UNIVERSITY STUDENTS' OPINIONS ON THE USE OF 3D HOLOGRAMS IN LEARNING ORGANIC CHEMISTRY

Stanislava Olić Ninković , Jasna Adamov
University of Novi Sad, Republic of Serbia
E-mail: stanislava.olic@dh.uns.ac.rs, jasna.adamov@dh.uns.ac.rs

Abstract

3D holograms are an effective tool for visualization, and their utilization in chemistry teaching can be beneficial in improving learning outcomes. However, studies on students' opinions about holograms in chemistry teaching and learning are scarce. The research aimed to examine the views of chemistry students on the application of 3D holograms in organic chemistry learning at the university level. In this cross-sectional study, 55 first-year chemistry students at the University of Novi Sad (Serbia) participated. The sample consisted of students aged 18-20, of which 85.5% were female and 14.5% were male. An online questionnaire designed for this research was used to collect quantitative data. Data obtained after an eight-week application of 3D holograms in organic chemistry classes revealed that students have a positive opinion about the application of 3D holograms in organic chemistry classes. Therefore, the research results imply that teachers should apply 3D holograms in chemistry classes.
Keywords: *augmented reality, 3D holograms, chemistry education, students' opinion*

Introduction

New generations of students, which are called Generation Z or Millennial students, have grown up in digital environments, developing specific attitudes, beliefs, social norms, and behaviors. Working with these students demands of educators a change in the strategies and design of teaching and learning. Therefore, teachers are constantly looking for new approaches to motivate and engage new generations of students in learning. Technological development plays a very important role in improving the educational process, which increased interest in the application of virtual and augmented reality (Cheng & Tsai, 2013). The potential of augmented reality for improving students' domain-specific knowledge and general skills (that is, collaboration) has been increasingly acknowledged (Ke & Hsu, 2015). The 3D hologram is one of the most advanced technologies recognized as an effective visualization tool (Hoon & Shaharuddin, 2019), which is based on the use of a computer system or smartphone to create the illusion of a three-dimensional image and mimic the real world (Moro et al., 2021). The representation of images goes beyond the two-dimensional (2D) screen to the 3D space through light diffusion, which allows a high sense of reality (Yoo et al., 2022). This projection of virtual content is mediated by the aid of technological devices and transparent surfaces.

Hologram technologies are applicable to a variety of industries (Yoo et al., 2022). In recent years, the application of 3D holograms has become more popular

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in various fields such as medicine (Barsom, et al., 2016; Mishra, 2017), architecture and engineering (Behzadan et al., 2015), and education (Akçayır et al., 2016; Hoon & Shaharuddin, 2019). In the field of education, 3D holograms aim to help students and teachers see objects from different angles that are not available in traditional teaching and learning environments (Hoon & Shaharuddin, 2019). Several empirical studies have confirmed that the application of 3D holograms in education has positive effects on students: it contributes to a better understanding of the material (Moro et al., 2021), improves learning outcomes (Akcaiır et al., 2016; Hoon & Shaharuddin, 2019), and increases student motivation (Akcaiır et al., 2016; Hoon & Shaharuddin, 2019; Moro et al., 2021). It can be said that the 3D holograms in the classroom represent a futuristic way to improve teaching and learning (Ramachandiran et al., 2019). One essential advantage of 3D holograms is their suitability for learners of all ages. Several studies have reported on the use of holograms in preschool, elementary, and high school education, and studies that specifically examined teachers' and students' perceptions of the use of technology in education are limited (Yoo et al., 2022). However, the use of 3D holograms in the classroom has limitations such as the costs of purchasing additional equipment, maintenance, and the costs of teacher training for their creation and implementation. Since the hologram is a major technological advance, its implementation and maintenance will not be cheap because resources are limited depending on institutions or countries (Ramachandiran et al., 2019).

