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APPLICATION OF AUGMENTED VIRTUAL REALITY TECHNOLOGY IN TEACHING CHEMISTRY IN HIGH SCHOOLS

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ABSTRACT

With the robust development of the fourth industrial revolution and advancements in the field of educational science due to the integration of technology with education, Augmented Reality (AR) stands out as a promising tool for enhancing learning experiences. AR offers significant potential and numerous essential benefits in teaching and learning processes, thanks to its interactive and visual nature. This article focuses on introducing AR and outlining designs as well as proposing chemistry lesson contents integrated with AR in three formats: providing knowledge to learners; constructing hypothetical situations, simulating processes; and assessment and evaluation. By leveraging AR, we encourage students' proactive engagement and foster an interest in chemistry by making the learning experience more immersive and hands-on. AR allows students to manipulate virtual objects and conduct experiments in a safe and controlled environment, enhancing their understanding of complex chemical concepts. The potential and benefits that AR brings have facilitated groundbreaking advancements in teaching and learning at the general education level.

KEYWORDS: Augmented reality, 3D model, Education, Chemistry

1. INTRODUCTION

In the current era, with the remarkable advancements in technology, the field of education is undergoing significant transformations (Khan et al., 2019). Tools and techniques previously considered advanced are now indispensable in shaping future teaching methods (Haleem et al., 2022). Among these notable technologies, Augmented Reality (AR) has stood out with its capability to blend the digital world with reality (Cai et al., 2017). Especially in subjects like chemistry, where abstract and dynamic concepts frequently emerge, AR has demonstrated substantial potential in visualizing and simplifying these complex ideas (Mohammed et al., 2022).

The challenges of teaching chemistry, especially at the secondary level, have been clearly acknowledged (Edomwonyi-Otu & Avaa, 2011). Concepts such as molecular interactions and atomic structures demand students to transcend the limitations of two-dimensional imagery and grasp threedimensional reality (Toledo-Morales & Sanchez-Garcia, 2018). Although teachers often employ diagrams, physical models, and verbal descriptions, these tools fall short in sparking curiosity and fostering active student engagement in the learning process (Kaur et al., 2020).

AR is a promising tool capable of revolutionizing the teaching space. By integrating virtual data into reality, AR enables students to experience more diverse and richer interactions (Fernandez, 2017). Students can not only visualize chemical structures in three dimensions but also interact with these models in real-time, deepening their understanding of matter (Titchiev et al., 2023).

The increased accessibility to AR-compatible devices, such as smartphones and tablets, has made integrating AR into classrooms more feasible (Soroko, 2021). While the initial strides in AR integration have shown considerable promise (Guntur et al., 2020), comprehensive research focused on AR applications in secondary school chemistry remains essential.

This article contributes the dedication of our research group in this domain. We have examined the advantages and potential challenges, along with methods related to the application of AR in teaching chemistry, aiming to provide an overview for the teaching community. Furthermore, our research team has proposed four modes of integrating AR in chemistry instruction, including knowledge delivery, creating hypothetical scenarios, diverse simulations (which might relate to mechanisms, models, or other simulations), and employing AR in assessment and evaluation processes. We believe that applying AR in these ways can enhance the effectiveness of teaching and learning.

In conclusion, given the evolution of education and the digital age, grasping and optimally utilizing tools like AR becomes crucial. Through detailed research and evidence-based proposals, this article seeks to uncover the potential of AR in teaching secondary-level chemistry, paving the way for richer and more varied learning experiences.

2. LITERATURE REVIEW

AR is increasingly becoming indispensable in the field of chemistry education at secondary schools. Utilizing AR in the educational environment not only enhances the quality of learning from merely memorizing knowledge but also promotes the active engagement of students rather than making them passive. AR offers a more visual and comprehensive perspective on learning content (Akcayir & Akcayir, 2017). Notably, AR allows teachers to create chemistry applications and games in which students can actively participate and interact (Criollo-C et al., 2021). For example, an AR application can transform a lecture about a chemical reaction into a simulation game, allowing students to participate and observe the results directly on their devices. This creates an engaging learning environment and fosters deeper interaction throughout the learning process (Yip et al., 2019).

