Augmented reality while studying radiochemistry for the upcoming chemistry teachers

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Abstract

The objective of the research is developing a mobile application (on Android) designed to visualize the basic definitions of the discipline "Radiochemistry and radioecology" in 3D. Studying the education material of this discipline (phenomena of radionuclide, radioisotope, the nucleus, the fundamental particle etc and their specifics) requires a more sophisticated explanation from the teacher and dynamic dimensional image from the student. Decent detailed visualization of the study material makes this process easier. So applying the augmented reality is rational for the purpose of visualizing the study material, applying it allows demonstrate 3D-models of the nucleus, the fundamental particles, the nature of radioactive decay, nuclear fission, the specifics of managing the nuclear weapon and the NPS. Involving this instrument of the up-to-date information and communication technologies while studying the new material gives the opportunity to develop and boost the spatial imagination of the students, "to see" the invisible and to understand the received material in a better way, which improves its better memorizing. As far as the augmented reality is one of the most recent new-age education trends, all the teachers are required to have the ability to use it. In this reason the upcoming teachers, the students of the "General Education (Chemistry)" specialty, must be trained with this technology. Within the study process the students have the opportunity to review the positive moments of applying AR from a student's stand of point and to understand, how to apply similar education tools in the future pedagogic work.

Keywords

augmented reality technology, mobile learning, mobile application, chemistry education, radiochemistry

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1. Introduction

Comprehensive involvement of information and communication technologies (ICT) within the study process and within managing the education system and the education establishments is the main way to supply effectiveness of the education reform. Applying the ICT into the whole education system will definitely expand the teachers' possibilities, set-up the teacher-student cooperation; build the students' technical skills, which are so important for our century [1].

Reforming the education provides reinforcement of the students' project, team and group activities within the study process. With this being said, the scenarios of organizing the education society will be diverse; the main focus will be on delivering mobile work places that can be reset for group management purposes [2]. Planning and design of the education space will target on the student's development and motivation for study with the instrumentality of ICT, multimedia devices, with upgrading the natural sciences laboratory [1].

Nowadays, children are getting used to availability of data wherever they are, 24 hours per day, 7 days a week. They are also getting used to the Virtual Reality. That is why the so-called SMART education, which requires the use of smartphones, tablets, interactive boards and other devices with Internet access, is becoming more and more popular [1].

The integration of the study process with mobile devices and computers, uniting the real objects with the virtual ones, supplying the necessary information about the studied objects, including their 3D visualizing becomes possible with the augmented reality [3]. That is why, the upcoming teachers, the students of the "General Education (Chemistry)" specialty, must be trained with this technology. Within the study process the students have the opportunity to review the positive moments of applying AR from a student's stand of point and to understand, how to apply similar education tools in the future pedagogic work.

The main features of the augmented reality are integration of both real and virtual objects in the natural environment, real-time operation practice, and interactivity, equalizing the specifics of real and virtual objects [4].

Per definition of Ronald T. Azuma, the Augmented Reality (AR) is one of the types of virtual environment (or virtual reality), that augments the external reality, but does not totally change it. Augmented Reality allows the user see the real world, when virtual objects are either laid over the real world or consolidate with each other [5]. The Augmented Reality can potentially be applied to all the receptors, including the sense of hearing, smell, somatic sense, but the most common augmenter is the sense of sight.

The augmenters can help the human to focus on certain elements of the image from the camera; increases understanding of the objects around by means of supplying the appropriate information that is laid on the image with a text message or a visual image.

Within the education sphere augmented reality helps students discover the world, because they can point the camera on the marker-image and get a lot more interesting information, than the two-dimensional picture of the school book or text book [6]. This augmenter may contain a 3D-model of the object, animation with some explanations of a certain mechanism or phenomena, video manual about an experiment etc [7].

Chemistry is considered to be a complicated science, it operates with the ideas that cannot be understood immediately and require specific images and associations in the students' mind. The controversy of the 2D images leads to the important ideas not received properly. The problems

of space visualization, which are easily resolved with tools like turning around the structure and analyzing the symmetric characteristics, are almost non-resolvable with 2D even for competent students. What even more, a lot of students are visuals [8]. This means, they can memorize an object, they saw, in a better way, comparing with the one they imagine with a two-dimensional picture, teacher's lecture or the paragraph they read in the school-book.

