to what extent the use of computer 3D models in teaching visual arts facilitates the presentation of space to students, and how it affects their motivation and interest in teaching content.

Hypothesis 2 (H2) – Based on the existing findings, it can be assumed that students will understand space more easily and that computer 3D models used in class will stimulate their motivation and interest in teaching content.

Problem 3 – To examine the desire of students to use computer 3D models in future classes, and their interest in further education in the use of 3D programs.

Hypothesis 3 (H3) – Based on the existing findings, it can be assumed that students, depending on the degree of development of spatial abilities, will have different attitudes towards these statements.

## PARTICIPANTS

The research included a total of 145 participants, including 47 (32.4 %) primary school students, 61 (42.1 %) secondary school students, and 37 (25.5 %) college (arts academy) students. Of these, there were 57 (39.3 %) male participants, 84 (57.9 %) female participants, while 4 (2.8 %) participants chose not to disclose the information on gender. The participants' ages ranged from 13 to 46 years (M=16.94; SD=4.41). Participants reported good (9.7 %), very good (48.3 %), and excellent success (42.1 %) at the end of the previous school or academic year. None of the participants repeated a class or year, nor did they pass with the lowest grade. An almost equal percentage states that they have (49 %) or

have not (51 %) encountered computer 3D models outside of class. Among the participants who claim to have encountered computer 3D models outside of class, 36 (52.2 %) stated that they had encountered them in models and animations in movies and computer games, 10 (14.5 %) in 3D applications and programs, and 23 (33.3 %) marked the "other" category. This category includes different places, such as: at home, in computer science, or vague and general answers such as the Internet or Google.

## INSTRUMENTS AND METHODS

The research data were collected through two questionnaires: a questionnaire gathering general information about the participants and a questionnaire that examined their familiarity with and attitudes towards the use of computer 3D models in teaching.

The general data questionnaire gathered information on gender, age, level of education and average school/academic success, and whether and where they had encountered computer 3D models outside of class. The questionnaire on the use of computer 3D models in teaching contained a total of six questions that examined the previous use of 3D models in teaching, the level of motivation, interest and easier understanding of the teaching material when computer 3D models are used, as well as the desire for the implementation of computer 3D models in teaching, and the motivation for education in the field of 3D technologies.[22] The participants expressed their agreement or disagreement with the statements on a 5-point Likert scale.

22) The mentioned six questions, or statements, were: In the previous teaching in the visual arts field, teachers have used computer 3D models in interpreting the material; I understand the space shown in a 3D model better and more easily than the one shown in a 2D picture; When the teacher uses a computer 3D model for interpreting graphics, it motivates me to pay more attention in class; The

The data were collected in Split, in the period from March to July 2022, in two primary schools (Kman-Kocunar Primary School, Lokve–Gripe Primary School), two secondary schools (3rd Grammar School of Science and Mathematics, 4th Grammar School – Marko Marulić) and at the Arts Academy of the University of Split. The collection of data was convenient and was carried out with primary and secondary school students during professional-pedagogical practice and the practical part of the Visual Culture Methodology and the Visual Arts Methodology course. The Arts Academy students were questioned randomly on the premises of the faculty. Prior to conducting the research, permission was obtained from the school principal and parents to survey students under the age of 14. Data collection was carried out at the group level using the paper-pencil technique. Before conducting the research, all participants were informed about the subject and purpose of the research, as well as the voluntary nature of the participation, anonymity, and confidentiality of the data. The research was conducted at Kman-Kocunar Primary School after the art lesson, during which the students were shown a PowerPoint presentation that contained computer 3D models used to reproduce certain works of art. After that, the students tried to design computer 3D models in the 3D modelling program Blender. At Lokve-Gripe Primary School, the research was conducted under the same conditions, except that there, the students used the TinkerCad 3D application. In the two secondary schools, the research was carried out after a visual arts lesson, during which a PowerPoint presentation containing computer 3D models and animations was used. Among the academy students, the research was conducted

material presented through a computer 3D model is more interesting to me; I wish 3D computer models would be used in future teaching; I would like to learn how to design 3D computer models in an appropriate program / I want to receive additional education in that field.

by randomly selecting respondents from different academy departments and study levels.

Statistical data processing was carried out using the statistical program IBM SPSS Statistics 23.[23] The mentioned statistical program was used to perform a descriptive statistical analysis of the data.

## RESULTS AND DISCUSSION

To the question from the first questionnaire, "Have you encountered computer 3D models outside of class?", 51 % of respondents answered negatively. Based on the obtained results, we can conclude that half of the respondents did not know how to recognize the presence and prevalence of this technology in everyday life. Every person who has access to the Internet, animated films made after 1995, films with special effects, commercials and video games has been in contact with computer 3D models and animations. The familiarity of young people with the methods used to create the visual digital content they observe every day is questionable. This fact also points to a failure of the education system, because half of the questioned young people do not understand where and how the content they interact with digitally was created. Of the respondents who answered positively to this question, the majority (52.2 %) stated that they had encountered 3D models in movies and video games.

