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SPECIFICS OF VISUALIZATION OF STUDY MATERIAL WITH AUGMENTED REALITY WHILE STUDYING NATURAL SCIENCES

Abstract. Augmented reality (AR) gives the ability to visualize an object (atoms and molecules, their interference, circuits of the devices, technological processes, etc.) as much as possible, meaning to convert a 2D image to 3D, as well as "make it alive". The objective of the work is development of a mobile application designed for reproduction of study material in natural sciences using Augmented Reality. The main task is the selection and creation of 3D-study demonstration material and video data of practical works and laboratory experiments, according to the current programs in physics, chemistry, biology for secondary education establishments, which can be used by the teacher and pupils to prepare an effective performance. Two methods of augmented reality implementation were combined for maximal visualization of the study material. The first one is using 3D-images, which made the 2D-images of handbooks "alive", converting them into 3D, with animation ability; the second one is reproduction of the developed video material on mobile devices by "connecting" them with individual markers for any practical or laboratory work. A mobile application for reproduction of video data in natural sciences provides the pupil with an ability to find out about the safety regulations before the work performance, chemicals and equipment, necessary for its performance and with the course of work in video. Pictures of laboratory work elements were chosen for the mobile app; they were created on "Vuforia" platform, realized in software as augmented reality objects with a multiplatform instrument for development of two- and three-dimensional applications, named "Unity 3D". Implementation of augmented reality objects will increase the level of data memorization as a result of interactivity of its image in 3D, will give the opportunity the modern teacher to explain a big volume of theory fast and understandable, update the demonstration of study material, and for the pupils to memorize it effectively, will improve the critical thinking, boost motivation for study and will give the ability to gain some skills while performing the experiment.

Keywords: information and communication technologies; augmented reality; mobile learning; mobile application; 3D-visualization

Rationale. Nowadays, the development of information and communicational technologies allows to modernize the education process in general schools, utilizing various trends of the contemporary education. New methods of teaching natural sciences, as well as chemistry, have to deal with up-to-date requirements for using information technologies (Midak, 2017, pp. 54-57). Applying information and communicational technologies (ICT) within chemistry training allows to intensify the educational process, accelerate the knowledge

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and experience transfer, as well as upgrade the quality of study and education (Midak, 2017, pp. 54-57). Multi-media presentations, Internet-resources during the lessons give teacher an opportunity to explain the theory understandable, increase the pupils' interest for study, keep their attention in a better way.

At the same time, natural sciences are mostly experimental ones. An effective pupils' knowledge perception in these subjects depends not only on the way of presenting the theory, but also on accomplishment of the experimental part in practical works and laboratory experiments, which demands decent theoretical background both from the teacher and the pupils. Besides, the nowadays condition of material support of the majority of schools demands an update and does not allow a proper performance of practical works and laboratory experiments by the pupils.

One of the methods of solving this problem while training upcoming natural sciences teachers is gaining mobile learning and augmented reality skills within physics, chemistry, biology and natural sciences lessons in secondary school establishments, which nowadays is an extremely crucial task of learning process modernization.

Analysis of the science investigations. In the modern era, there are a lot of views about the definition of mobile study (Midak, 2017, pp. 211-214). The European eLearning Guild defines it as (BBC News, 2017) any activity, allowing people to be more productive in consumption, interference or creating information by compact digital gadgets, if they do these actions on a regular basis, has a reliable connection and the gadget can be stored in a pocket or a little bag. In this case, using present day mobile gadgets (iPhones, smartphones, tablets etc.), which are an inevitable attribute of a general school pupil, can be easily used for realization of BYOD (Bring Your Own Device) conception, known as the most prospective ways for increasing the education quality (Plyevako, 2015, pp. 54-57). Providing the study material on a mobile device the pupil can be prepared for performance of practical and laboratory works in natural sciences, provided with safety regulations and the performance technique (Midak, 2018, pp. 184-187), the study material can be visualized and explained in a qualified manner.

Visualization of the study material makes its perception and memorization easier. Natural sciences require a decent illustration of the theory. The properly-selected demonstration material helps understand various processes and phenomena, the structure of chemical compounds as well as mechanisms of their interference in a better way. Usual 2D-images of the traditional handbooks, textbooks do not give the full image about spacial structure of molecules, mechanisms of chemical reaction paths, etc. In this way, for an effective study of natural sciences it is more than reasonable to use different demonstrations, which are impossible without using multi-media presentations, Internet-resources, special chemical programs, simulation programs and augmented reality programs.