The researches [9, 10, 11] analyze the effectiveness of using ICT while studying chemistry in order to build the students' basic qualities and, especially, with-in the research-based learning. In this case, the augmented reality is the remedy, designed for supplying the correct study material and its proper visualization [1]. With that being said [1], nowadays, there is only a few Ukrainian mobile AR apps designed for studying chemical disciplines [12]. As far as the augmented reality is one of the most recent new-age education trends, all the teachers are required to have the ability to use it. This subject has become crucial nowadays, in the era of distance education [13, 14, 15, 16, 17]. Transition of the education process to the distance ones, when a part of the study material is memorized individually by students, makes applying ICT extremely important both for the purpose of remote cooperation with the students, and for the purpose of demonstrating the study data. The mixed reality in this case makes the irreplaceable assistance for the teacher [18], as far as it allows the student receive the information whenever they are, and at the same time, it does not require access to the computer.

Applying augmented reality while studying chemistry is described in numerous articles [19, 20, 21, 22]. It is emphasized that involving 3D visualization gives the opportunity to make the unseen by the human objects visible (an atom, molecule, chemical bonds etc.) and understandable. This approach makes it easier to learn the structure of the atom, mechanisms of chemical bonds etc. Cai et al. [19] have claimed the rationality of AR technology within the process of lecturing chemistry for the purpose of developing the dimensional thinking of students, their ability to imagine and manipulate three-dimensional molecular structures using as an example the subject "The speciation and structure of substances". On the other hand, Cai et al. [19] note, that visualization of separate questions had a negative result on understanding some of the text data by the pupils. Fjeld et al. [20] notes that the quality of chemical 3D objects in AR has a positive effect on the motivation level of students and the process of memorizing new knowledge. Núñez et al. [21] mark that providing AR-technology increases the motivation for studying chemistry, develops understanding the crystal structure of substances and improves the student's skills of manipulating 2D and 3D patterns. Taçgin et al. [22] states that AR-technologies are the most important technological tools designed for the purpose of demonstration and studying the definitions like "an atom", "a molecule", "a chemical bond" etc., which are invisible for the students.

The augmented reality gives the opportunity to visualize the object to the max (atoms and molecules, their correlations, laboratory device setups, technology processing etc.), meaning to convert the 2D images into 3D, and "make it alive" [23]. That is why it is a must to include the digital acumen into the training of the upcoming chemistry teachers.

The *objective of the research* is developing a mobile application (on Android) designed to visualize the basic definitions of the discipline "Radiochemistry and radioecology" in 3D; they can be used by the teacher and the students in order to study the education material effectively.

2. Methods

As a result of the study, for the purpose of visualizing the study material, a free mobile application "LiCo.Radiochemistry" was developed; it can be downloaded with the QR-code (figure 1). Including the mobile application within the study process is designed to visualize the study material, receive short information about the visualized objects (mini-outline), and to examine the students' knowledge by means of test control.

Figure 1: QR-code for downloading the mobile app LiCo.Radiochemistry.

3D models of the nucleus, fundamental parts (α, β, γ rays), as well as animation designed to explain the nature of nuclear reactions were developed for the mobile application.

Augmented reality markers were developed [24] on the platform Vuforia; 3D objects were modeled [24] in the 3D Max, augmented reality objects were realized with the multiplatform tool designed for developing 2D and 3D mobile applications Unity 3D [25] (figure 2). All of this was designed to apply the AR technology.

3. Discussion and results

The developed mobile application contains the study material of the discipline "Radiochemistry and radioecology", learned by the students of the specialty "General Education (Chemistry)" of Vasyl Stefanyk Precarpathian National University during the first year of study and is one of the imperative disciplines. This discipline supplies the basics of ecologic competencies and the key principles of the "green" chemistry.

Learning this subject requires introduction with phenomena of radionuclide, radio-isotope, the nucleus, the fundamental particle etc. Most of these definitions are mostly imaginary for the students and do not have a live visual recognition. Phenomena of nuclear fission and radioactive decay are imaginary as well. While studying the subject "The chain nuclear reaction" the mechanisms of nuclear weapon and the nuclear pile on the nuclear power stations (NPS) are learned theoretically. In this way, studying the education material of this discipline (the definitions, phenomena and their specifics) requires a more sophisticated explanation from the teacher and dynamic dimensional image from the student. Decent detailed visualization of the study material makes this process easier. Unfortunately, the 2D images of the contemporary handbooks in this discipline do not provide the opportunity to visualize the study material in good manner, as well as to supply the exact context of the definitions, demonstrate the reaction mechanisms etc. That is why applying the augmented reality is rational for the purpose of

