https://doi.org/10.25038/am.v0i29.568

Bea Tomšič Amon
Department of Art Education, Faculty of Education, Ljubljana, Slovenia

Didactic Tool Based on Virtual and Augmented Reality in Art Education: Learning through an Interactive Game

Abstract: This article presents research on the results of using a didactic tool based on virtual and augmented reality, developed for solving tasks from the field of spatial design. The theoretical part presents the context of the tool's development and discusses spatial perception in new media, spatial design of images and screen views, and new media and augmented reality in school practice. The didactic tool consists of a computer, a computer screen, a computer camera, and a set of markers with symbols for different architectural elements that allow different composition operations. Manipulation of the markers is captured by a computer camera, which recognizes the symbols as function keys and allows interaction with a computer program. The computer decodes the data and displays it on the screen as surfaces and solids. This strategy promotes learning like a computer game. We tested it with eighth grade elementary students. The goal was to determine the extent to which the tool would affect the implementation of artistic tasks, creativity, motivation, satisfaction, and understanding of art concepts. The results presented here are encouraging, especially in the area of creativity, which was confirmed by teachers and students after the evaluation.

Keywords: art teaching; artistic tasks; digital didactic tool; computer game; creativity.

1. Introduction

The objectives of art education in the different educational areas include the development of observation, performance spaces, creativity, imagination, knowledge of art theory and history, art techniques – in short, the development of processes that have a direct relationship between practice and theory. Teachers and students need or use different didactic tools, which are aids in the implementation of the educational process and independent learning. Therefore, they are an important basic component of the teaching and learning process. Didactic aids are various media: sources of knowledge, materials, data carriers, means of transferring and processing information, or work tools.[1]

There is a growing interest in introducing new media tools into the classroom.

[1] Tonka Tacol, *Didaktični pristop k načrtovanju likovnih nalog. Izbrana poglavja iz likovne didaktike* [Didactic Approach to Planning Art Assignments: Selected Chapters from Art Didactics] (Ljubljana: Debora, 1999), 19–21.

*Author contact information: bea.tomsic@pef.uni-lj.si

The market for computer games, one of the largest markets in the entertainment industry, is growing due to features such as game attractiveness, interactivity, and immersion. All this can have a great impact on the educational environment and learning resources.

The fact that an educational game is set in a computer environment intrinsically motivates students because it provides them with a popular starting point for playing. Computer games can be adapted to the user's abilities. Different levels of difficulty can be set, and it is possible to monitor the user's progress based on what they have experienced up to the point where they engage with the game. The goal is to put the user in an appropriate difficulty level where they can manage the situation with their skills and motivate their progress.[2]

With these ideas in mind, we have developed a new media learning tool consisting of a computer, a computer screen, a computer camera, and a set of markers with symbols for various architectural elements that activate changes to these elements and various compositional operations. Manipulation of the markers is captured by a computer camera, which recognizes the symbols as function keys and allows interaction with a computer program. For building with models, the application allows students to insert objects according to the markers they activate. With an additional command, the models are glued together and react to the assigned marker representing the built whole. The application practically works like an interactive game in augmented reality and provides the user with many opportunities to solve artistic problems in spatial design.

In order to introduce the ideas we had in mind when developing the tested didactic tool, we must explain some features that formed the theoretical background of our research, such as the characteristics of spatial perception in new media, the nature of digital spatial formations and images, the role of the computer screen, and the use of augmented reality in teaching. These are the contents of the first part of the article. Since the particular aim of the research was to determine the extent to which the tool we developed influences students' implementation of artistic tasks, creativity, motivation, satisfaction, and understanding of art concepts, the results are presented in the second part of this article.

2. Perception of Space in the New Media

The world we experience through electronic media is completely different from the world we experience when we look through the window of an apartment. A virtual window changes the materiality of physical space by adding new openings to it that dramatically alter our perception of space. When we look at the street below our apartment block, we can easily determine the depth, color, and distance to the objects and people there. In our perception of physical space, the foundations of which go

[2] Pablo Moreno-Ger, Daniel Burgos, José Luis Sierra, and Baltasar Fernández-Manjón, "A game-based adaptive learning unit with IMS Learning Design," in *Lecture Notes in Computer Science: Creating New Learning Experiences on a Global Scale*, ed. Erik Duval, Ralf Klamm, Martin Wolpers (Berlin: Springer, 2007), 247–261.

back to early childhood, the window of the apartment does not hinder us. The digital window or screen offers us a completely different experience with the same view. If we place a video camera where we used to look through the window at the street and record a completely identical scene as we saw it, while sitting in front of the screen in another room or even in the room of the next block, knowing the scene and perhaps even imagining ourselves standing in the place of the camera, we cannot completely avoid the feeling of dislocation. The shot or the perspective of the camera would be perceived as something that belongs to the device, we placed there to take the shot, not to us. We would feel that what the camera is recording is happening in real time, but not feel that it is happening in our immediate vicinity. Heydon describes the feeling of transcending the physical boundaries of perception when the body becomes lateral in comparison to the dimensions of the mind. This means that the ability to perceive a camera shot requires the complete ignorance of the body. He emphasizes that the shot, as a representation of the real world, must contain elements that can be identified or decoded based on experience with similar objects. Without images that are imprinted in our memory and by which we recognize what the apartment screen shows us, ignorance of the body is essentially impossible.[3]

3. Spatial Formations and Images

Despite the obvious differences, modern variations of graphic effects owe their origins to the representational experiments of the modern era. While the scope of representational techniques has grown more than significantly, little has changed in the way space is bounded or framed. Perspective representation of space remains the norm in virtual reality, and objects continue to be represented in ways that were already common in the 18th and 19th centuries. At first glance, there is little difference between a window by Alberti and a computer screen. The only thing that has really changed to this day is the way or technique of simulation, and thus the position of the traditional viewer of that representation. There is a gap between the modern virtual space and the idea of a space created by a computer program that is completely blind to the presence of the viewer. In this sense, the screen is certainly neither an image nor a substitute window, but a vague and indeterminate position for the viewer.[4]

The new media with digital images transform the viewer into an interactive user and thus our perception of images. An image is no longer just something we observe or look at as viewers, but we actively enter the image by zooming in, rotating, and clicking on it, assuming that it contains a link to some other related content. The image thus becomes interactive and at the same time a tool for interacting with new media.[5]

---

[3] Jeff Heydon, "The View from the Window," *Canadian Journal of Communication* 38, 4 (2013): 531–544.

[4] Anthony Vidler, *Warped Space: Art, Architecture, and Anxiety in Modern Culture* (Cambridge MA: The MIT Press, 2001), 19–21.