Augmented reality (AR) is a concept that defines a process of augmentation the existing reality with virtual objects (Shabelyuk, 2014, pp. 215-218). The communication with virtual reality is performed on-line. For a proper effect a web-camera is required, the image from the camera will be augmented with virtual objects.

Augmented reality (AR) gives the ability to visualize an object (atoms and molecules, their interference, circuits of the devices, technological processes, etc.) as much as possible, meaning to convert a 2D image to 3D, as well as "make it alive". Per A.Vovk (BBC News, 2017), thanks to AR, allowing to visualize information, show 3D-models, the pupils can receive it ready to be precepted and they will not waste time and cognitive efforts on its interpretation.

Per Ronald Azuma (Shabelyuk, 2014, pp. 215-218), the augmented reality can be defined as a system, which:

1) Combines the virtual and the real;
2) Interferes in the real-time environment;

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3) Works in 3D.

The modern implementation of this technology mostly looks like this: a special image-marker is placed in front of a web-camera, plugged in to the computer (Shabelyuk, 2014, pp.215-218, Kravets, 2017, pp. 151-154). It can be a two-dimensional image, printed out on a regular sheet of paper. A special program, loaded on the computer, analyzes the image received from the camera, and augments it on the monitor screen with virtual objects.

With the development of the AR the demonstration material set will also change, because the massive models won't be as necessary (Matviyenko, 2015, pp.157-159). The teacher will just have to place a small marker-image in front of the camera and project an already augmented image to the screen. The image is beneficially different in ability to be modified, reverted, zoomed (Matviyenko, 2015, pp.157-159). There will be an ability to view three-dimensional halls, zoom in objects without a microscope, to investigate the geometry of molecules just sitting in the class.

Research objective and goal. The objective of the research is creation of a mobile application for reproduction of the study material in natural sciences using Augmented Reality. The main goal is the selection and creation of 3D-study demonstration data and video material of the practical works and laboratory experiments, according to current program requirements in physics, chemistry, biology for secondary education establishments, which can be used by the teacher and effective preparation for its performance.

Statement of the basic material. Two methods of augmented reality implementation were combined for the maximal visualization of the study material. The first one is utilization of 3D-images, which made the 2D-pictures of handbooks alive, with animation support; the second one is reproduction of the developed video-data on mobile gadgets by "connecting" to individual markers for every practical or laboratory work.

The stated methods give the opportunity to apply different approaches for using augmented reality in education (Tarng, 2012, pp. 62-66, Chien, 2010, Núñez, 2008, pp. 271-277, FitzGerald, 2012, pp. 2-5, Kaufmann, 2003, pp.339-345) that can be provisionally divided into three main groups:

1) Visualization of 3D pictures to create a demonstration image of the study material.

So, during an explanation of the atom structure, in case of 3D-visualization of n atom model, the pupil receives, an image, provided on the fig. 1, which gives an ability to understand the structure of the compound, mechanisms of chemical bonds and course of chemical reactions.

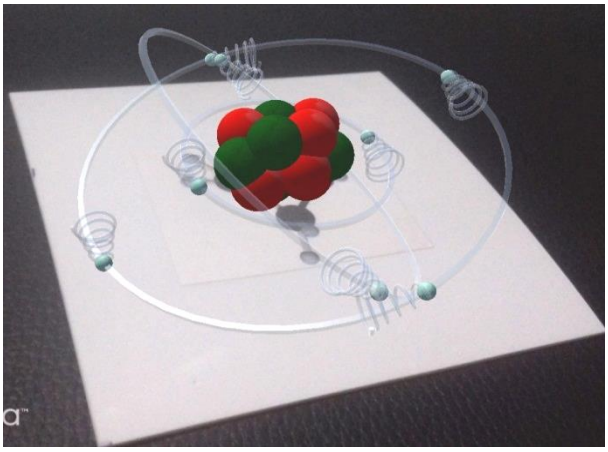

Fig. 1.AR 3D-image of an atom model, generated with AR

Pictures 2-3 provide us with examples of 3D-images, generated from specifically developed 2D markers-images for organic chemistry (fig. 2) and crystal chemistry (fig. 3).