The results related to respondents' opinions and attitudes towards the six research claims from the second questionnaire are shown graphically in **Fig. 1**. When it comes to the first

23) IBM SPSS Statistics 23 – a statistical software package used for data management, advanced analytics, and multivariate analysis; https://www.ibm.com/products/spss-statistics, accessed during August 2022.

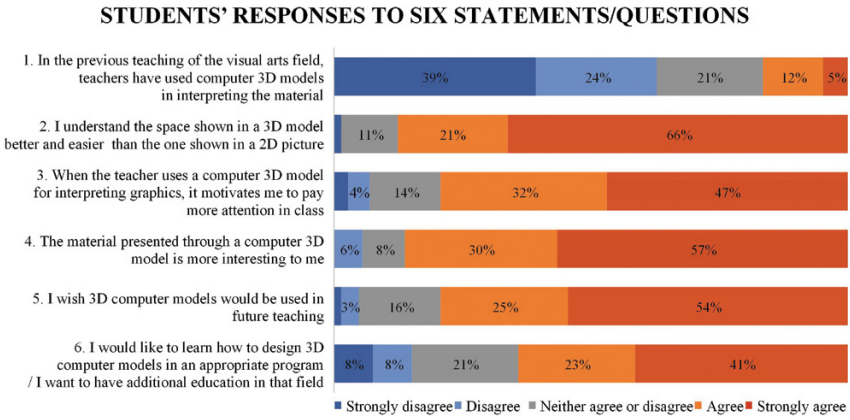


Fig. 1. Graphical representation of the results of all students' responses to six statements from the second questionnaire.

research statement: "In the previous teaching in the visual arts field, teachers have used computer 3D models in interpreting the material", 62.7 % of all respondents disagree, 16.5 % agree, and 20.8 % are undecided.[24] Among primary school students, 55.3 % disagree with the first statement, which indicates that more than half of the surveyed students have not encountered computer 3D models in the subject Visual Culture. Among secondary school students, as many as 78.6 % disagree with the first statement, which indicates that their Visual Arts teachers did not use computer 3D models in their classes at all or that they used them very rarely. A large proportion of academy students (45.9 %) responded negatively to this statement, while 21.6 % expressed their agreement, that is, they confirmed that university teachers used computer 3D models in their classes. These results confirm the first hypothesis (H1), i.e., the assumption that teachers rarely used computer 3D models in teaching visual arts.

24) In the graphical representation of the results of all students' responses to six statements from the second questionnaire, the results are rounded and shown as whole numbers, because as decimals they would not fit into certain small fields within the display.

As many as 87.6 % of all respondents agree with the second statement, which refers to a better and easier understanding of space shown by a computer 3D model compared to that shown in a 2D image. All three groups of respondents believe that computer 3D models significantly help in understanding the displayed space (primary school students 87.2 %, secondary school students 93.4 %, and academy students 78.4 %).

The third claim was related to the impact of computer 3D models on the intensification of students' motivation and attention during classes in which the models are used. Out of the total number of respondents, 79.3 % believe that the application of computer 3D models in classes motivates them additionally and positively affects their attention during classes. When it comes to different groups of respondent, 76.6 % of primary school students, 85.2 % of secondary school students and 72.9 % of academy students agree with this.

A total of 86.3 % of respondents agreed with the fourth research statement: "The material presented through a computer 3D model is more interesting to me." In the group of primary school students, 80.8 % of them agree, in the group of secondary school students, even 91.8 % agree with this statement, and among academy students, the percentage of agreement with the statement is 83.7 %.

The results referring to the second, third, and fourth research statement confirm the second hypothesis (H2), i.e., the assumption that students understand the space better and more easily when it is shown by a computer 3D model compared to a 2D image. Furthermore, the results confirm that the use of computer 3D models in teaching has a positive impact on the motivation and attention of students during teaching and their interest in teaching content.

The respondents' opinions about the fifth research statement give us insight into their desire to use 3D computer models in future learning. Even 79.3 % of the total number of respondents want that, i.e., 68 % of primary school students, 82 % of secondary school students, and 89.2 % of academy students expressed their desire to use computer 3D models in future classes.

The last, i.e., the sixth claim, was aimed at examining the respondents' desire for additional education in the computer-aided 3D modelling. Out of the total number of respondents, 64.2 % expressed a desire for additional education in the computer 3D model design. Among the surveyed primary school students, 63.8 % expressed interest in this, indicating that more than half of the students want to learn how to create 3D models in a computer program. The same is true for 29.5 % of secondary school students and 86.5 % of academy students.

The results related to the last two statements confirm the third hypothesis (H3), which assumed that some students, most likely depending on the level of their spatial abilities, have a certain desire for further education in creating computer 3D models and their use in future classes.