[5] Lev Manovich, *The Language of New Media* (London: Routledge, 2001), 71–74.

In today's world, new media have accustomed children to flatness to the point that they no longer even question the composition of the image. Pallasmaa[6] adds that in our image culture, the view of the image has flattened and lost its plasticity, and that we do not experience our existence in the world but view it from the outside as viewers of images projected onto the retina. Significantly, in the text that refers to the representation of space through digital technologies, the author states that seeing no longer means seeing, but also not seeing.

3.1. Screen Views

Manovich[7] sorts screens into a horizontal order. The classical screen, as he calls static paintings and photographs, is followed by a dynamic screen type that retains all the features of classical paintings or screens and has a novelty: an image that is dynamic and shows something that happens in time. When the viewer looks at the image, it is already in the past. This new, changing and moving image on television, with its tendency towards total illusion and visual fullness, confronts the viewer with a new state of seeing. It demands from him total concentration on what it represents; it demands not only the exclusion of doubts about its authenticity, but also the complete exclusion of the space in which the viewer finds himself, and not least the identification of the viewer with the image itself. However, these conditions can only be fulfilled if the displayed image fits perfectly on the screen. Any deviation of the image from the screen format leads to the disintegration of the illusion. Similarly, the next type of screen is the real-time screen, which is a dynamic type that shows the present, the real-time. The sub-concepts of the classic and the dynamic screen are the interactive screen or the touch screen, i.e., the screens of computers, tablets and modern cell phones, which Kesim and Ozarslan[8] cite as one of the key foundations for enhancing learning with augmented reality.

To explain how screens work in new media, Friedberg[9] draws on an analogy with windows. He describes the screen as something that can define space (e.g., here and there, and outside and inside), a membrane between surface and depth. Friedberg also understands the window as a frame that can limit the view, reducing the outside from a three-dimensional to a two-dimensional surface, becoming a kind of screen. Like a window, the new media screen is a two-dimensional surface bounded by a frame. He further argues that the comparison of a window to a screen is based on the assumption that the word window does not mean the entire screen surface, but only a part of it, its subset or set of windows within windows, frames within frames, and screens within screens.

[6] Juhani Pallasmaa, *The Eyes of the Skin: Architecture, and the Senses* (Chichester: John Wiley & Sons Ltd., 2005), 58.

7 Manovich, *The Language of New Media*, 105–106.

[8] Mehmet Kesim and Yasin Ozarslan, "Augmented Reality in Education: Current Technologies and the Potential for Education," *Procedia – Social and Behavioral Sciences* 47 (2012): 297–302.

[9] Anne Friedberg, *The Virtual Window: From Alberti to Microsoft* (London: The MIT Press, 2006), 28–30.

Manovich[10] describes the exterior of a computer screen as a flat rectangular surface designed for frontal viewing and divides it into three segments: Content, Frame, and Desktop. The latter, according to Manovich, consists of a series of icons with specific functions that transform the screen surface into a virtual, interactive control panel. The screen can be perceived as both surface and depth, as something that may or may not be transparent. Thus, according to both Manovich and Friedberg, the screen can function both as a window into an imaginary space and as a surface. The proportions of the screen are similar to the proportions of paintings in classical painting, even the names landscape and portrait come from landscape and portrait painting.[11]

4. New Digital Media as Teaching and Learning Tools

If visual materials such as photographs, copies, and originals of works of art, and videos can be called teaching aids, then today's teaching aids also include cameras, projectors, televisions, computers, cell phones, and other digital technologies or inventions without which we cannot imagine modern teaching.

Digital media that display interactive graphics via screens, monitors, and projectors can be used to present content in various combinations: Static images can become animations, two-dimensional displays can become three-dimensional representations of objects, text becomes sound, and non-interactive content becomes interactive. All of these changes in the way material is presented can be very effective in the learning process. Knowledge conveyed in this way is easier for students to acquire because multiple learning types are addressed simultaneously.[12]

One of the most important contributions that art education owes to new technologies is the possibility to create and use didactic tools based on animations with dynamic images. This requires a particular readiness since they represent a kind of reduction of the authentic spatial experience. Dynamic images imply a total dedication to virtual reality. In virtual reality, the panoramic view is joined by sensorimotor exploration of the image space, which gives the impression of a real-life environment. Heim[13] notes that interactive media transform our conception of images into a sensory-interactive experiential space with time frames. Most virtual realities hermetically guide the viewer along a path that first shows external visual impressions, then addresses the plasticity of the objects presented, extends the perspective of real space into a space of illusion, and uses direct lighting effects to present the image as the source of reality.[14]

A virtual learning environment allows the learner to have a greater number of interactions. Information that exists in the real world is enriched with information

[10] Lev Manovich, "New Media from Borges to HTML," in *The New Media Reader*, ed. Noah Wardrip-Fruin and Nick Montfort (Cambridge, Massachusetts: The MIT Press, 2003), 13.

[11] Jonathan Crary, *Suspensions of Perception* (London: The MIT Press, 1999), 12–13.

[12] Iulian Radu, "Augmented reality in education: A meta-review and cross-media analysis," *Personal and Ubiquitous Computing* 18 (2014): 1533–1543.

[13] Michael Heim, *Virtual Realism* (New York: Oxford University Press, 1998), 7.

[14] Oliver Grau, *From Illusion to Immersion* (London: The MIT Press, 2003), 13–15.

conveyed through virtual objects and images.[15] Information and communication technology has been used in education for about half a century and is known to create a variety of learning opportunities. Virtual reality, as a component of information and communication technologies, is a more advanced technology that allows users to interact on two levels, the real world, and the virtual world, using information and communication technology. Information and communication technology brings improvements to the learning process using virtual reality.[16]

4.1. Augmented Reality

The first study of augmented reality was written by Azuma,[17] who gave it a commonly accepted definition: that of a combination of real and virtual environments. With this definition, Azuma

compares virtual and augmented reality, explaining that virtual reality technology allows the user to be fully immersed in a synthetic environment, meaning that the user is not visually aware of the real environment while immersed in a virtual environment. Augmented reality, unlike virtual reality, allows the user to visually perceive the real environment by implementing objects that are fully or only partially virtual and merge with the real world by overlaying objects within it.

Augmented reality integrates sensory information into the user's perception of the real world by overlaying a digital layer on top of real world images captured in digital devices such as smartphones and tablets that the user would otherwise not be able to see with the naked eye.[18] Its purpose is to integrate the interactive real environment with interactive computer-generated elements, and the goal of integration is to implement computer-generated information into the individual's real environment in such a way that the user perceives the merging of the two as a whole.