An essential aspect of chemistry education is understanding molecular structures and interactions. AR has the capability to create 3D molecular models and allows students to interact visually with them

(Wu et al., 2001). When students have the ability to rotate, zoom in, and observe molecules from every angle, they get a deeper understanding of the chemical structure and its properties. This is crucial in helping students build a stronger foundation in chemistry knowledge (Abdinejad et al., 2021).

Through pre-class learning with materials, videos, images, and 3D models prepared by teachers in virtual space, students can approach basic knowledge more proactively (Toledo-Morales & Sanchez-Garcia, 2018). This allows teachers to spend classroom time explaining abstract concepts and reinforcing knowledge for students (Ebadi & Ashrafabadi, 2022).

Conducting chemical experiments can be time-consuming and may not always be feasible in a regular classroom setting. However, AR allows students to view the entire experimental process from start to finish, enabling them to understand the procedure and how it works more clearly. Practicing experimental steps in virtual space boosts students' confidence when conducting actual chemistry experiments (Hoai & Thao, 2020).

According to several studies, the use of AR can enhance the effectiveness of learning and student assessment in science subjects, including chemistry. Sirakaya and Cakmak's study (2018) indicates that using AR improves students' recognition and understanding of chemistry compared to those not using AR. Meanwhile, research by Cai and colleagues (2014) suggests that AR enhances students' imagination and self-learning capabilities. It's evident that AR has increasingly become a powerful tool to support the learning process and elevate knowledge in the field of chemistry.

3. METHOD

3.1 Introduction to CoSpaces Edu software

CoSpaces Edu is a 3D graphics application tailored for education, compatible with web browsers, and operating systems such as iOS, Android, and Windows. The CoSpaces Edu app allows users to design and experience content in various modes like a gyroscope, virtual reality, augmented virtual reality, and more.

Being specifically developed for educational purposes, it is highly suitable for teachers and students. CoSpaces Edu does not require users to possess advanced programming or designing skills. Creating content on CoSpaces Edu is made easier with its drag-and-drop programming and a comprehensive 3D library covering a wide range of themes suitable for various subjects. Experiencing AR through the CoSpaces Edu app can be easily accomplished using a smartphone with an internet connection that has the app installed. To take full advantage of the application's features, users need to purchase a license or enter a trial code. After considering the features and usability of the CoSpaces Edu app, we decided to choose CoSpaces Edu for designing our AR products.

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3.2 Design Principles for AR Applications in Chemistry Education

To effectively implement AR in chemistry education, when designing augmented reality products, one must base their research on established theories and practical knowledge. When creating an AR product, it's essential to ensure the following objectives: knowledge, skills, attitudes, and competency development orientation. When designing an AR product, the following principles should be adhered to:

Figure 1: Design Principles

- In line with Vietnam's new general education program, it is essential to closely align with theoretical knowledge.
- From a scientific standpoint, the information presented in AR products should ensure accuracy, logical coherence, and systematic knowledge organization.
- Regarding pedagogy, the learning tasks associated with AR products should be suitable and manageable for students. When students are first introduced to AR, they may not be familiar with the operations, so it's crucial to provide them with simple products along with instructional guidance until they become proficient. AR products should contribute to nurturing and developing students' self-learning abilities while fostering creativity in the field of Chemistry education.
- Interactivity is a prominent advantage of AR. Therefore, teachers should maximize this feature. Augmented reality products should be designed in a way that when students interact with them, they receive feedback and can proceed with corresponding interactions (two-way interaction). These products should include suggestions and exercise questions to facilitate interaction between students and teachers.
- To ensure aesthetic appeal, images, and 3D models should be visually designed in a vivid and balanced manner. Choices of colors, typography, and arrangement of objects should be carefully considered to engage students in learning activities, making the self-learning process more enjoyable.

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3.3 Process of Designing AR Products for Chemistry Education

The process of designing AR products for chemistry education consists of 5 main steps, as illustrated in Figure 2.