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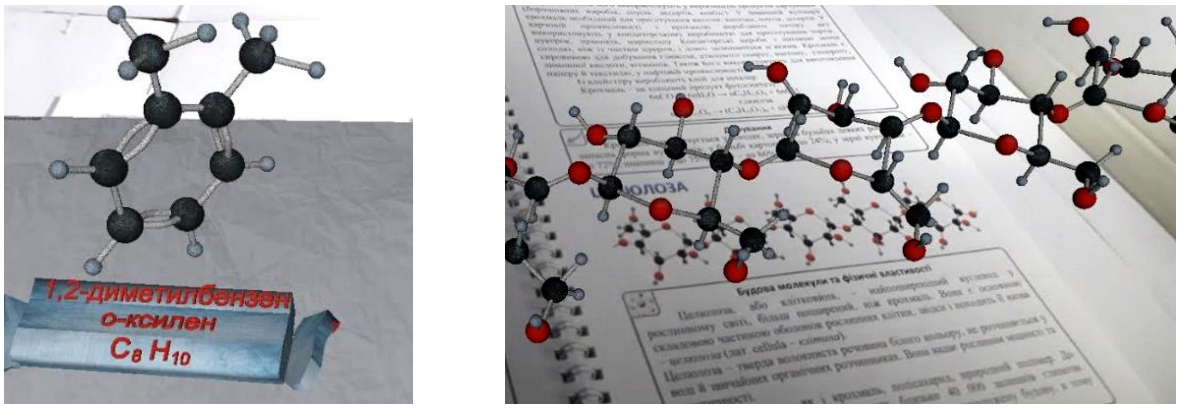
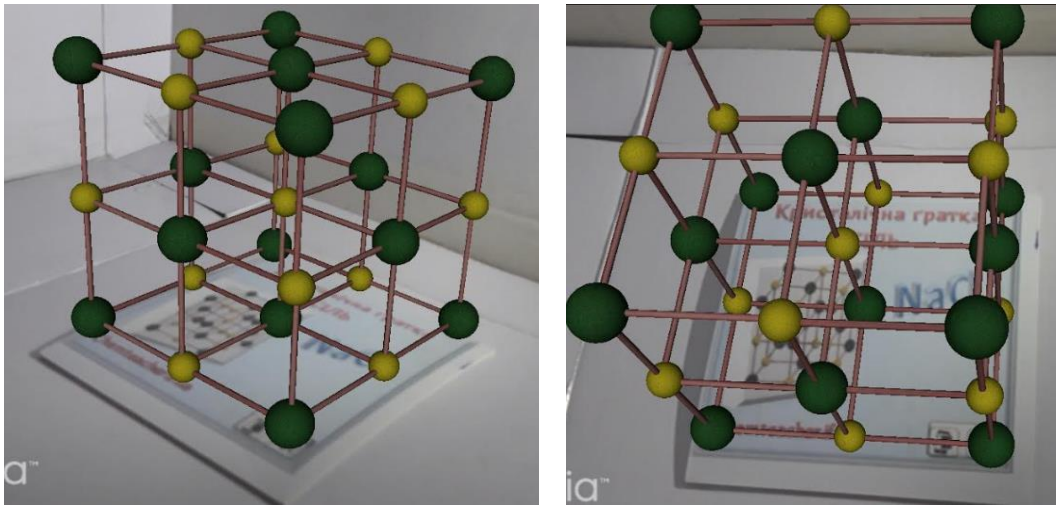


a) b)

Fig. 2. AR 3D-images of a molecule of csylene (a), and a snip on a molecule of cellulose (b).



a) b)

Fig. 3. 3D-images of crystal grating of sodium chloride: view from the side (a), view from above (b), generated with AR.

2) Recognition and marking the real objects.

The stated approach gives an opportunity to develop video material for the experimental part of studying natural sciences. Taking to consideration the fact that mobile gadgets are simple, effective and, nowadays, popular in the pupils' environment, the study material is appropriate to be reproduced not through a traditional PC, but with a mobile application (Midak, 2017, pp. 211-214). In order to improve its portability and to decrease the resource consumption of the mobile gadget, the stated project was realized with a system of "connecting" the video material, located on an open-to-public Internet-resource, to special images-"markers", developed according to the subject of every practical or laboratory work.