Augmented reality thus has two main characteristics in terms of its utility: The first is that the user perceives the video environment in the digital space as a real environment, and the second is that the integration of the digital image and the geometric model to create a virtual-real connection is not perceptible to the user.[19] While virtual reality completely replaces the real space, augmented reality merely complements it, expanding the user's sensory and cognitive reality.

---

[15] Lucinda Kerawalla, Rosemary Luckin, Simon Seljeflot, and Adrian Woolard, "'Making it real': exploring the potential of augmented reality for teaching primary school science," *Virtual Reality* 10 (2006): 163–174.

[16] Heather L. O'Brien and Elaine G. Toms, "Engagement as a process in human-computer interactions," in *Proceedings of the American Society for Information Science and Technology* 42, 1 (2006).

[17] Ronald T. Azuma, "A Survey of Augmented Reality," *Presence: Teleoperators and Virtual Environments* 6 (1997): 355–385.

[18] Li Shanshan, "Assessing the user experience when using mobile augmented reality in advertising," (Ph.D. diss. Purdue University, 2014), https://docs.lib.purdue.edu/cgi/viewcontent.cgi?referer=&httpsredir=1&article=1232&context=open_access_theses, acc. June 21, 2022.

[19] Shen Zheng, "Research on Mobile Learning Based on Augmented Reality," *Open Journal of Social Sciences* 3, 12 (2015): 179–182.

4.2. Augmented Reality in Education

Augmented reality allows us to convey information and interact with the real world in ways previously unknown. This involves the use of virtual objects that the augmented reality user would not be able to perceive with his senses without them. We can change the position, the shape or even the graphic properties of virtual objects based on the real world. Using interaction techniques supported by any augmented reality technology, the user can move around a three-dimensional virtual object and view it from all angles as if they were looking at a real-world object. By touching and moving the device, the user can manipulate this object or manipulate both the virtual and real objects simultaneously. In this way, a rich interactive experience becomes accessible to all, even those who are not computer literate. Rountree, Wong, and Hannah[20] investigated the effectiveness of using virtual objects in the classroom and found that virtuality allows for high levels of attention and the development of useful tools to increase visual literacy.

Kesim and Ozarslan[21] present it as a new medium that brings together many computer domains and provides a unique experience of combining the physical and virtual worlds through the user's continuous and implicit control over the type of viewing and the degree of interactivity. Augmented reality provides the user with a combination of real and virtual spatial views, maximizing the user's natural and intuitive real-time user experience. According to the authors, this approach is expected to improve the effectiveness and attractiveness of learning and teaching.

Hsiao and Chen[22] also investigated the use of augmented reality in education. They suggest that virtual reality and augmented reality have the potential to enhance exploratory learning that takes place between the real world and virtual objects. Heim[23] reported that virtual reality can provide powerful and unique information on which to base educational experiences. When Rountree, Wong, and Hannah[24] investigated the effectiveness of using virtual objects to teach classical art, they found that virtual reality provides a high level of attention through the display of virtual images and provides useful and effective tools to promote visual literacy.

According to Stokes,[25] we should focus first on learning or teaching and only then on digital learning tools to fully exploit the potentials of digital technology, such as ease of access, stimulation of imagination, video and photo management features,

[20] Janet Rountree, William Wong, and Robert Hannah, "Learning to look: Real and virtual artifacts," *Educational Technology & Society* 5, 1 (2002): 129–134.

[21] Kesim and Ozarslan, "Augmented Reality in Education," 297–298.

[22] Kuei-Fang Hsiao and Nian-Shing Chen, "The evolution of the AR -fitness system in education," in *Edutainment Technologies: Educational Games and Virtual Reality/Augmented Reality Applications*, Proceedings of the Sixth International Conference on E-learning and Games, September 7–9, 2011, Taipei, Taiwan, ed. W. Y. Chang, M. P. Hwang, W. Mueller (Berlin: Springer, 2011): 2–11.

[23] Heim, *Virtual Realism*, 27.

[24] Rountree, Wong, and Hannah, "Learning to look: Real and virtual artifacts," 130–131.

[25] Suzanne Stokes, "Visual literacy in teaching and learning: A Literature Perspective," *Electronic Journal for the Integration of Technology in Education* 1, 1 (2002): 10–19.

easy integration with other digital technologies, visualization features, and directing attention to the screen. He argues this with the example of digital interactive whiteboards, which, when used correctly, can deepen knowledge and enrich the learning experience, while when used incorrectly, such a board is just a substitute for an ordinary whiteboard and textbook. Digital technologies must therefore be integrated into the learning process so that everyone can benefit, both teachers and students.

5. The Research

To understand why we conducted the research in the field of spatial design, it is important to introduce briefly the curriculum scheme of elementary school. It is divided into two core areas in all grades: two-dimensional artistic expression, which includes drawing, painting, printmaking and graphic design, animation, and fashion design in the last three grades, and three-dimensional artistic expression, which includes sculpture, ceramics and architectural design during the nine years of elementary school.

5.1. The Main Instrument

For implementation in the teaching-learning process of spatial design or architecture, as we mentioned in the introduction, we have developed a new media learning tool consisting of a computer, a computer screen, a computer camera, and a set of markers with symbols for different architectural elements that activate changes in these elements and different compositional operations (Figure 1). Manipulation of the markers is detected by a computer camera that recognizes the symbols as function keys and allows interaction with a computer program (Figures 2 and 3).

The designed instrument detects markers using an augmented reality toolkit library. The program runs interacting with each assigned marker pattern and calling a function within the programming environment. When building with models, the application allows the student to insert objects according to the enabled markers (Figure 4). With an additional command, the models are glued into a whole and react to the assigned marker (Figures 5 and 6).[26] To manipulate model properties, the application allows various changes to models or three-dimensional bodies. The following manipulations can be triggered with the markers: Scaling along all three axes, rotation around two axes, deviation of the starting point along all three axes, change of texture or material properties and reset.

In order to facilitate students' use of the application, we designed maps with markers that allow the following operations within the new media interface: operations with architectural elements, creation of architectural elements in three-dimensional rendering, shape of spatial components such as shell, ceiling, walls, floor, etc., design elements of architectural space such as wall, arch, pillar, lintel, vault, dome,

[26] Luka Debevec, "Application as a tool for research on the use of new media in teaching spatial design in primary schools," (Ph.D. diss. University of Ljubljana, Faculty of Computer and Information Sciences, 2014), 24–28.

roof, openings, changes in the quality of elements and composition operations by manipulating elements through computer vision maps (Figures 7 and 8).