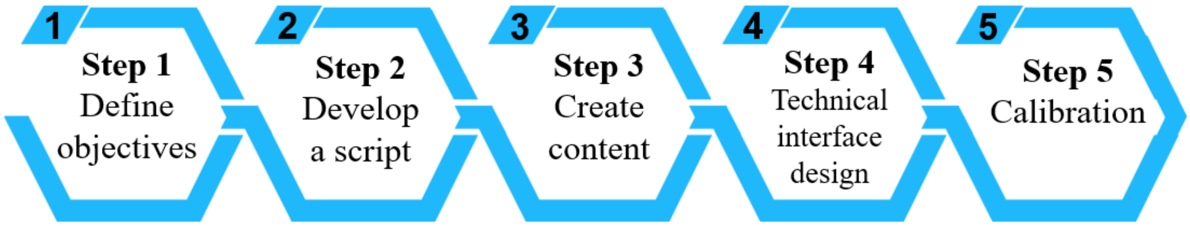

Figure 2: The AR Product Design Process

Step 1: Define the Objective This is the most crucial step in the process, playing a guiding role for the subsequent steps. In this phase, the teacher (GV) needs to clearly identify the requirements and objectives of the product. Analyze the content, the essence of objects, and phenomena.
Step 2: Develop a Script Based on the set objectives, the teacher (GV) proceeds to draft a script regarding the content, format, and organization of teaching activities using the AR product. Through this, the teacher can select appropriate design tools and search for resources to implement their teaching ideas.
Step 3: Create Content Based on the script and the resources found, the teacher (GV) develops detailed content for the AR product. The content includes introductions, information, images, models, questions, the order of appearance, etc., and how to set up effects between content parts.
Step 4: Technical Design The teacher (GV) uses the selected design tool, inserts the developed content into the AR product, and adjusts objects in the product in terms of color, size, layout, and font style to make it harmonious and visually appealing. Then, effects are set up for objects according to the proposed idea.
Step 5: Adjustments Review the product to identify any inconsistencies in the technical design, content development, and sometimes even in the idea or objectives. Find ways to explain and conclude if any shortcomings of the product are discovered.

4. RESULTS

The research team focused on creating 15 AR products for teaching chemistry, integrated into lessons including 5 products providing knowledge, 2 hypothetical situation and simulation products, and 8 assessment and evaluation products. Diversifying these AR products caters to various teaching methods, from traditional to modern methods, promoting students' active participation and engagement. Below are some illustrative AR products:

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4.1 Product "3D Block: Applications of Halogen Elements in Everyday Life" The product "3D Block: Applications of Halogen Elements in Everyday Life" is designed for use in the Hydrogen Halide and Hydrohalic Acid lessons of grade 10 inorganic chemistry.

Product description: Each face of the block provides information about the applications of the halogen group. Students can observe the applications of some hydrogen halides in a 3D space and interact with each face of the block to gather information. The product also simulates the structural formulas and spatial hybridization states of the substances.

Depending on the teaching and learning objectives, this product can be used in various ways. Given the product's knowledge-providing nature, teachers can have students explore the content independently at home or use it for revision and recapitulation of learned content. Students can also engage in group activities, jot down the applications of the halogen group on an A0 paper, and present it to the class.

● Design process for the product "3D Block: Applications of Halogen Elements in Everyday Life":

Step 1: Define the Objective - Provide knowledge on the applications of Hydrogen Halide and Hydrohalic Acid for grade 10 inorganic chemistry. - Develop interaction skills with augmented reality software.

Step 2: Script Development - Build a script based on the most common and practical applications in daily life and production. - The script content should detail molecular models, objects, and the practical applications of each distinct compound.

Step 3: Content Development Based on the developed script and combining ideas and available resources, teachers select suitable tools for the script and construct detailed content for the AR product.

Step 4: Technical Design - Design molecules, adjust colors, size, and layout appropriately. - Prepare content for applications. - Simulate real-life applications of the compounds.

Step 5: Refinement This step aims to review each face of the block, identifying any inconsistencies in technical design, content, and whether the product truly represents its intended practical application, leading to necessary adjustments.