Although the positive attitudes of the respondents towards the implementation of 3D computer models in the field of visual arts education were expected, the obtained results indicate a strong interest of students in the application of this aspect of technology in the teaching process. The results regarding the first question (statement) in the survey indicate that teachers rarely use 3D technology in teaching. Some primary school students responded affirmatively to the statement, although their teachers provided information that they do not use 3D technology in their classes, indicating that some primary school students did not understand the question well. Therefore,

additional clarification of this question would provide more accurate results, and almost all students would answer that they have never encountered computer 3D models in Visual Culture classes. Given that primary school students tried their hand at making their own computer 3D models, it is not surprising that more than half of them (63.8 %) expressed a high interest in further education in designing computer 3D models. It can be assumed that these are individuals who have highly developed spatial abilities, which they could further develop in class, if given the opportunity. Also, it can be assumed that the other primary school students, who provided an average or a negative response to this statement, have less developed spatial abilities, and that they did not do well in the 3D modelling program. Although they did not express a desire for further education in computer-aided 3D modelling, according to research by Ali Ihsan Benzer and Bunyamin Yildiz,[25] further education in computer 3D design would probably enable them to develop better spatial abilities. As many as 87.2 % of primary school students stated that they understand the space represented by a computer 3D model more easily than a 2D image, therefore teachers should use computer 3D models in teaching architecture and sculpture so that students can experience and understand them as fully as possible. The research results indicate that 3D technology is used for understanding and learning teaching content in the visual arts lessons in secondary schools less than in primary schools and at the academy. Given that it was secondary school students who showed the greatest interest in 3D technology when answering the other questions, it is necessary to implement this aspect of digital media in classes in secondary schools. Modern teaching, which is student-centred, must provide visually and cognitively interesting teaching

25) Benzer and Yildiz, "The Effect of Computer-Aided 3D Modeling Activities," 343.

approaches, which stimulate interest in teaching content and enable better memorizing and understanding of what has been taught. As many as 91.8 % of secondary school students believe that teaching contents are more interesting if they are presented using computer 3D models, 93.4 % understand the space shown through a computer 3D model more easily, and 85.2 % participate in classes with greater motivation if the teacher uses 3D technology. The surveyed students of the Arts Academy of the University of Split expressed an overall interest in the additional implementation of 3D technology in classes and confirmed that the teaching content demonstrated with the help of computer 3D models is more interesting to them. Also, they confirmed that such an approach to teaching motivates them more than the traditional way of teaching using 2D visual aids. The results of the research conducted by Milan Matijević among the students of the Faculty of Teacher Education at the University of Zagreb led to two conclusions significant in the context of this paper: "students do not like to be forced to participate in didactic scenarios in which they are not active and students expect constant changes in teaching media and places and learning strategies."[26] Both of the above conclusions support the use of computer 3D models in teaching because they emphasise the importance of student motivation and active learning.

## CONCLUSION

Before the conclusion itself, we must point out the main limitations of this research, namely: a small number of respondents and a random sample. Furthermore, the research

26) Milan Matijević, "Na tragu didaktike nastave za net generacije" [In Line with Teaching Didactics for the Net Generations], in *Nastava i škola za net-generacije*, ed. Milan Matijević (Zagreb: Učiteljski fakultet Sveučilišta u Zagrebu, 2017), 40–41.

questionnaire is somewhat limited, because it examines the attitudes of the participants exclusively in the written form without accompanying visual material and tasks that would allow an insight into the level of spatial abilities of the respondents. Also, to obtain more comprehensive results, a larger number of variables should be used, while only six of them were used in this questionnaire. Therefore, participants were only able to provide a self-report measure.

The advantage of the research is the fact that the results indicate that students have a great interest in the implementation of computer-aided 3D models in teaching and learning the content of teaching subjects in the field of visual arts education and emphasize the educational aspect of the application of 3D technology. The results of the research highlight the importance of incorporating 3D technology across all educational levels, including primary, secondary, and higher education. At all levels, the teaching process should be enriched and modernised using 3D technology in learning and teaching. The field of visual arts education offers many opportunities for the application of computer 3D models. The use of 3D technology in the teaching of Visual Culture, Visual Arts and many other art-historical and artistic subjects at colleges will modernize the teaching and the learning process, enrich the teaching contents, make them more interesting to students and have a positive impact on the development of students' spatial abilities. This is exactly what the attitudes and wishes of the students participating in this research indicate.

The limitations of the research indicated the need for further study related to this area. In future research, the number of respondents should be equalized by gender, age, and level of education. Also, instead of using only a subjective self-evaluation scale, respondents could be exposed to tests and

tasks that would serve as objective measuring instruments. To obtain precise results regarding the use of computer 3D models in teaching and their impact on students in general, longitudinal research should be conducted. Thus, in addition to personal attitudes, it would examine how and to what extent the long-term use of this digital medium within classes affects the development of spatial abilities among young people, as well as the impact on acquired competencies and the selection of students' future interest areas.

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