Pictures of snips of a practical work or a laboratory experiment, developed by "Vuforia" platform, realized in software, as objects of augmented reality with a multiplatform instrument for development of two- and three-dimensional applications "Unity 3D", were chosen as "markers". Fig. 4-6 show examples of "markers" developed for practical works in chemistry for pupils of 7 – 9th forms and parts of video-reproduction on a mobile gadget:

- Practical work#5 (7th form) "Production of aqueous solutions with a stated weight percentage of the dissolved solids" (Fig.4)

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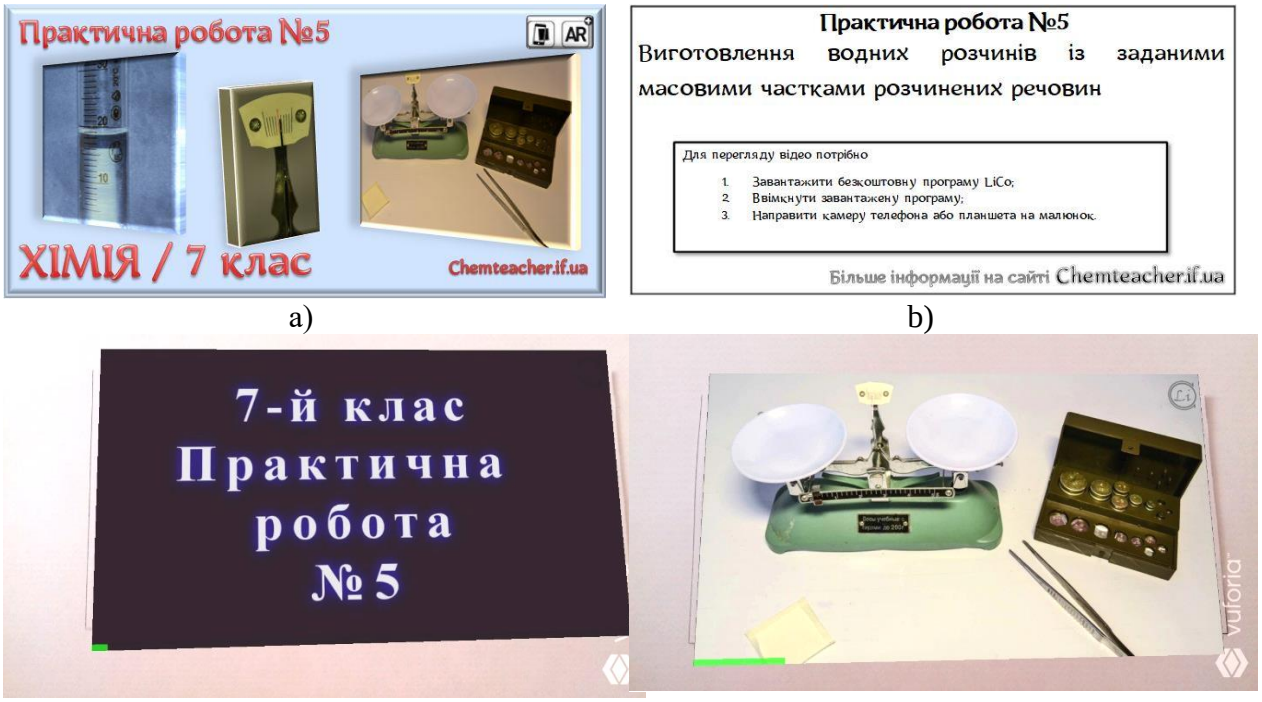
- Practical work#1 (8th form) “Analysis of physical characteristics of chemicals with different types of crystal grating” (Fig. 5)
- Practical work#5 (9th form) “Identification of organic compounds in meal products” (Fig. 6)

The developed video data demonstrate the performance of practical works and laboratory experiments in chemistry, provided by the program, by an experienced lab assistant, with compliance to all the safety regulations in the chemical laboratory. This gives an opportunity for the pupil, while preparing for the practical work, to study all the equipment and chemicals, needed for the work performance, its content, experiment performance course and the appropriate safety regulations. Such method of information transfer provides the pupil with an ability to see the correct techniques of work performance and to represent it during the lesson in a school chemistry class. Besides, the program requirements in chemistry provide a performance of a home experiment. In our opinion, for performance of experiments at home, and for compliance of the safety rules during the performance, individually, without a teacher, this method is significantly effective.



