CREATING AUGMENTED REALITY OBJECTS AND USING THEM AS A TEACHING TOOL UTILIZING ZAPPAR SOFTWARE

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ABSTRACT

This paper presents the construction of augmented reality objects with the aim of studying the three-dimensional structure by middle school students. Traditional methods of teaching chemistry face challenges due to the sub-microscopic nature of chemical structures. Augmented reality provides tools to visualize and interact with them, encouraging student interest and engagement, while providing motivation. Augmented objects depicting 3D molecular models can be created using Zappar software. However, their use requires appropriate infrastructure and teacher training. A balanced approach must be maintained to enhance learning while avoiding common teaching misconceptions, making education more dynamic and interesting.

Keywords: Augmented reality, 3D molecular models, Teaching tools.

INTRODUCTION AND BACKGROUND

Teaching chemistry faces challenges due to the sub-microscopic nature of chemical structures. Students often have difficulty understanding the structure and behavior of atomic, molecular, and ionic compounds. As a result, many alternative concepts occur about the three-dimensional (3D) behavior of them [1]. The phenomenon is intensified when studying subatomic particles and various models or the structure of the atom. Getting students to understand that a molecule is so small that it cannot be observed but has volume and yet remains structured in three dimensions, is a challenge. Teachers try to close the gap between the macroscopic and sub-microscopic world using analogies with experiences from everyday life and the behavior of the compounds, but that can also result in alternative frameworks in students' minds [2].

The initial attempt to bridge this gap in teaching was through modeling with plastic or other materials, which allow teachers to demonstrate chemical structures. The use of plastic models is considered of great help in enhancing students' spatial awareness, but has limitations too. This approach then evolved into electronic simulations, made accessible via the internet [3]. According to research, utilizing both physical and virtual models can help students better understand the concepts in question [4]. However, augmented reality offers a more dynamic and realistic experience.

AUGMENTED REALITY

Augmented Reality (AR) is an innovative technology that has focused on enhancing the real user experience by adding virtual elements to the physical environment [5]. For an experience to be classified as augmented not only it has to provide a connection between physical and virtual reality, but it should be three-dimensional, and the user can interact with it in real time [6]. The portal that connects the two worlds can be accessed through scanning a Qr Code unique to each AR object [7].

In recent years, education has been shifting from teacher-centered transfer of knowledge to more student-centered approaches that are more in line with constructivist learning theory [8]. According to constructivism, knowledge is the result of experiences gained by the individual and is built on pre-existing knowledge by constructing mental models that represent the new knowledge [9], [10]. The use of augmented reality in education is inextricably linked to these trends, as it helps students build mental models.

According to research, the use of augmented reality in the educational process significantly improves the overall performance of students. This is achieved through the motivation it provides to students, causing active participation in the learning process, as well as through its ability to facilitate the understanding of complex concepts and problems [11].

Through it, students can interact with the sub-microscopic level of chemical structures in a way that was previously impossible [12]. They can explore the structures of molecules and ionic compounds, rotate them, and observe their behavior in space [13]. They can also study the way macromolecules such as proteins and nucleic acids are structured in space and observe bond lengths and angles. This interactive feature provides students with a more comprehensive understanding of chemical structures and can help minimize the appearance of alternative concepts about them [14].

However, the use of augmented reality in the teaching of chemistry is not limited to the subatomic world. There are apps that leverage AR to study concepts like the properties of chemical elements and the periodic table or nomenclature. In addition, augmented reality enables the creation of virtual laboratories, where students can perform experiments and observe the effects of changing parameters in real time. This interactive approach fosters engaging and immersive learning.

Zappar software is a great tool for creating augmented reality content in the education sector. Through ZapWorks Studio, educators can create augmented objects that leverage 3D models and provide information about them, while providing the ability to interact in 3D space. This technology is a valuable tool for chemistry education, enhancing students’ understanding and interest.

ZAPPAR SOFTWARE

In the field of augmented object creation there are a variety of platforms and software that support the creation, and implementation of AR, including Unity 3D, BlippAR and Metaverse Studio [15]. For this particular project, the Zappar software was chosen, which was developed in Cambridge in 2011. The main reasons for this choice include ease of use and management, as well as the relatively low cost of obtaining a license [16].