Virtual reality allows us to freeze or interlace three-dimensional models in space without the physical constraints we are used to in the real world. In this way, the system allows us to form compositional formations with new creative solutions without limiting the physical properties.

5.2. Research Problem

Our research questions focused on the characteristics of the use of the created instrument. We were interested in whether students would make appropriate artistic use of the new instrument and whether they would demonstrate motivation and satisfaction. We hypothesized that students would display great creativity and show better understanding of the art concepts presented than when learning about architecture in the traditional way with drawings, photographs, and paintings. Thus, the goal of the study was to answer these questions and test our assumptions.

5.3. The Participants

One hundred and fifteen 8th grade elementary school students from four schools in Slovenia participated in the study. The study took place in 2022. Thirteen-and fourteen-year-old students expressed themselves artistically based on clearly thought-out criteria and were able to find rich and varied solutions to artistic problems. Special attention was paid to students' understanding of visualizations and the use of visual elements in virtual reality as they mastered the use of digital technologies.

5.4. Methodology

The survey was conducted according to the principles of a qualitative study. Prior to conducting the experiment, in addition to collecting demographic data, students performed a hands-on art task that allowed us to analyze each student's results and compare them to the results of tasks performed with the new media instrument. Rating scales were used to measure the factors of artistic creativity: Originality of the artistic product, Sensitivity in perceiving artistic qualities, Complexity in implementing artistic elements and materials, Complexity in esthetic planning and solving artistic problems, and Flexibility. Students' products were also evaluated qualitatively based on predetermined criteria for understanding art concepts. Three independent scorers, who evaluated the products according to precisely prescribed instructions based on predetermined evaluation criteria, also qualitatively evaluated the students' products made before and after the investigation.

At the end of the investigation, quantitative data were also collected using questionnaires for teachers and students. The questionnaires for students consisted of closed-ended questions on a Likert scale from 1 to 5, which we used to test their opinions about working with a new media device. The questionnaire for teachers was also designed to capture the opinions of the seven participating teachers. Questions were both closed-ended and open-ended, and we asked teachers to elaborate on their responses. Three independent raters scored the results according to carefully prescribed instructions on how to apply the scoring criteria, with which they were familiarized prior to scoring.

5.5. Results

The average score measured for creativity after the use of the created instrument was 4.2 out of 5 points. As for the factors of artistic creativity, the originality of the artistic product had an average score of 4.75, sensitivity in the perception of artistic qualities 4.31, complexity in the implementation of artistic elements and materials 4.00, complexity in the esthetic planning and solution of artistic problems 4.24, and flexibility 3.90. It is worth noting that 13 percent of the students who performed the worst in the first evaluation before using the didactic aid improved more than the students who performed well. These results are in general 10 percent higher than the marks within the first task where students did not use digital media.

Students who actively used new media as part of their assignments on architecture completed the student questionnaire. The new media provided students with a comprehensive picture of spatial design and architecture, as they could easily determine the proportions and relationships between different architectural elements. This can be inferred from their responses (Table 1).

In the questionnaire for teachers, who had a comprehensive overview of all research steps, the majority of them estimated that the quality of performance and perception of art tasks improved in spatial design with the use of new media tools compared to traditional working methods (Table 2).

All teachers agreed that the introduction of new media is useful as a didactic tool in the context of spatial design in elementary school. They stated that students use these tools to improve their creativity and spatial representations, and that it is important for students to be exposed to contemporary media.

6. Discussion

While observing the work process with the teaching-learning tool, we found consistently positive attitudes in students' implementation of art tasks, creativity, motivation, satisfaction, and understanding of art concepts. According to the responses to the questionnaire, students were motivated and improved their work through the learning medium of new media and augmented reality. The research results showed good effects through the use of new media in space design in the cognitive, affective and psychomotor areas of students' artistic expression. In the first phase of learning with markers, students responded enthusiastically and positively and mastered the use of markers without any problems.

The use of architectural elements to build spatial formations, which was a new media phenomenon triggered by virtual reality and enhanced by augmented reality, was a process that conveyed knowledge that had a positive impact on students' cognitive levels. Students were more creative than average.

They were able to build significantly more in virtual reality in a given amount of time than they would have with traditional methods of building like cardboard or paper models. Students mastered a greater number of transferred concepts with new media. They could build at will in augmented reality without the constraints that would be physically present. The affective state deepened and increased their attention. The three-dimensional digital bodies the students worked with fostered a positive attitude toward architecture. Students were more satisfied and motivated than when they worked traditionally, as evidenced by the qualitative results as well as analysis of the artwork and observation of students in the classrooms. Students were able to work with architectural elements, recognize changes in the quality of elements, and perform compositional operations. Students created virtual spatial entities from architectural elements in which they could intervene from one object to another or through them, strung three-dimensional bodies could be placed anywhere in space, in virtual reality. They could freeze a digital object anywhere and at any time because they did not have to wait for the glue to dry or create a base to build a model. This could be done regardless of the physical properties of the objects. Digital objects are not bound by gravity, which means that digital architectural elements or three-dimensional bodies can float or merge in virtual space as if they were transparent and without consistency. In the artistic expression, the students dealt with the art problem in an open, coordinated, and thoughtful way and realized solutions in which it became clear that they understood the specifics of the architectural materials.

When asked about the use of computers, cameras, and markers in the open-ended part of the questionnaire, teachers were positive. They indicated that students' motivation and spatial awareness increased, that they had more combination options, that students viewed the markers as a game, and that they enjoyed learning how to use the equipment.

Teachers indicated that they particularly liked that students were able look creatively for ways to solve tasks, implement ideas, and improve spatial performance through three-dimensional effects. Some indicated that this approach led to a reduction in the time it took to solve an art task, while also correcting mistakes quickly.

Teachers also indicated that students expected an easier way to use the didactic tool; they also had problems with devices that required assessment from a computer assistant in schools that had an inadequately equipped computer lab. However, it was also noted that these technologies should be used over a longer period to assess potential problems.

Teachers expressed a desire for further collaboration in the form of training, as they did not feel able to handle such technologies themselves or develop learning tools in the future.

At this point, it is important to cite Chandrasekera and Yoon,[27] who focused their research on the relationship between creativity and user preferences of different learning types when using augmented and virtual reality. The results of their research showed that the students included in the study were generally more inclined toward augmented than virtual reality, and the augmented reality-based learning environment seemed to be most useful for students with kinesthetic and visual learning types. Saltan and Arslan[28] showed that augmented reality learning can address multiple learning styles – visual, auditory, and kinesthetic – simultaneously, which many traditional learning aids cannot. This was also one of the advantages of using the created didactic aid.