The number of studies concerning the application of 3D holograms in the teaching of natural sciences is thin and relates primarily to the development of visualization tools for scientific spatial understanding: the understanding of the geometric structure of molecules (Hinsen, 2000; Cheng & Tsai, 2013), laboratory work (Akçayır et al., 2016), inquiry-based learning (Squire & Klopfer 2007). The great potential of applying 3D holograms in education has been recognized. However, the application of augmented reality and holograms in education is still in its infancy, and studies on this issue are still rare (Cheng & Tsai, 2013). Few existing studies have focused on the development, usability, and initial implications of 3D holograms (Akçayır et al., 2016; El Sayed et al., 2011). Yoo et al (2022) found that there was a lack of examining the educational effects in a more structured, generalized, and replicable manner. These questions require further attention to stably apply the new technology and maximize the benefits of the 3D holograms for enhancing students' learning experience, outcomes, and performance.

Research Problem

With the increased interest and application of 3D holograms in teaching, the need for research into the effectiveness and perception of teachers and students increases. Furthermore, their users must also be asked for their opinion on their usefulness and usability. The focus of this research was the students' opinions about the possibilities of applying 3D holograms in chemistry classes. The contribution of this research is to provide insight into students' feedback on the integration of 3D holograms into the chemistry learning environment, understanding the factors for motivating and engaging students to improve their skills at the higher education level. Due to the complexity of the chemical contents, every support in overcoming the problems and understanding the chemical contents is necessary.

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Research Aim and Research Questions

This research aimed to examine chemistry students' opinions about the application of 3D holograms in learning organic chemistry at the university level. The following research questions were posed:

1. To what extent have students used 3D holograms in education so far?
2. How much do students perceive the values of 3D holograms in learning organic chemistry?
3. What are the students' perceptions of possibilities for using 3D holograms in other chemistry disciplines?

Research Methodology

General Background

This research examined the perceptions of chemistry students about the application of 3D holograms in university organic chemistry learning. The research was conducted during the 2021-2022 school year on a sample of 55 first-year students (aged 18-20). We conducted a preliminary study to examine students' opinions on the application of 3D holograms in chemistry classes. During the eighth week, holograms were used in theory classes, which were made for research purposes following the curriculum of Organic Chemistry I. After the course, students were surveyed with an online questionnaire on the role and importance of 3D holograms in organic chemistry classes using their mobile phones.

Sample

The convenience sample consisted of first-year students of one study program–Bachelor in Chemistry at the Department of Chemistry, Biochemistry, and Environmental Protection of the Faculty of Science, University of Novi Sad in Serbia. In the first year of study, 60 students enrolled in this program, while in the present research, 55 students participated and filled out the survey. The research was conducted during the summer semester of the 2021/2022 school year. The age of the students was in the range of 18 to 20 years. The sample consisted of 14.5% male and 85.5% female students. The students were informed that the research was anonymous and that their participation was voluntary so that they could withdraw from the research at any time without consequences.

Instrument and Procedures

This research was conducted on the subject of Organic Chemistry I. The course is compulsory, and it is conducted during the summer semester with 4 theoretical hours and 3 hours of laboratory work per week. This course includes teaching content on characteristic functional groups in organic molecules, structure, and bonds, nomenclature, and their physical and chemical properties. Due to their complex nature and study at the micro level, the above contents are often very difficult for students to understand. Understanding the structure of molecules is often abstract to students, so it is much easier to represent them with the help of holograms.