Zappar provides end-to-end AR solutions that appeal to a variety of user groups, from ordinary citizens who want to get familiar with the technology, educators who want to integrate AR into their classroom, and businesses looking to create immersive experiences for their customers. This software offers a range of tools that allow the user to create custom objects with the desired content, as well as servers that ensure access to the material by scanning a simple pointer.

Through the use of Zappar software, simple pointers can be created that lead to AR objects, products and packaging that offer augmented experiences, as well as online augmented reality (WebAR) material. For material creation, there are two main platforms: ZapWorks Designer online and ZapWorks Studio desktop application.

ZapWorks Studio is an advanced application that offers a wide range of capabilities for creating augmented reality (AR) material, going beyond the functionality of Designer, and offering additional options. However, its use is more advanced and requires more technical familiarity. This application allows the creation of AR material without the constraints of being connected to a specific real-world object or person. In addition, it provides the possibility to create animations and timelines that allow the presentation of the object in motion. Although Studio provides all these features without the need for programming knowledge, users with a programming background have the ability to create even more complex experiences, such as games and content that dynamically adapts to each user's needs. This enables the creation of customized and layered AR experiences, offering a wide range of applications in various fields, from education to entertainment and entrepreneurship.

DEVELOPMENT OF THE TEACHING TOOL

In this paper, three augmented objects are presented which contain a total of 13 3D molecular models. For each 3D model, the name and chemical symbol of the element or molecular formula of the compound is provided.

For the development of the augmented reality objects, ZapWorks Studio was used, which allows the import of 3D models produced using modeling software. It is important to note that only specific types of 3D model format can be supported in Zappar [17]. The one more accessible to chemists without virtual 3D modeling knowledge is the Object format (files with extension .obj). These files can be saved from websites such as ChemSpider that use Jmol software to visualize 3D molecular models [18]. Each model is imported into Studio along with the .mtl file generated when it is exported from Jmol. At this stage, the size and position of the molecule is adjusted in the space defined by the application for viewing on the user's smart device. In addition, with the appropriate commands the user can have the ability to rotate and enlarge each model, a characteristic necessary for a more substantial understanding of the three-dimensional structure.

Studio gives the ability to enter parameters of appearance/disappearance, movement, and rotation of the molecule as well as any other object that is imported. In this way buttons can be inserted which are activated by the user's touch. Each button activates a series of commands (timeline) which displays the elements required each time and eliminates all the rest. In the objects created for this paper, the buttons enable the display of the 3D molecular model, return the user to the main menu, or display additional information about the compounds.

Another interesting feature of the application is the accelerometer tool that allows the content of the screen to adapt to the direction in which the user's mobile is facing. By using the two possible orientations, vertical (portrait) and horizontal (landscape) and appropriate adjustment of the elements inside the screen, the user can see the model in any orientation he wishes.

At each stage of the creation of the object, the Studio provides the possibility of viewing and checking through the preview feature, which creates a temporary Qr Code each time. When the construction of the augmented reality object is complete, it can be published through Zappar and is available to any user who has access to the Qr Code or Zap Code generated by the application. This is done with the scanner present on the smart device giving permission to use the camera, or through the dedicated Zappar app available for Android and iOS.

The augmented material that appears after scanning the Qr or Zapp Code for each object is depicted on the respective figures below each object.

AUGMENTED OBJECTS

The first object is about visualizing Carbon, both in its compounds and its allotropic forms. It contains four (4) common chemical compounds that contain carbon:

- Carbon Dioxide
- Carbon Monoxide

- Methane
- Butane

And two (2) forms of pure Carbon and their 3D structures:

- Diamond
- Graphite

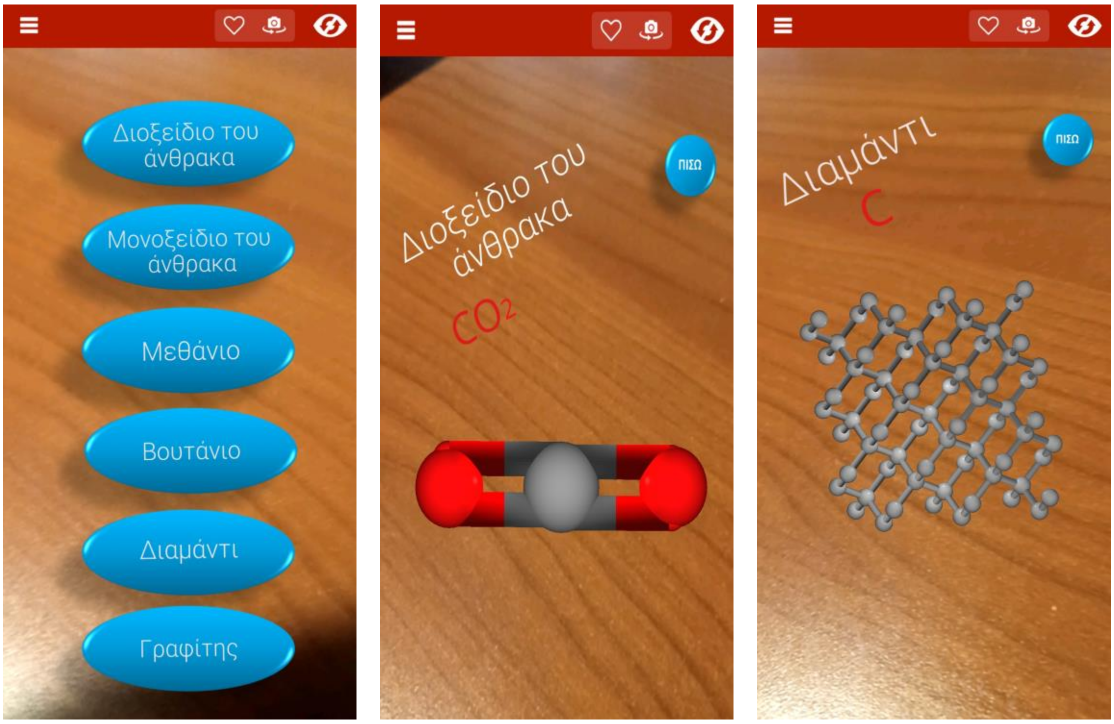

Figure 1: Compounds – Forms of carbon.

Figure 2: Qr and Zapp Codes for Compounds – Forms of carbon.

The second item shows two (2) ionic compounds and their crystal lattice structures:

- Barium sulfate
- Sodium chloride

In the main menu of this object the user has the opportunity to learn some additional information about salts (in Greek) via a link to the ChemNoesis website [19]. Alongside the sodium chloride crystal, there is an info button that activates the state that contains additional information about table salt and a picture of crystals in the microscope.

Figure 3: Ionic Compounds

Figure 4: Qr and Zapp Codes for Ionic Compounds

The third object presents five (5) Covalent compounds and their 3D molecules:

- Hydrochloride
- Water
- Nitric acid
- Acetic acid
- Ammonia.