7. Conclusion

The main focus of the research was to identify and explore an innovative system that uses a computer and a computer camera as a means of user interaction with new media through an interface, and its use in the 8th grade elementary school.

Learning always occurs in two phases: Perception, i.e., obtaining information about the content, whether based on observations, ideas, memories, or imaginations, and processing of the obtained data, i.e., checking the meaningfulness of information and storing it. There are different ways of perceiving and processing information. Learners perceive information in different ways: concretely, e.g., sensory information through touch, vision, or hearing, or abstractly, not based on previously acquired mental, visual, or conceptual models. The next step is to process the perceived or acquired information. Students process it by actively experimenting, performing certain activities, or using information by merely thinking about it.

The results obtained show that the use of new media is an example of good practice in spatial design and architecture in art education.

The qualitative part of the study clearly showed high perception of spatial visualization, recognition of patterns, positive attitudes, and behaviors towards the learning process.

Students made predictions independently, checked their accuracy and reliability themselves, had a broader view of the content and quality of implementation of solutions in the problem-solving process, and showed great autonomy in their creative process. The questionnaires we used to collect data on the organization and implementation of teaching with new media, attitudes toward the work environment, time management, and student satisfaction with artistic expression confirmed greater

[27] Tilanka Chandrasekera and So-Yeon Yoon, "Augmented Reality, Virtual Reality and their Effect on Learning Style in the Creative Design Process," *Design and Technology Education* 23, 1 (2018): 24–27.

[28] Fatih Saltan and Ömer Arslan, "The use of augmented reality in formal education: A scoping review," *Eurasia Journal of Mathematics, Science & Technology Education* 13, 2 (2017): 505–510.

efficiency, a faster process of visual exploration, and, consequently, faster development of ideas. The research results showed the characteristics of the learning process and the results of the use of new media in spatial design in the cognitive, affective, and psychomotor areas of students' artistic expression.

The use of new media with computer vision allows students to dive deep into the content and means an interesting experience with the interface and markers. The aim of the application is, among other things, to promote creativity, motivation, satisfaction and understanding of artistic concepts, as well as the development of a sensory perception of physical elements and the experience of virtual space.

The advantages of this type of new media application include feedback, the ability to choose the level of difficulty, experiential learning, selective sorting, working with information in a polyhedral manner, and immersion in content in both vertical and horizontal directions.

The scientific contribution is mainly concerned with the development of contemporary educational technology and the development of learning media within the framework of art didactics, in order to achieve the best possible vividness and complexity of teaching.

The present results and findings contribute to the optimization of spatial design teaching in elementary schools. The study provides a guideline for the use of new media and thus encourages teachers to use them. Nevertheless, the presented didactic tool is only one example in the variety of didactic materials available today. Even though digital technologies have many advantages in the pedagogical process, nothing can replace the manual aspect of art education. For a holistic development of students' personalities, both approaches are essential and must complement each other.

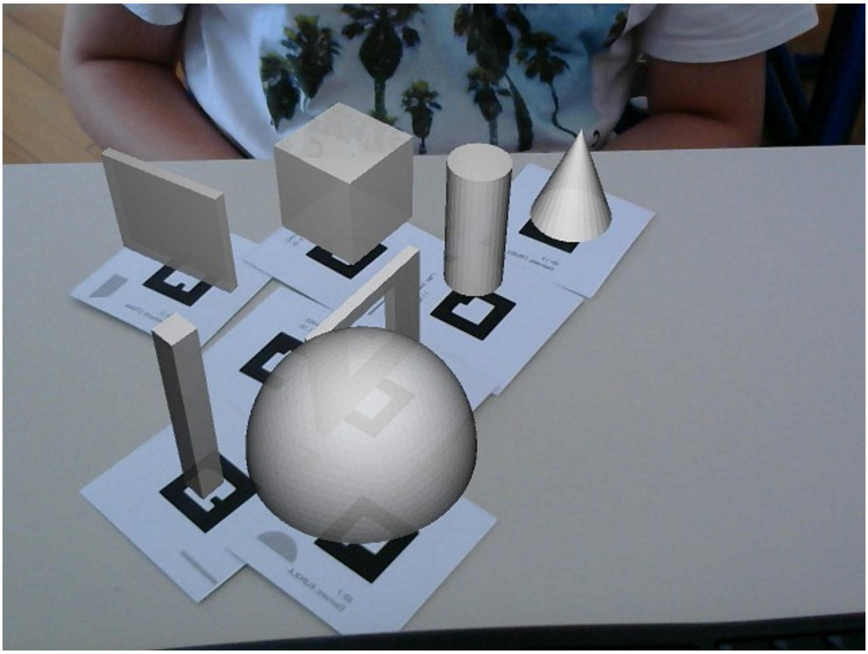

Figure 1. Image of the recognized markers with three-dimensional renderings of the virtual models. Source: author's archive.

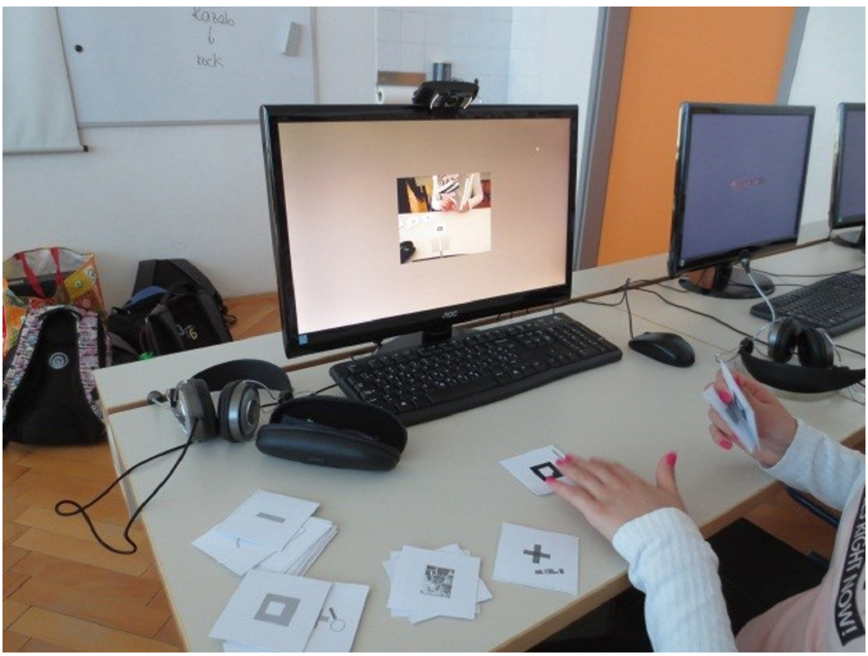

Figure 2. Handling of markers recognized by computer vision. Source: author's archive.