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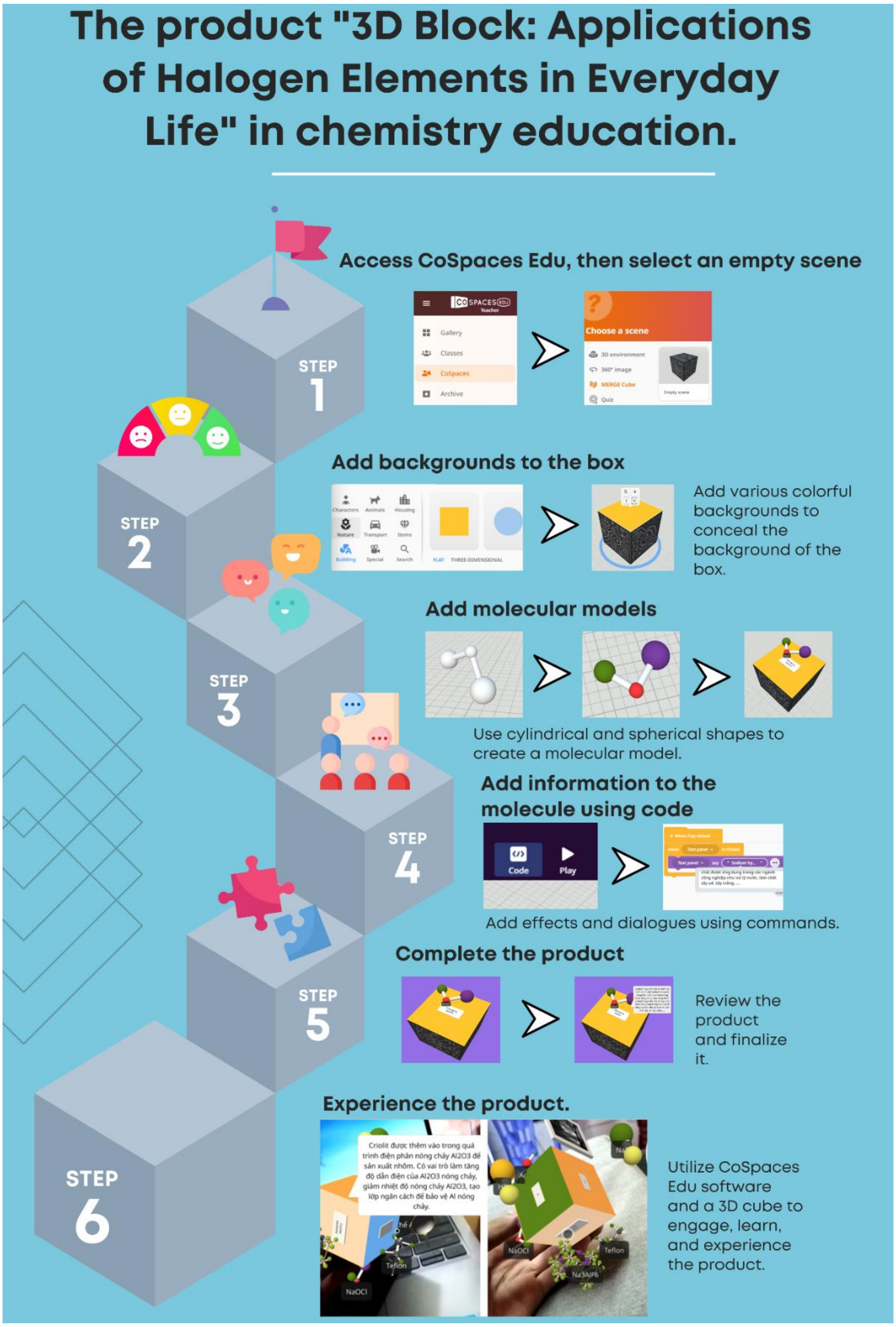

Figure 3: The process of designing the product 3D Block: Applications of HalogenElements in Everyday Life.