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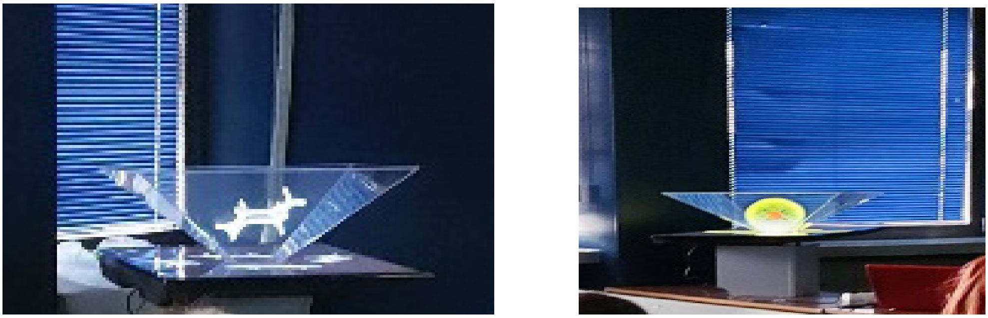
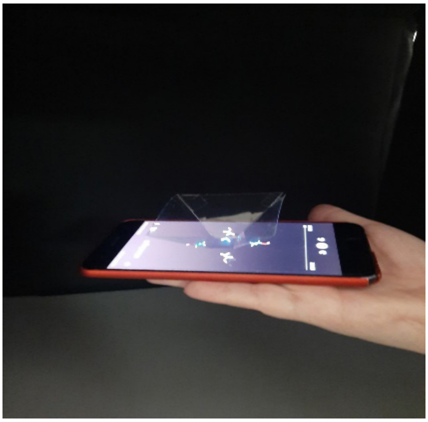
The 3D holograms used were created in Filmora's Wondershare program as 1- to 3-minute non-narrated videos (Figure 1). Two university professors from the field of organic chemistry and one professor from the field of educational technology participated in the videos. They consulted and relied on the opinion of pedagogues during the drafting process.

Figure 1
Examples of 3D Holograms for Teaching Organic Chemistry



During the summer semester of the 2021/2022 academic year, holograms were used in organic chemistry classes during the new material processing. 3D Holograms were used every week, for 8 weeks of lecture classes. During work, there were no technical problems such as connection problems, power outages, etc. The students watched the 3D holograms with the teacher's explanation, with the possibility of rewatching the holograms during the lesson. The students received mini prisms that they could also use when studying at home via their own mobile devices (Figure 2). In this way, it was ensured that students see the 3D holograms over and over again while studying the course content at a pace that suits them.

Figure 2
Students' 3D Holograms for Smartphones



After the course, students were surveyed about the role and importance of 3D holograms in chemistry classes. To collect quantitative data, a questionnaire that was constructed for this research was used. The survey consisted of six questions that were asked to students through an electronic voting system accessed through their mobile phones. The questions were of different types; three questions were given in the form of multiple choices, two questions in the form of a 5-point Likert scale, and one open-ended question. All survey questions are provided in Appendix.

Data Analysis

Descriptive statistics were used in the analysis of the collected data. Students' answers to open-ended and multiple-choice questions were analyzed by calculating frequencies and percentages. In addition to that, the mean values for students' answers to questions in the form of a 5-point scale were calculated. The analysis was done in MS Excel.

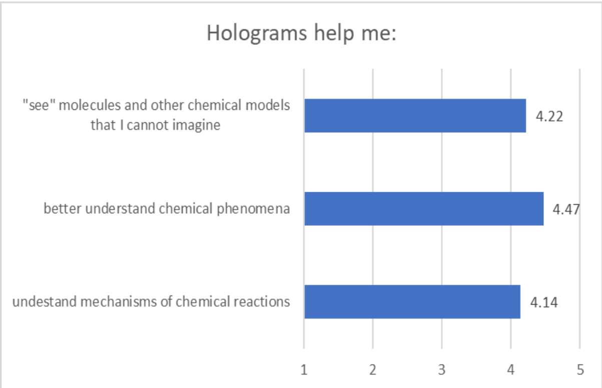
Research Results

Students' answers to the first question provided information on their previous experience and the opportunity to see 3D holograms. Of the total sample of students, 90.9% had never had the opportunity to see live three-dimensional 3D holograms before. The other 9.1% of students have seen them but never used them during teaching/learning.

After the organic chemistry classes were held using 3D holograms, the majority of students (49 students, i.e., 89.1%) liked the use of 3D holograms in classes. Only 3.6% of the sample (that is, 2 students) had a negative opinion about their application, while the other 4 students (7.3%) did not have a certain attitude towards 3D holograms.

The reasons provided by the students for their opinion are given in Figure 3. Students rated the three offered statements on a 5-point Likert scale, where 1 means complete disagreement, and 5 - complete agreement. Figure 3 displays the mean values of the students' responses.