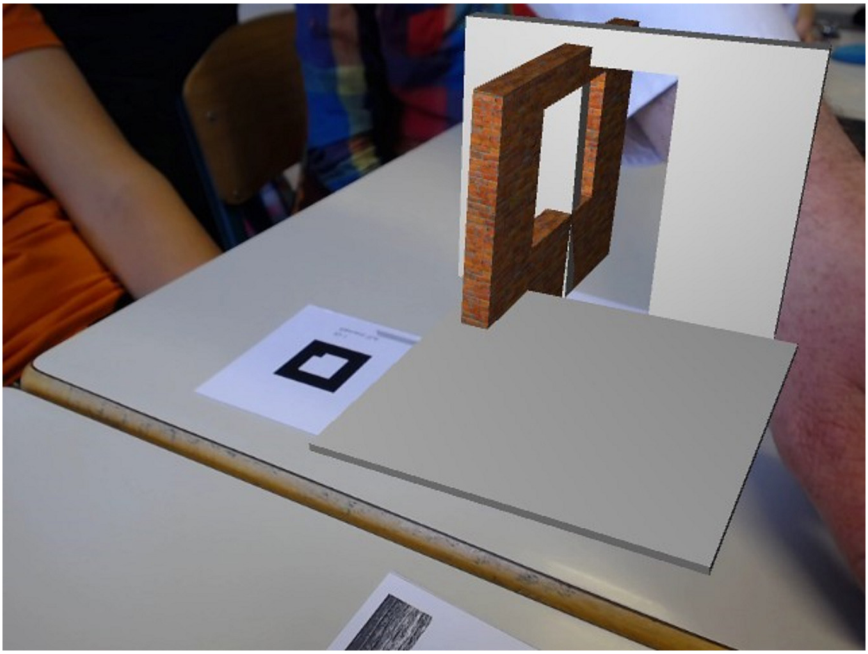

Figure 3. Markers detected by computer vision with a three-dimensional rendering of virtual models. Source: author's archive.

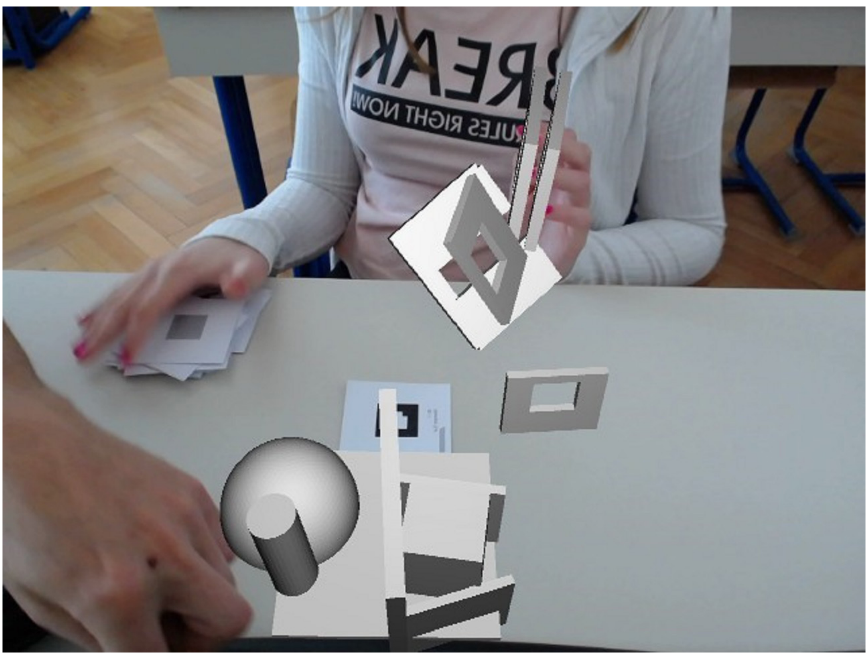

Figure 4. Construction and manipulation of a spatial formation using a new augmented reality media tool. Source: author's archive.

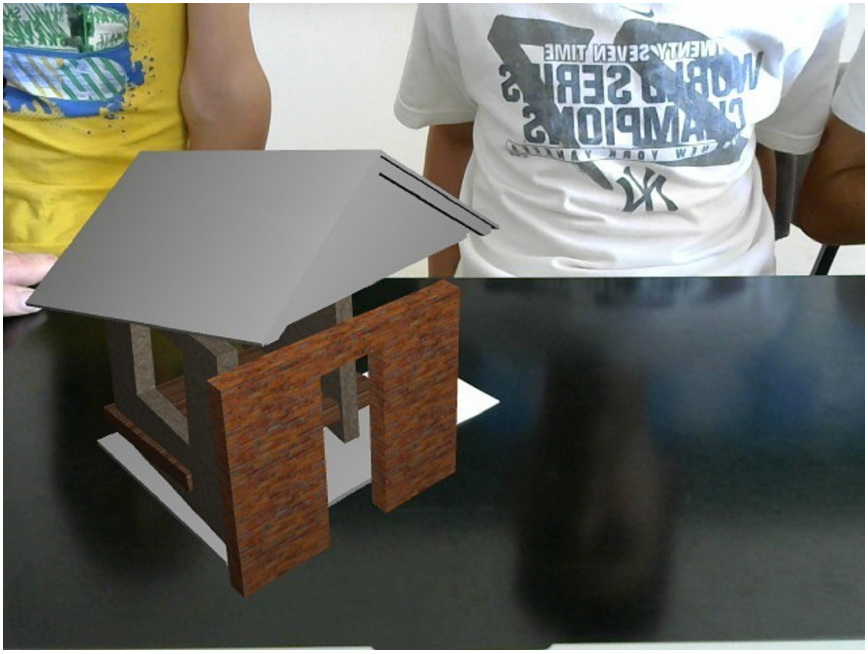

Figure 5. Virtual reality-based spatial formation with an assigned texture triggered by an augmented reality marker. Source: author's archive.