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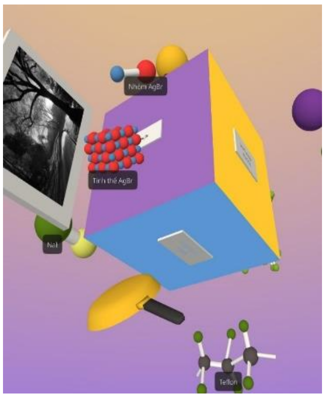
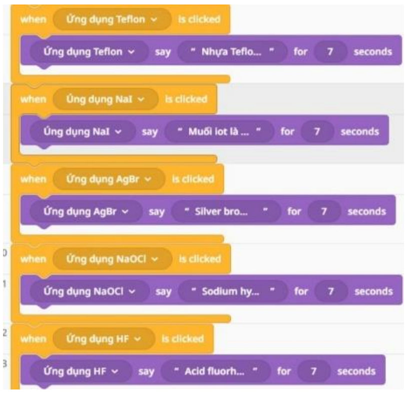
Table 1: Product design process - "3D Block: Applications of Halogen Elements in Everyday Life"

			
Step 1: Use the widgets available in Cospace to create molecules	**Step 2:** Attach information to each object	**Step 3:** Program the information display command	**Step 4:** Switch to AR mode

4.2 Product "Virtual Chemistry lab" used in chemistry laboratory experiments.

The "virtual laboratory" product is a breakthrough tool in teaching Chemistry - a fundamental natural science subject with a strong connection between theory and experimentation. Here, our research team has designed a "virtual laboratory" product, which is a type of hypothetical situation and simulation product. Simulating an interactive actual laboratory has brought many benefits to teaching and learning Chemistry. Students can realistically experience chemical reactions, study substances, observe experimental phenomena, or simply familiarize themselves with correct procedural operations right on their mobile devices. This significantly alleviates many challenges in learning.

Step 1: Access the CoSpace Edu app

• Select the CoSpaces tab, then choose Create CoSpaces to create a new space.

• Choose the design type corresponding to the intended use (3D Environment -> Empty scene).

Step 2: Identify tools and chemicals to attach information to the objects.

• Tools and chemicals: Na (Sodium), K (Potassium), HCl (Hydrochloric acid), HBr (Hydrobromic acid), NaCl (Sodium chloride), HI (Hydroiodic acid), HBr (Sodium bromide), H2SO4 (Sulfuric acid), Test tube, Triangular vase, glass flask.

Step 3: Script (procedures) for the virtual experiment. Take the experimental apparatus, then add a few drops of H2SO4 to the glass flask containing HBr. The reaction produces highly toxic Br2 gas, which is yellow-brown (display a warning for students to take note).

Step 4: Design the virtual experiment in the "Virtual chemistry lab" product.

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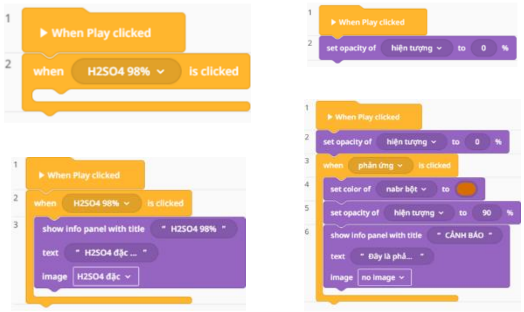
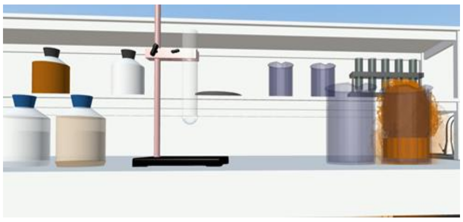
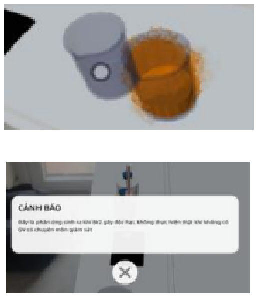
Table 2: Product design process - "Virtual Chemistry lab"

		
Step 1: Use the resources available in Cospace to create a lab	**Step 2:** Design a chemical cabinet with information	**Step 3:** Program commands for object interaction and chemical reaction phenomena
		
Step 4: Switch to AR mode	**Illustrate chemical information**	**Illustrate reaction phenomena**

● How to use AR products

- For regular products:

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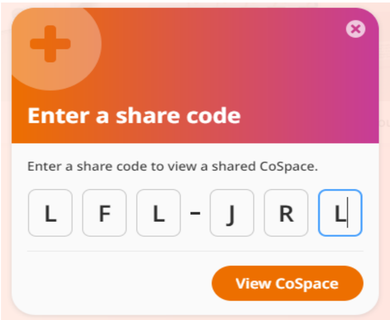
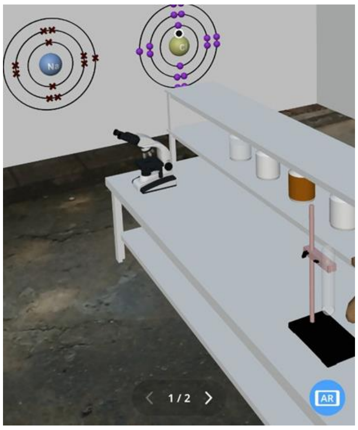


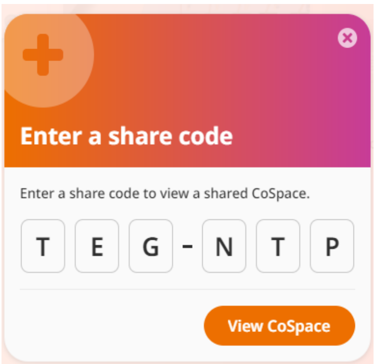
Step 1: Enter product code

Step 2: Press play and switch to AR mode

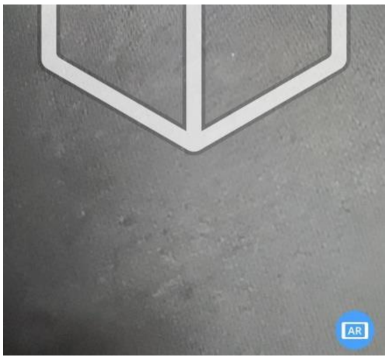


Step 3: Click on the selected plane and use

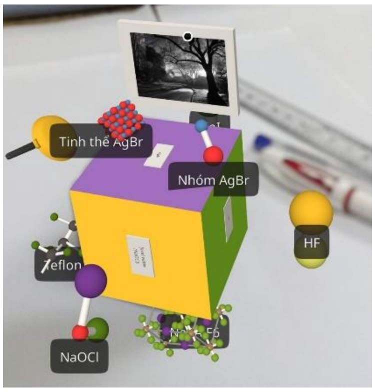
- For products using boxes:



Step 1: Use the merge cube to use



Step 2: Enter the code and press play



Step 3: Put the cube behind

the camera and scan to use

5. CONCLUSION

The application of Augmented Reality (AR) technology in teaching chemistry in high schools promises to transform the way students approach and grasp complex scientific concepts. Integrating AR into the classroom environment provides a dynamic and engaging learning experience, enhancing both the motivation and understanding of students. However, it's essential to acknowledge that successfully deploying AR technology in chemistry education requires careful planning, teacher training, and access to appropriate resources. Teachers must be equipped with the necessary skills to effectively integrate AR into their teaching practices. Schools and educational institutions should invest in the required infrastructure to implement AR, ensuring equitable access for all students. In conclusion, the application of Augmented Reality technology in teaching chemistry has the potential to revolutionize science education, making it more engaging, interactive, and accessible.

REFERENCES

[1] 1.Abdinejad, M., Talaie, B., Qorbani, H. S., & Dalili, S. (2021). Student Perceptions Using Augmented Reality and 3D Visualization Technologies in Chemistry Education. Journal of Science Education and Technology, 30(1), 87–96. https://doi.org/10.1007/S10956-020-09880-2/METRICS

[2] 2.Akcayir, M., & Akcayir, G. (2017). Advantages and challenges associated with augmented reality for education: A systematic review of the literature. Educational Research Review, 20, 1-11. https://doi.org/10.1016/j.edurev.2016.11.002

[3] 3.Cai, S., Chiang, F.-K., Sun, Y., Lin, C., & Lee, J. J. (2017). Applications of augmented reality-based natural interactive learning in magnetic field instruction. Interactive Learning Environments, 25(6), 778-791. https://doi.org/10.1080/10494820.2016.1181094

[4] 4.Cai, S., Wang, X., & Chiang, F. K. (2014). A case study of Augmented Reality simulation system application in a chemistry course. Computers in Human Behavior, 37, 31–40. https://doi.org/10.1016/J.CHB.2014.04.018