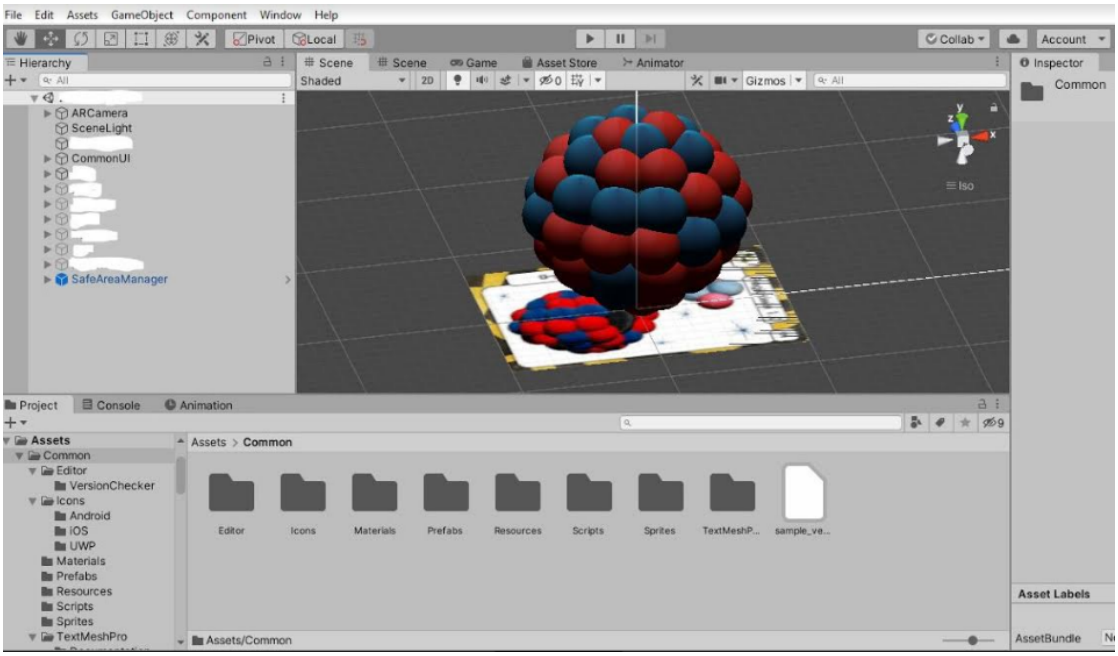

Figure 2: Setting up a 3D model of an atom nucleus in Unity 3D.

visualizing the study material, applying it allows demonstrate 3D models of the nucleus, the fundamental particles, the nature of radioactive decay, nuclear fission, the specifics of managing the nuclear weapon and the NPS. Involving this instrument of the up-to-date information and communication technologies while studying the new material gives the opportunity to develop and boost the spatial imagination of the students, "to see" the invisible and to understand the received material in a better way, which improves its better memorizing. However, the application includes study text content, suitable for memorizing by the modern age students.

Figure 3: Operation modes of the mobile application LiCo.Radiochemistry.

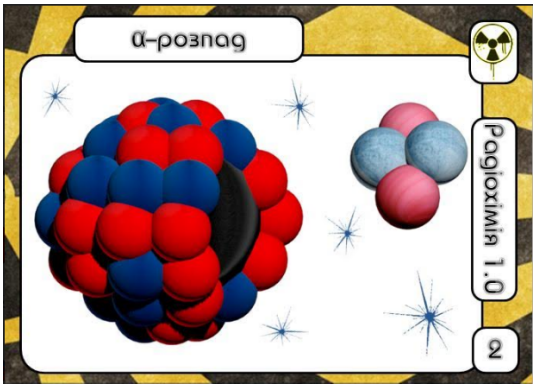

Figure 4: Image marker of the α-decay, viewed with the AR technology in the LiCo.Radiochemistry mobile app.

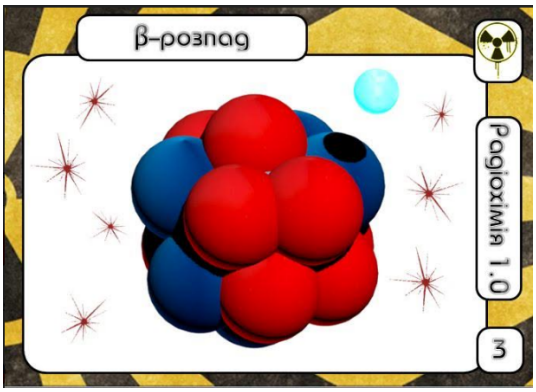

Figure 5: Image marker of the β-decay, viewed with the AR technology in the LiCo.Radiochemistry mobile app.