a) b) c) d)

Fig. 4. Title (a) and back (b) parts of a «marker» for practical work № 5 in chemistry in the 7th form and snips of its video reproduction (c, d).

a) b)

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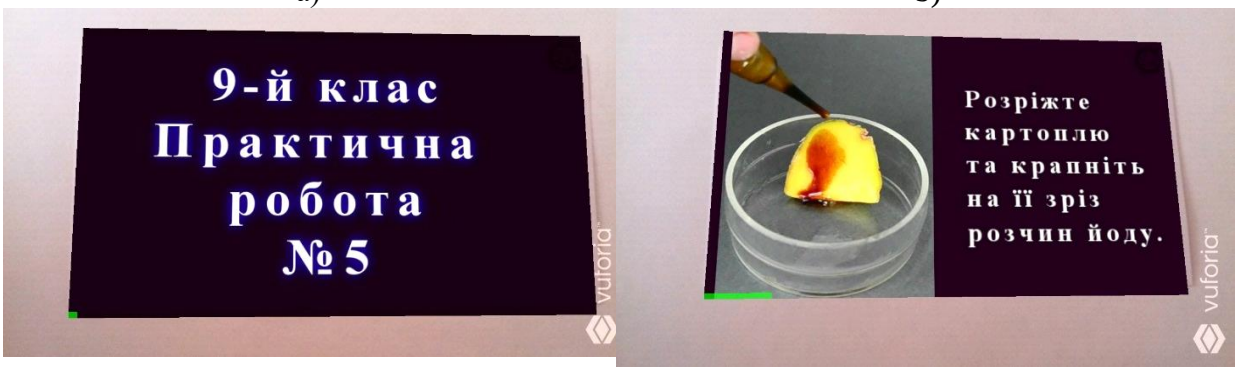
c) d)

Fig. 5. Title (a) and back (b) parts of a «marker» for practical work № 1 in chemistry in the 8th form and snips of its video reproduction (c, d).

a) b)



c) d)

Fig. 6. Title (a) and back (b) parts of a «marker» for practical work № 5 in chemistry in the 9th form and snips of its video reproduction (c, d).

Preview of the video by the pupils with the practical work, as well as with home chemical experiment has an advantage above usual handbook reading, because it turns on the perception activity, gives an opportunity to learn some rules of using chemical glassware and the basic approaches to work with them, boosts creativity. If there is no glassware or chemicals in the chemistry room, the pupils will have the possibility to find out about the practical work with a video lesson. Utilization of this mobile app would be really appropriate for pupils with special needs, that learn most of the study material at home and don't have ability to visit chemistry lessons in schools and perform practical works.

3) Interaction of the virtual object, created by a computer (smart phone),with a human in a real-time environment.

Fig. 7 provides the mechanism of reproduction of 3D-images for studying plant cell structure. When the mobile gadget is pointed on the black and white image of the leaf, it is generated into a 3D-picture (Fig. 7a). At the same time, an instrument for zooming the object