[5] 5.Criollo-C, S., Abad-Vásquez, D., Martic-Nieto, M., Velásquez-G, F. A., Pérez-Medina, J. L., & Luján-Mora, S. (2021). Towards a New Learning Experience through a Mobile Application with Augmented Reality in Engineering Education. Applied Sciences 2021, Vol. 11, Page 4921, 11(11), 4921. https://doi.org/10.3390/APP11114921

[6] 6.Ebadi, S., & Ashrafabadi, F. (2022). An exploration into the impact of augmented reality on EFL learners' reading comprehension. Education and Information Technologies, 27(7), 9745-9765. https://doi.org/10.1007/s10639-022-11021-8

[7] 7.Edomwonyi-Otu, L., & Avaa, A. (2011). The Challenge of Effective Teaching of Chemistry: A Case Study.

[8] 8.Fernandez, M. (2017). Augmented virtual reality: How to improve education systems. Higher Learning Research Communications, 7(1), 1-15.

[9] 9.Guntur, M. I. S., Setyaningrum, W., Retnawati, H., & Marsigit, M. (2020). Assessing the Potential of Augmented Reality in Education. ACM International Conference Proceeding Series, 93–97. https://doi.org/10.1145/3377571.3377621

[10] 10. Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. Sustainable Operations and Computers, 3, 275–285. https://doi.org/10.1016/J.SUSOC.2022.05.004

[11] 11. Kaur, D. P., Mantri, A., & Horan, B. (2020). Enhancing student motivation with use of augmented reality for interactive learning in engineering education. Procedia Computer Science, 172(2019), 881-885. https://doi.org/10.1016/j.procs.2020.05.127

[12] 12. Khan, T., Johnston, K., & Ophoff, J. (2019). The impact of an augmented reality application on learning motivation of students. Advances in Human-Computer Interaction, 2019, 7208494. https://doi.org/10.1155/2019/7208494

[13] 13. Mohammed, S., Javier, L., Villalba, G., Tarng, W., Tseng, Y.-C., & Ou, K.-L. (2022). Application of Augmented Reality for Learning Material Structures and Chemical Equilibrium in High School Chemistry. Systems 2022, Vol. 10, Page 141, 10(5), 141. https://doi.org/10.3390/SYSTEMS10050141

[14] 14. Sirakaya, M., & Cakmak, E. K. (2018). The effect of augmented reality use on achievement, misconception and course engagement. Contemporary Educational Technology, 9(3), 297-314. https://doi.org/10.30935/cet.444119

[15] 15. Soroko, N. (2021). The augmented reality functions to support the STEAM education at general education institutions. Физико-математическое образование, (3 (29)), 24-30. https://doi.org/10.31110/2413-1571-2021-029-3-004

[16] 16. Titchiev, I., Caftanatov, O., Iamandi, V., Talambuta, D., & Caganovschi, D. (2023). An approach to Augmented Reality Classification and an example of its usage for application development with VAK learning styles Markers. Computer Science Journal of Moldova, 92(2), 248-271.

[17] 17. Toledo-Morales, P., & Sanchez-Garcia, J. M. (2018). Use of augmented reality in social sciences as educational resource. Turkish Online Journal of Distance Education, 15(5), 38-52. https://doi.org/10.17718/tojde.444635

[18] 18. Vu, T. T. H., & Tran, T. T. (2020). Performance Analysis of Experimental Process in Virtual Chemistry Laboratory using Software-based Virtual Experiment Platform and Its implications in Learning Process. In 2nd International Conference on Innovative Computing and Cutting-edge Technologies (2nd ICICCT Conference 2020, 11,12, Sep. 2020) (pp. 499-585). ISBN 978-3-030-65406-1.

[19] 19. Wu, H. K., Krajcik, J. S., & Soloway, E. (2001). Promoting understanding of chemical representations: Students’ use of a visualization tool in the classroom. Journal of Research in Science Teaching, 38(7), 821–842. https://doi.org/10.1002/TEA.1033

[20] 20. Yip, J., Wong, S.-H., Yick, K.-L., Chan, K., & Wong, K.-H. (2019). Improving quality of teaching and learning in classes by using augmented reality video. Computers & Education, 128, 88-101. https://doi.org/10.1016/j.compedu.2018.09.014