This ICT tool is also crucial in the remote study days, when the classic explanations of the study info are replaced with on-line lectures and lack of straight communication with students makes it impossible for the teacher to monitor the memorizing the study material.

The developed mobile application operates in three modes, which is its huge advantage: studying the basics of radiochemistry with augmented reality, test control of the knowledge and the vocabulary (figure 3).

The mobile application in AR operates the traditional model: select the image and identify it is a marker → search for the image that goes along with the marker → apply the 3D model on the marker-image → demonstrate it on the device screen.

While working with the augmented reality (AR) mode, the students can look into the external view of the objects and receive short summary about them through a mini-outline. The markers of the mobile app are presented in the figures 4, 5, 6, 7, 8, 9. Through these markers one can receive information about:

- Types and mechanisms of nuclear decay (α-decay, β-decay, γ-rays);
- Specifics of radiation and its correlation with the substance;

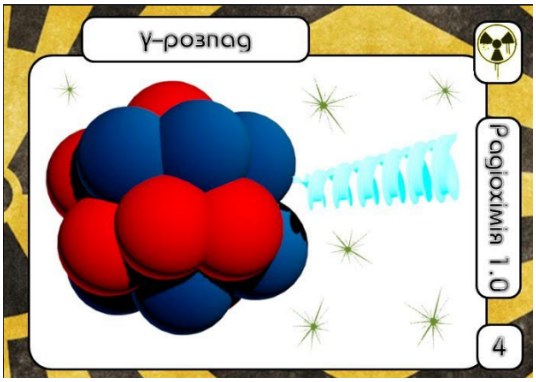

Figure 6: Image marker of the γ-decay, viewed with the AR technology in the LiCo.Radiochemistry mobile app.

Figure 7: Image marker of the chain reaction path, viewed with the AR technology in the Li-Co.Radiochemistry mobile app.

- The nature of chain reaction;
- Principles of nuclear weapon deployment (out-of-control chain reaction);
- Principles of nuclear weapon deployment (controlled chain reaction).

If the smartphone or tablet with the mobile app is pointed on the marker, the image "becomes alive", the three-dimensional model appears on the screen figure 10, 11, 12, and the image can be manipulated in certain ways (turn-around, zoom-in, view from different angles) in order to better understand its structure, specifics, and for the animations – the nature of the reaction paths.

Mode number two, the testing mode (figure 13, 14) gives students the opportunity to verify their knowledge. The app has selected tests on the topic "Atomic nucleus. Radioactive decay and nuclear transformation" (sub-topic "Radioactivity. Main types of radioactive transformations and its characteristics"). The tests are classified by two complexity levels: two variants of enclosed-type tasks with one correct answer were developed (10 questions per variant).

Mode number three, the vocabulary gives the opportunity to learn and revise the basics on the topic "Atomic nucleus. Radioactive decay and nuclear transformations".

Figure 8: Image marker of the nuclear weapon pattern, viewed with the AR technology in the LiCo.Radiochemistry mobile app.

Figure 9: Image marker of the nuclear pile, viewed with the AR technology in the LiCo.Radiochemistry mobile app.

This guidance paper was approved by Vasyl Stefanyk Precarpathian National University while studying the disciplines "Radiochemistry and radioecology" and "The contemporary technologies in chemistry" designed for students of the field of study "General Education (Chemistry)". Also, with the appropriate explanations the mobile app can be used by physics teachers during their lessons in the 9^{th} grade of school while studying "Physics of the nucleus and physics of the atom. The basics of nuclear energy in physics" and in the 11^{th} grade while studying the subject "Atomic and nuclear physics".

4. Conclusions

The mobile application (on Android) was developed for the purpose of visualizing the basics of the course "Radiochemistry and radioecology", it can be used by the teacher and the students in order to understand the study material effectively.

The developed mobile app is a Ukrainian software product, which provides the study material in two forms: graphics (providing the 3D models) and text. Compared to other mobile app, the developed one has also the testing mode, designed to control the knowledge of students.