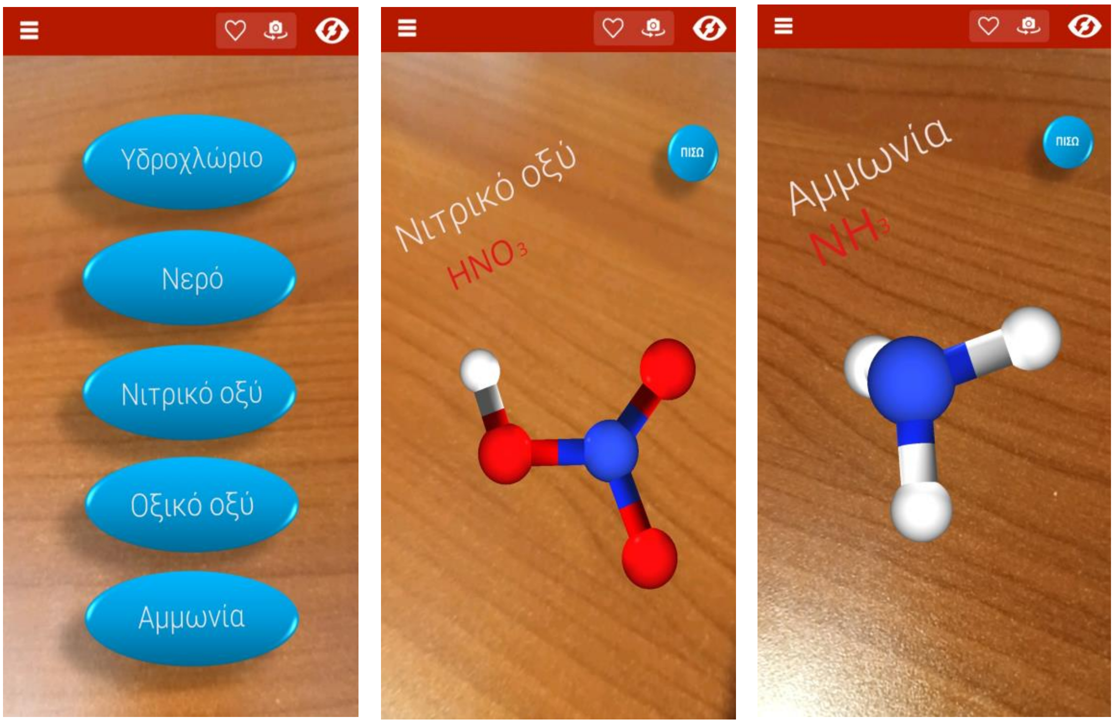

Figure 5: Covalent Compounds

Figure 6: Qr and Zapp Codes for Covalent Compounds

The three objects provide 3D structures for compounds used in everyday life and can all be used in teaching both middle and high school students. In the middle school curriculum, they can be applied in teaching about molecules and ionic compounds in second grade. In the third grade, the first object can be used as supplementary material in teaching about carbon and its properties. High school students can use the second and third object to better understand the ionic and covalent bonds in first grade. The application of the AR objects can be studied farther in all grades of middle and high school to help students understand more about the sub microscopical level of chemistry.

RESULTS

The augmented objects were utilized in teaching students that are in the second grade of middle school and there was a significant increase in the students' motivation to participate. In general, the use of mobile phones during the educational process arouses the interest of students as they are now a large part of their everyday life. The students reacted positively to the whole teaching approach, although some technical problems regarding the simultaneous use of augmented reality in a large group of students arose during the application. The problems concern access to a fast wireless network and familiarity with the use of the software.

The ability to view and rotate the 3D molecular models proved to help significantly in the more effective understanding of the existence of 3D structure of the compounds in space and reduced to a satisfactory extent the misconceptions that appear when studying these concepts with conventional teaching methods. Students were able to see how atoms are connected, the differences in size that exist in chemical elements, and the angles that exist between atoms. As a result, they understood more efficiently and faster concepts concerning atoms, molecules, and chemical compounds.

CONCLUSIONS

Augmented reality is a modern approach to technology that seeks to integrate virtual elements into the real world.

While this technology holds great promise in the field of education, its limitations should not be overlooked. One of the main limitations is the need for personal devices, such as smartphones or tablets, and access to wireless internet. At the same time, access to the internet via a wireless network is necessary, which is not available in all school units. This type of equipment is not always available in all educational units, causing problems of accessibility and equity in the educational process.

In addition, the successful adoption of AR also requires the training of teachers. Familiarizing them with new technologies, as well as understanding their function, are essential to be able to use it effectively in the educational process. However, it is observed that many educators express apprehension or fear towards the technology, which may negatively affect the adoption and effective use of AR in educational practice.

In addition, using augmented reality in an irresponsible way can lead to cognitive load problems for students. Excessive use of images and models can create confusion rather than enhance understanding. Therefore, the successful use of AR requires a balanced approach that takes into account students' needs and abilities, as well as teacher supervision to ensure effective learning.

Overall, augmented reality provides a valuable opportunity to improve the educational process, but its successful adoption requires well-designed approaches and adequate training of teachers and students.

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