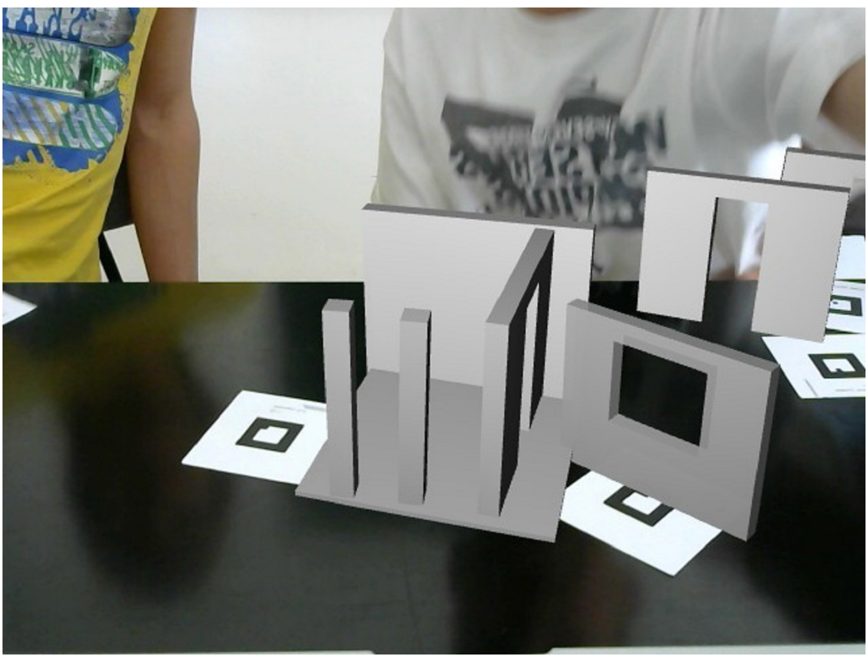

Figure 6. Architectural design using new media and augmented reality tools. Source: author's archive.

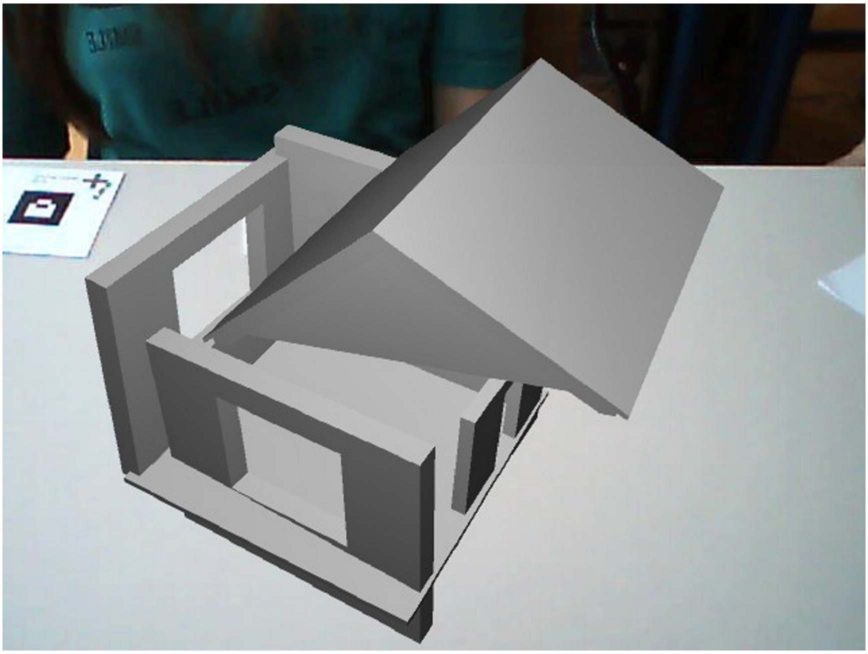

Figure 7. Example of composition of an architectural formation with a floating roof. Source: author's archive.

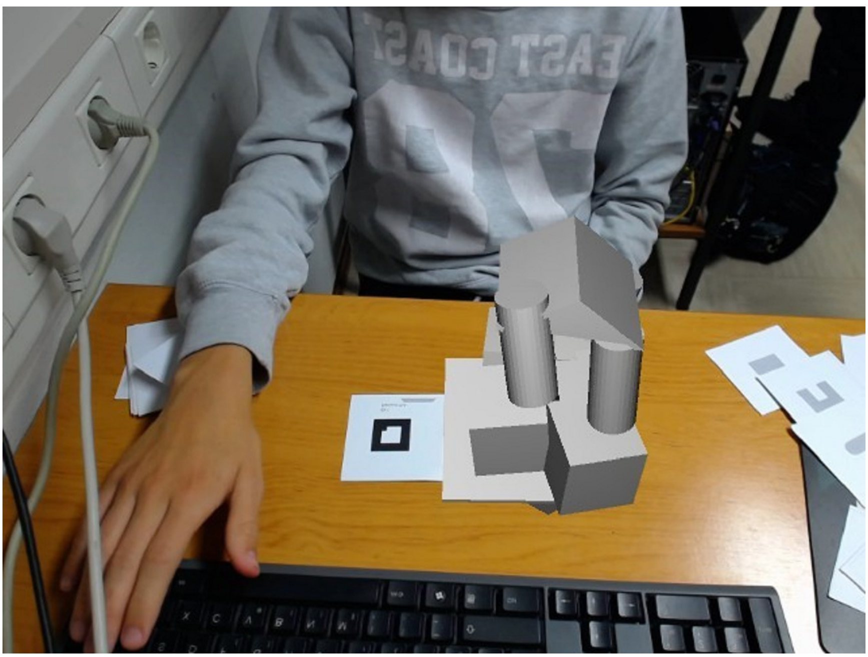

Figure 8. Composition of a spatial design with virtual architectural elements using the new augmented reality media tool. Source: author's archive.

Table 1. Questionnaire for students with results.

Assertion	*M*	*SD*	Min	Max n	total
Using cards and the computer I easily changed the position of architectural elements and their surfaces.	3,87	1,01	1,00	5,00	115
Working with cards and the computer screen took place relaxed and freely.	4,31	0,99	1,00	5,00	115
I used the computer screen and cards without any problems.	3,57	1,10	1,00	5,00	115
Working with cards and computer screen gave me a better insight into the space and object I was creating.	4.13	0,93	2,00	5,00	115
I found it easier to build with cards when I had them used a second time for another task.	3,82	1,08	1,00	5,00	115
The way of solving tasks was more interesting than usual.	4,31	0,99	1,00	5,00	115
The way of solving tasks was more dynamic than usual.	4,13	0,93	2,00	5,00	115
The work process was more creative than usual.	3.87	1.01	1.00	5.00	115
Work was easier than usual.	4.13	0.93	1.00	5.00	115

Table 2. Teacher agreement with statements about the use of new media tools. All results are expressed as percentages.