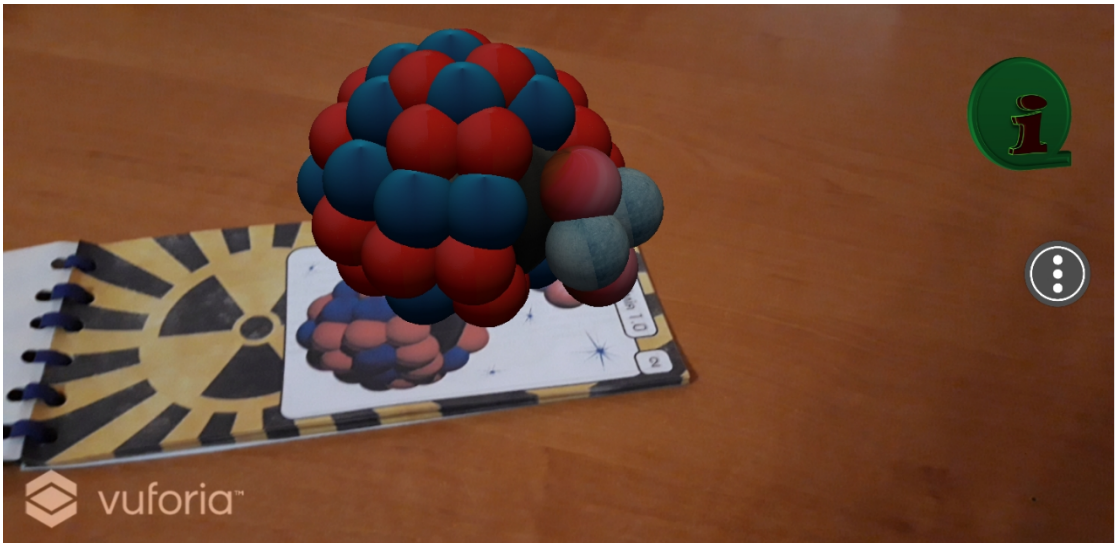

Figure 10: Simulation of the α-decay with the AR technology in the LiCo.Radiochemistry mobile app.

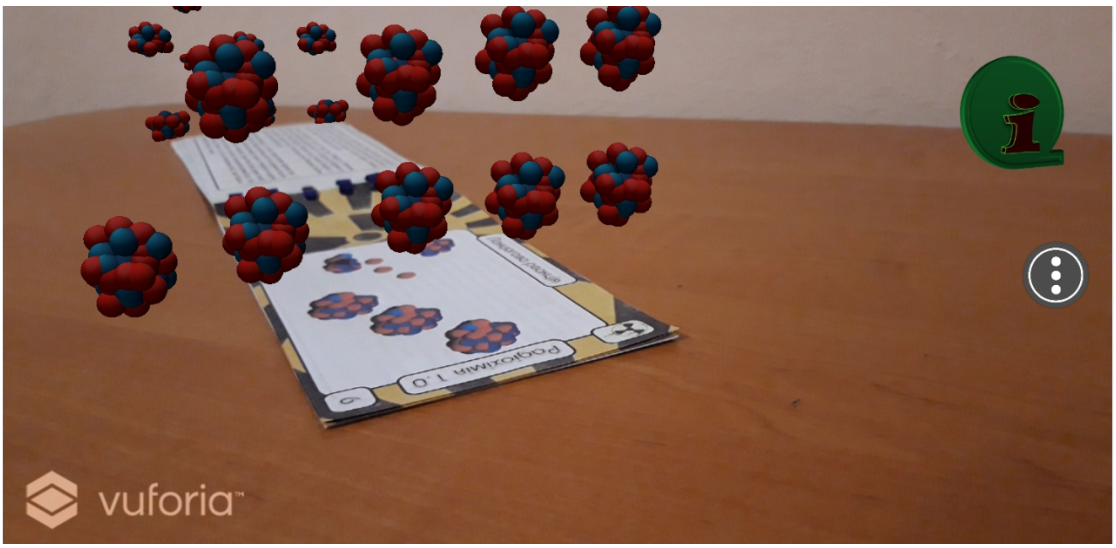

Figure 11: Simulation of the chain reaction path with the AR technology in the LiCo.Radiochemistry mobile app.

Applying the augmented reality objects gives teacher the opportunity to explain the theory, which cannot be illustrated with 2D images appropriately, and to review it live, and the students perceive it effectively.

Studying the education material involving AR gives the upcoming teachers the ability not only to perceive the information in good manner, as a student, but also build the skills to use it

Figure 12: Simulation of the nuclear pile model with the AR technology in the LiCo.Radiochemistry mobile app.

Figure 13: Testing task in the testing mode of the developed mobile app.

Figure 14: Selecting the right answer in the testing mode of the developed mobile app.

in the future pedagogic work during chemistry lessons, get prepared to discover new education technologies and learn throughout the lifetime.

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