Figure 3
Students` Opinions Regarding Usefulness of Holograms in Learning



Note: 1 means complete disagreement, and 5 - complete agreement

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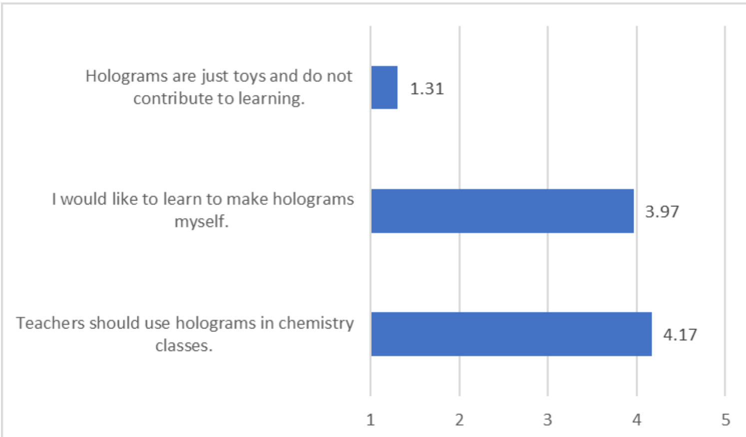
When asked about the applicability and role of 3D holograms in teaching, the students rated the statements on the same Likert scale. Figure 4 displays the mean values of the students' responses.

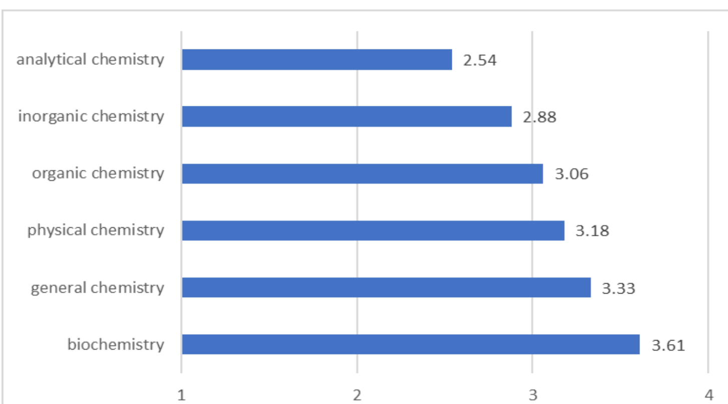
Figure 4
Students` Opinions about the Applicability and Role of 3D Holograms in Learning



Note: 1 means complete disagreement, and 5 - complete agreement

In the fifth question, students were asked to arrange the offered chemical disciplines in descending order according to the possibilities and the need to apply 3D holograms within classes in the courses in those fields. Their opinions are shown in Figure 5. In the first place there is the discipline in which the implementation of 3D holograms, according to the students, was the most useful, and in the sixth place - is the discipline for which holograms are the least important.

Figure 5
Students` Opinions about the Application of 3D Holograms in Differences Chemical Disciplines



In response to the sixth open-ended question, students reported which 3D holograms they would like teachers to make and use in explanations during lectures and exercises. The students could provide multiple answers to this question. More than a third of the students (34,5%) reported that they would like to see teachers present chemical reaction mechanisms. Furthermore, 23.6% of the participants reported that they would like to see holograms of the 3D structures of molecules and the spatial arrangement of the atoms in them. 11% of students indicated that holograms provided the possibility of isomerism, while 9% of students indicated that they were interested in the rotation of molecules by a certain angle to better understand the structural characteristics of the molecule. According to the students, holograms should show the formation of chemical bonds and hybridization (9%), the structure of crystal lattices (9%), as well as the development of some technological processes (9%).

Discussion

Chemistry is a complex subject for many students because it contains many abstract concepts (Santos & Arroio, 2016). Understanding these phenomena is often difficult without the use of various visualization tools (Jones et al., 2005). Given that 3D holograms are one of the most advanced technologies for visualization (Hoon & Shaharuddin, 2019), this research was conducted to examine the opinions of chemistry students about the application of 3D holograms in the learning of organic chemistry at the university level.

The obtained results indicated that none of the students included in this research had ever had the opportunity to use or see 3D holograms during learning before. However, few students have had the opportunity to see live 3D holograms outside of an educational context. This result unequivocally confirms that 3D holograms are a new teaching tool and that their application is in its infancy in education environments and other fields (Cheng & Tsai, 2013).