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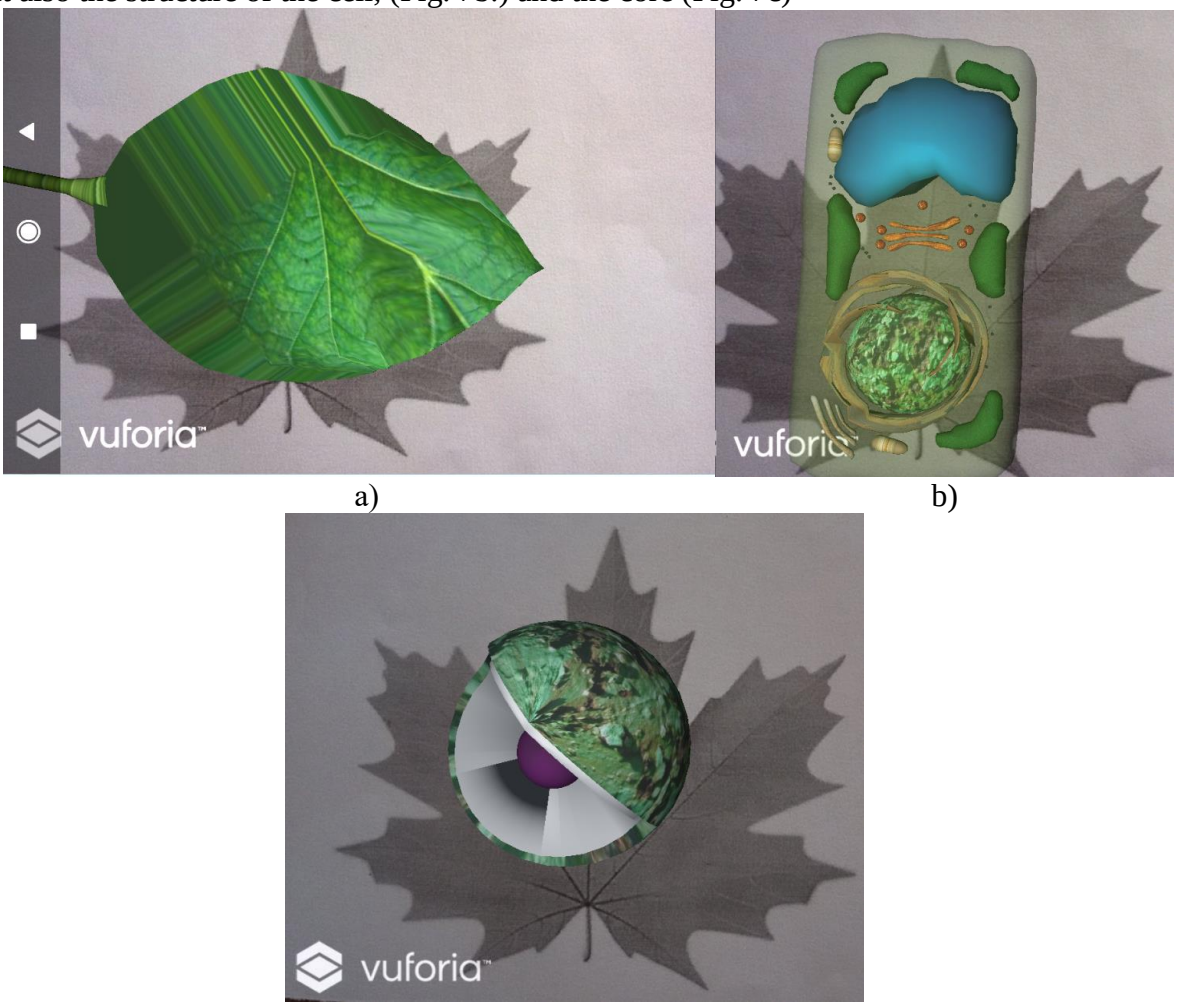
appears on the screen; it provides the ability to view not only the external structure of the leaf, but also the structure of the cell, (Fig. 7b.) and the core (Fig. 7c)



a) b)

c)

Fig. 7. AR 3D-images of the external structure of the leaf (a), cell (b) and core (c).

Fig. 8 shows an image of starch molecule, which can be “held in hand”, looking at it through a mobile phone camera.

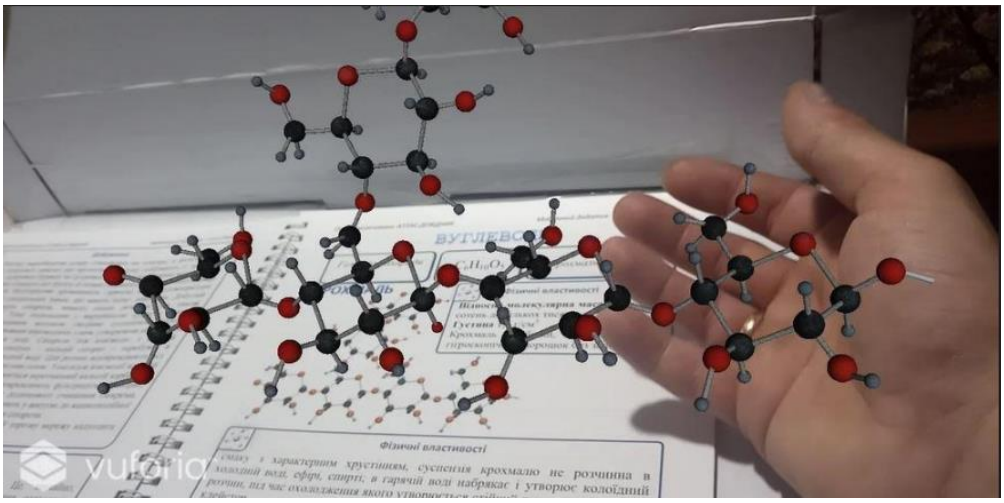


Fig. 8. AR 3D-image of a snip on a molecule of starch.