The assertion	I do not agree at all	I do not agree	I cannot decide	I agree	I absolutely agree
The implementation of the learning process with new media in the field of spatial design or architecture makes a lot of sense to me.	0.0	0.0	0.0	57.1	42.9
The use of new media has had an impact on increasing creativity in solving artistic tasks.	0.0	0.0	14.3	57.1	28.6
The use of new media has had an impact on increasing understanding of artistic concepts, materials, and equipment.	0.0	0.0	28.6	57.1	14.3
The use of new media has had a positive impact on students‘ attitudes toward work and scheduling.	0.0	0.0	14.3	57.1	28.6
The use of new media has had a positive impact on students' sensitivity to artistic elements and their interrelationships.	0.0	0.0	28.6	42.9	28.6
The use of new media has positively impacted students' satisfaction with artistic expression.	0.0	0.0	14.3	28.6	57.1
The new media tool was too sophisticated for use in spatial design or architecture.	14.3	71.4	14.3	0.0	0.0
The new media tool was completely unmanageable in use in the field of architecture.	0.0	0.0	14.3	71.4	14.3
The use of the new media allowed students to gain deep insight into the content.	0.0	0.0	14.3	57.1	28.6
The use of new media allows the student to better visualize three-dimensional objects in space.	14.3	0.0	0.0	0.0	85.7
Efforts should be made to increase the use of new media tools in the art classroom.		0.0	28.6	28.6	42.9

References

Azuma, Ronald T. "A Survey of Augmented Reality." *Presence: Teleoperators and Virtual Environments* 6 (1997): 355–385. https://doi.org/10.1162/pres.1997.6.4.355

Chandrasekera, Tilanka and So-Yeon Yoon. "Augmented Reality, Virtual Reality and their Effect on Learning Style in the Creative Design Process." *Design and Technology Education: An International Journal* 23, 1 (2018): 55–75.

Crary, Jonathan. *Suspensions of Perception*. London: The MIT Press, 1999.

Friedberg, Anne. *The Virtual Window: From Alberti to Microsoft*. London: The MIT Press, 2006.

Debevec, Luka. "Application as a tool for research on the use of new media in teaching spatial design in primary schools." Ph.D. diss. University of Ljubljana, Faculty of Computer and Information Sciences, 2014.

Grau, Oliver. *From Illusion to Immersion*. London: The MIT Press, 2003.

Heim, Michael. *Virtual Realism*. New York: Oxford University Press, 1998.

Heydon, Jeff. "The View from the Window." *Canadian Journal of Communication* 38, 4 (2013): 531–544. https://doi.org/10.22230/cjc.2013v38n4a2676

Hsiao, Kuei-Fang and Nian-Shing Chen. "The Development of the AR-Fitness System in Education." In *Edutainment Technologies. Educational Games and Virtual Reality/Augmented Reality Applications.* Proceedings of the Sixth International Conference on E-learning and Games, September 7–9, 2011, Taipei, Taiwan, edited by W. Y. Chang, M. P. Hwang, W. Mueller, 2–11. Berlin: Springer, 2011.

Kerawalla, Lucinda, Rosemary Luckin, Simon Seljeflot, and Adrian Woolard. "'Making it real': exploring the potential of augmented reality for teaching primary school science." *Virtual Reality* 10 (2006): 163–174.

Kesim, Mehmet and Yasin Ozarslan. "Augmented Reality in Education: Current Technologies and the Potential for Education." *Procedia – Social and Behavioral Sciences* 47 (2012): 297–302. https://doi.org/10.1016/j.sbspro.2012.06.654

Manovich, Lev. *The Language of New Media*. London: Routledge, 2001.

Manovich, Lev. "New Media from Borges to HTML." In *The New Media Reader*, edited by Noah Wardrip-Fruin and Nick Montfort, 13–25. Cambridge, Massachusetts: The MIT Press, 2003.

Moreno-Ger, Pablo, Daniel Burgos, José Luis Sierra, and Baltasar Fernández-Manjón. "A game-based adaptive learning unit with IMS Learning Design." In *Lecture Notes in Computer Science: Creating New Learning Experiences on a Global Scale*, edited by Erik Duval, Ralf Klamm, Martin Wolpers, 247–261. Berlin: Springer, 2007.

O'Brien, Heather L. and Elaine G. Toms. "Engagement as a process in computer-mediated environments." In *Proceedings of the American Society for Information Science and Technology* 42, 1 (2005). https://doi.org/10.1002/meet.14504201233

Pallasmaa, Juhani. *The Eyes of the Skin: Architecture, and the Senses*. Chichester: John Wiley & Sons Ltd., 2005.

Radu, Iulian. Augmented reality in education: A meta-review and cross-media analysis. *Personal and Ubiquitous Computing* 18 (2014): 1533–1543.

Rountree, Janet, William Wong, and Robert Hannah. "Learning to look: Real and virtual artifacts." *Educational Technology & Society* 5, 1 (January 2002, Integrating Technology into Learning and Working, Part 1): 129–134.

Saltan, Fatih, and Ömer Arslan. "The use of augmented reality in formal education: A scoping review." *Eurasia Journal of Mathematics, Science & Technology Education* 13, 2 (2017): 503–520. https://doi.org/10.12973/eurasia.2017.00628a.

Shanshan, Li. "Assessing the user experience when using mobile augmented reality in advertising." Ph.D. diss. Purdue University, 2014. https://docs.lib.purdue.edu/cgi/viewcontent.cgi?referer=&httpsredir=1&article=1232&context=open_access_theses. Accessed on June 21, 2022.

Stokes, Suzanne. "Visual literacy in teaching and learning: A Literature Perspective." *Electronic Journal for the Integration of Technology in Education* 1, 1 (2002): 10–19.

Tacol, Tonka. *Didaktični pristop k načrtovanju likovnih nalog. Izbrana poglavja iz likovne didaktike* [Didactic approach to planning art assignments. Selected chapters from art didactics]. Ljubljana: Debora, 1999.

Vidler, Anthony. *Warped Space: Art, Architecture, and Anxiety in Modern Culture*. Cambridge MA: The MIT Press, 2001.

Zheng, Shen. "Research on Mobile Learning Based on Augmented Reality." *Open Journal of Social Sciences* 3, 12 (2015): 179–182, 2015. https://doi.org/10.4236/jss.2015.312019

Article received: April 19, 2023
Article accepted: June 23, 2023
Original scholarly paper