The majority of students said that they liked the use of 3D holograms in classes. The obtained results showed that students had a coherent opinion that the application of 3D holograms in the learning of organic chemistry was useful. The results of other research have mostly shown positive attitudes (satisfaction or perceived usefulness) of students towards augmented reality and the application of 3D holograms (Akçayır et al., 2016; Cheng & Tsai, 2013; Hoon & Shaharuddin, 2019, Moro et al., 2021).

All student responses indicated a high level of agreement with the given statements. Surveyed students reported that 3D holograms made it easier for them to visualize models of molecules and mechanisms of chemical reactions, and thus helped them to gain a better understanding of various abstract concepts, phenomena, and processes encountered in chemistry classes. According to scientific studies, organic chemistry concepts are burdensome for many students and are the source of numerous misconceptions (Duis, 2011).

In summarizing the students' responses about the applicability and role of 3D holograms in chemistry classes, it can be concluded that most students consider them very useful in regular classes. Furthermore, many students who participated in the survey expressed a desire to learn how to make 3D holograms themselves. Only a small number of students felt that in chemistry classes, holographic technology was an expensive toy that did not contribute to learning.

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According to the results, students believe that 3D holograms can be applied in other chemical disciplines as well. The students indicated that holograms would be most useful for studying the biochemical structures and mechanisms of metabolic transformations of biomolecules. The following are the contents of general and physical chemistry, which include numerous abstract concepts. In the fourth place are the contents of organic chemistry. In the last two places, students put analytical and inorganic chemistry. These disciplines require practical laboratory work and experimental acquaintance with the properties of various substances and methods for their qualitative and quantitative determination. According to students' perceptions, 3D holograms cannot significantly help them to improve their laboratory skills.

Despite the importance of the obtained findings, the following limitations should be kept in mind. The sample included only first-year students, so the research results cannot be generalized to the entire student population. Potential future research should include students from other years, and the topics covered with the application of holograms should be from other chemical disciplines such as biochemistry and general chemistry, etc.

Conclusions and Implications

Based on the results obtained in the conducted research, a general conclusion can be drawn that chemistry students have a positive opinion about the application of 3D holograms in learning organic chemistry at the higher education level. Although the students did not have the opportunity to see 3D holograms before this research, they believe that they are useful for understanding the content of organic chemistry and that they help them visualize models of molecules and mechanisms of chemical reactions and thus help them to gain a better understanding of various abstract concepts, phenomena, and processes encountered in chemistry classes. In addition, they believe that the implementation of 3D holograms would be useful for other chemical disciplines such as biochemistry, general chemistry, etc. Also, the students pointed out that they would like to learn how to make 3D holograms. All the above results suggest that the application of 3D holograms in the teaching and learning of chemistry should be implemented and that this is an area that will be followed by further accelerated development and implementation in the educational system.

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Declaration of Interest

The authors declare no competing interest.

References

Akçayır, M., Akçayır, G., Pektaş, H. M., & Ocak, M. A. (2016). Augmented reality in science laboratories: The effects of augmented reality on university students' laboratory skills and attitudes toward science laboratories. *Computers in Human Behavior*, *57*, 334-342. https://doi.org/10.1016/j.chb.2015.12.054

Barsom, E. Z., Graafland, M., & Schijven, M. P. (2016). A systematic review on the effectiveness of augmented reality applications in medical training. *Surgical Endoscopy*, *30*, 4174-4183. https://doi.org/10.1007/s00464-016-4800-6

Behzadan, A. H., Dong, S., & Kamat, V. R. (2015). Augmented reality visualization: A review of civil infrastructure system applications. *Advanced Engineering Informatics*, *29*(2), 252-267. https://doi.org/10.1016/j.aei.2015.03.005

Cheng, K. H., & Tsai, C. C. (2013). Affordances of augmented reality in science learning: Suggestions for future research. *Journal of Science Education and Technology*, *22*, 449-462. https://doi.org/10.1007/s10956-012-9405-9