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Conclusions. In summary, the increase of mobility of the population stimulates the search of new approaches to organization of the study process and creation of study material in natural sciences with usage of mobile gadgets and augmented reality. Utilization of augmented reality objects will boost the level of memorizing information by means of interactivity of its reproduction in 3D format, will give the opportunity to the contemporary teacher to explain big amount of theory quick and understandable, will increase the demonstration ability of study material, and for the pupils to memorize it effectively, improve the development of critical thinking, boost motivation to study and provide the possibility to develop certain skills for experimental performance.

Perspectives for further study. Applying the stated technologies can be used for training natural sciences subject teachers (physics, chemistry, biology, geography), because learning these subjects requires visualization of study material and realization of school experiments within current education programs. Implementation of the stated technologies will also be appropriate for realization by teachers in the "Natural Sciences" cource, which is integrated for the high professional-oriented school, designed for pupils of human sciences, and consists of a few modules: physical and anstronomical, chemical, biological, ecological and geographical.

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ОСОБЛИВОСТІ ВІЗУАЛІЗАЦІЇ НАВЧАЛЬНОГО МАТЕРІАЛУ ЗА ТЕХНОЛОГІЄЮ ДОПОВНЕНОЇ РЕАЛЬНОСТІ ПРИ ВИВЧЕННІ ПРИРОДНИЧИХ ДИСЦИПЛІН

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Анотація. Доповнена реальність дає можливість максимально візуалізувати об'єкт (атоми та молекули, їх взаємодії, схеми приладів, технологічних процесів тощо), тобто перевести 2D зображення у 3D, а також «оживити» його. Метою роботи є створення мобільного додатку для відтворення навчального матеріалу з природничих дисциплін з використання технології Augmented Reality. Основним завданням є підбір та створення 3D-навчального демонстраційного матеріалу та відеоматеріалів практичних робіт і лабораторних дослідів, відповідно до чинних програм з фізики, хімії, біології для закладів загальної середньої освіти, які можна використати вчителям та учням для ефективної підготовки до їх проведення. Для максимальної візуалізації навчального матеріалу було поєднано два методи реалізації доповненої реальності. Перший – використання зображень у 3D форматі, що дозволило «оживити» 2D-зображення підручників, перетворивши їх в 3D, з можливістю анімації;

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другий – відтворення розроблених відеоматеріалів на мобільних пристроях шляхом їх «прив'язування» до індивідуальних маркерів для кожної практичної чи лабораторної роботи. Мобільний додаток для відтворення відеоматеріалів практичних робіт та лабораторних дослідів з природничих дисциплін дає можливість за допомогою мобільного пристрою учню познайомитися з правилами техніки безпеки перед виконанням роботи, приладами або реактивами, які необхідні для її виконання, та ходом роботи у формі відеоматеріалів. Для «маркерів» мобільного додатку були обрані рисунки фрагментів практичної роботи чи лабораторного досліду, створені на основі платформи «Vuforia», які програмно реалізовані, як об'єкти доповненої реальності, за допомогою багатоплатформового інструменту для розробки дво- та тривимірних додатків «Unity 3D». Використання об'єктів доповненої реальності підвищить рівень засвоєння інформації за рахунок інтерактивності її представлення у форматі 3D, дасть можливість сучасному вчителю швидко та доступно пояснити великий об'єм теоретичного матеріалу, підвищити наочність навчального матеріалу, а учням ефективно його засвоїти, сприятиме розвитку критичного мислення, підвищить мотивацію до навчання та дасть можливість сформувати певні вміння та навички під час виконання експерименту.

Ключові слова: інформаційно-комунікативні технології; технологія доповненої реальності; мобільне навчання; мобільний додаток; 3D-візуалізація

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