Duis, J. M. (2011). Organic chemistry educators' perspectives on fundamental concepts and misconceptions: An exploratory study. *Journal of Chemical Education*, *88*(3), 346-350. https://doi.org/10.1021/ed1007266

El Sayed, N. A., Zayed, H. H., & Sharawy, M. I. (2010). Augmented reality student card. *Computer & Education*, *56*, 1045-1061. https://doi.org/10.1016/j.compedu.2010.10.019

Hinsen, K. (2000). The molecular modelling toolkit: A new approach to molecular simulations. *Journal of Computational Chemistry*, *21*(2), 79-85. https://doi.org/10.1002/(SICI)1096-987X(20000130)21:2%3C79::AID-JCC1%3E3.0.CO;2-B

Hoon, L. N., & Shaharuddin, S. S. (2019). Learning effectiveness of 3D hologram animation on primary school learners. *Journal of Visual Art and Design*, *11*(2), 93-104. https://doi.org/10.5614/j.vad.2019.11.2.2

Jones, L. L., Jordan, K. D., & Stillings, N. A. (2005). Molecular visualization in chemistry education: the role of multidisciplinary collaboration. *Chemistry Education Research and Practice*, *6*(3), 136-149. https://doi.org/10.1039/B5RP90005K

Ke, F., & Hsu, Y. C. (2015). Mobile augmented-reality artefact creation as a component of mobile computer-supported collaborative learning. *The Internet and Higher Education*, *26*, 33-41. https://doi.org/10.1016/j.iheduc.2015.04.003

Mishra, S. (2017). Hologram the future of medicine – From Star Wars to clinical imaging. *Indian Heart Journal*, *69*(4), 566–567. https://doi.org/10.1016/j.ihj.2017.07.017

Moro, C., Phelps, C., Redmond, P., & Stromberga, Z. (2021). HoloLens and mobile augmented reality in medical and health science education: A randomized controlled trial. *British Journal of Educational Technology*, *52*(2), 680-694. https://doi.org/10.1111/bjet.1304

Ramachandiran, C. R., Chong, M. M., & Subramanian, P. (2019). The 3D hologram in the futuristic classroom: A review. *Periodicals of Engineering and Natural Sciences*, *7*(2), 580-586. http://dx.doi.org/10.21533/pen.v7i2.441.g325

Santos, V. C., & Arroio, A. (2016). The representational levels: Influences and contributions to research in chemical education. *Journal of Turkish Science Education*, *13*(1), 3-18.

Squire, K., & Klopfer, E. (2007). Augmented reality simulations on handheld computers. *The Journal of the Learning Sciences*, *16*(3), 371-413. https://doi.org/10.1080/10508400701413435

Yoo, H. W., Jang, J. H., Oh, H. J., & Park, I. W. (2022). The potential and trends of holography in education: A scoping review. *Computers & Education*, 186, 104533. https://doi.org/10.1016/j.compedu.2022.104533

Appendix - Instrument

1. Have you seen/used a hologram in learning before this class?
   - □ Yes
   - □ Used them during teaching/learning
   - □ No

2. Do you like the holograms made for chemistry classes?
   - □ Yes
   - □ No
   - □ I do not know

3. How much do you agree with the following statements?
   1 - means complete disagreement
   5 - complete agreement

Holograms help me					
“see” molecules and other chemical models that I cannot imagine.	1	2	3	4	5
better understand chemical phenomena.	1	2	3	4	5
understand mechanisms of chemical reactions.	1	2	3	4	5

4. How much do you agree with the following statements?
   1 - means complete disagreement
   5 - complete agreement

Holograms are just toys and do not contribute to learning.	1	2	3	4	5
I would like to learn to make holograms myself.	1	2	3	4	5
Teachers should use holograms in chemistry classes.	1	2	3	4	5

5. In what disciplines of chemistry would holograms be most useful? Rank the given areas from most important (6) to least important (1).

   - □ General chemistry
   - □ Inorganic chemistry
   - □ Analytical chemistry
   - □ Physical chemistry
   - □ Organic chemistry
   - □ Biochemistry

6. If you have any suggestions for holograms that you would like teachers to use in their explanations, please write them here.

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