

## Using 3D modelling in design training simulator with augmented reality

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**Abstract.** The article is devoted to the theoretical consideration of the problem and the use of innovative technologies in the educational process in the educational establishment of secondary education in the process of studying the school course of computer science. The main advantages of using educational simulators in the educational process are considered, based on the new state standard of basic and complete general secondary education. Based on the analysis of scientific and methodological literature and network sources, the features of the development of simulators for educational purposes are described. Innovative tools for simulator development have been investigated, as augmented reality with the use of three-dimensional simulation. The peculiarities of using a simulator with augmented reality when studying the topic of algorithmization in the course of studying a school computer science are considered. The article also describes the implementation of augmented reality simulator for the formation of algorithmic thinking skills by students, presents the results of development and describes the functionality of the software product. In the further prospects of the study, it is planned to conduct an experimental study to determine the effectiveness of the use of software development in the learning process.

**Keywords:** elementary school, educational process, computer science, algorithms, training simulator, augmented reality, three-dimensional modelling.

### 1 The problem statement

The modern world is filled with a variety of different digital technologies that are already an integral part of society. One of the most promising is the augmented and virtual reality technologies that have recently brought to the fore. There are many options for using these technologies in training – from elementary virtual tours of famous museums to the opportunity to see and take part in a historical event of any period with your own eyes. It is the augmented reality technology that will serve as a new stage in the development of modern education, allowing us to reach a new level of visualization. The main feature of this technology is the attachment to the real world, which is so lacking in the already implemented virtual reality [32]. A great number of scientists are focusing on the special possibilities of using augmented reality technology

in the study of computer science [3; 22; 31]. This is of particular socio-pedagogical relevance in the current context of reforming and improving the efficiency and quality of education against the backdrop of the introduction of modern progressive information technology. As a result of intensive reform of education in Ukraine, the concept of which is set out as the “New Ukrainian School”, the content and methodology of teaching computer science is substantially updated, which in turn requires improvement of the process of its teaching. It should be noted that the basics of algorithmization in the school course of computer science are studied starting from the 2nd class, and given the complexity of learning the basics of the algorithmization of this age group, it is necessary to create effective learning tools and put them into practice. In this regard, there is an urgent need to develop educational software for the study of algorithms, taking into account the age characteristics of these students, which are augmented reality simulators.

## **2 The aim of article**

The aim of article is to research and analyze information about the problem of using three-dimensional simulation technologies for the development of augmented reality simulator to study the topic of algorithmization in the school computer science course, as well as to describe the functionality of the software product.

## **3 The results of research**

### **3.1 Training simulator as an effective training tool**

Classical tutorials and textbooks do not always fully meet the requirements of “digital learners” who seek to catch up everywhere and immediately. The need to reform the current education system is now being talked about by everyone, even those whose field of activity is far from education. Many teachers pay attention to the fact that without the use of modern technologies it is impossible to make a significant breakthrough in solving the problems of reforming education and improving the qualitative parameters of training of future specialists. In this case, informatization is one of the key conditions that determine the further development of the economy, science and culture in general [6]. Undoubtedly, the correct and optimal use of information and communication technologies allows to obtain a number of advantages in improving the efficiency of the educational process, namely: providing visibility of the educational material and combining different ways of perceiving educational information; increasing motivation due to novelty and variety of training using computer equipment; increasing the student's time to work with the study material individually; the presence of objective control and self-control in the correct preparation of test tasks [7, p. 128].

World experience has shown that in recent decades, many workspaces (simulators) have been widely used in many fields of human activity, especially in the learning process [10; 15; 16; 28; 36]. For example, a number of foreign publications are devoted

to the use of augmented reality applications for smartphones and tablets in the study of computer science [34], biology [17; 25], chemistry [24], astronomy [8], physics [11], mathematics [12] and other subject areas [20; 21]. Simulators allow to expand resources and training opportunities. These resources include additional visibility and accessibility of training material.

One of the important conditions for enhancing the development of theory and practice is the creation of a system of tasks, their consistency and diversity [19, p. 178]. A computer simulator is a software-hardware training and control tool for training and developing practical skills. A training simulator for educational purposes is a training device that simulates circumstances, actions, creates a situation close to real [23, p. 94]. In a narrower sense, it is a training program for developing the skills and competences of a particular activity, as well as developing related skills.

The training simulators are based on the use of a specific training task. Its essence is that in a short period of time, using different methods of working with educational material, you can quickly teach students to remember it.

### **3.2 Using an augmented reality in educational software**

One way to improve education technologies is to use virtual and augmented reality systems, 3D e-learning systems [4]. Virtual and augmented reality are three-dimensional human-computer interaction technologies implemented using modern ICT tools. Augmented reality technology allows real-time image capture devices to recognize special tags (markers), as well as their position in space, with the subsequent introduction of imaginary objects into real space. Such devices may be used for smartphones, tablets or special augmented reality goggles [30].

The prospect and pace of implementation of virtual and augmented reality technologies indicate that the learning tools developed on their basis will become an integral part of education at all levels of education, and their role will increase significantly both within traditional and e-education [14; 35]. The use of augmented and virtual reality training tools will significantly shorten the training time, improve the quality of training and enhance the practical orientation of the learning process. The main idea of using virtual and augmented reality is to increase the possibilities of human interaction with the environment [18]. The use of augmented and virtual reality training tools will significantly shorten the training time, improve the quality of training and enhance the practical orientation of the learning process. The main idea of using virtual and augmented reality is to increase the possibilities of human interaction with the environment [1, pp. 1–2]. For the education system, virtual and augmented reality are promising in terms of using these technologies as innovative learning tools that will retain the student's interest. Today, these are mostly simulators and simulators. Such training tools allow you to gain knowledge and skills by working with them virtually. The use of augmented reality tools not only visualize the training material, but also combine virtual reality with the physical environment, to face the 3D world, which means to make it brighter, more memorable, even more memorable to even closer modern students. Tutorials, booklets, and other educational material may contain embedded markers that, when scanned with augmented reality devices, provide the

student with additional information presented in a multimedia format. Instead of remaining passive recipients, students become active, able to interact with their learning environment [5].

### **3.3 Features of three-dimensional modelling for training simulator with augmented reality**

On the prospect of using 3D modelling technologies as a promising direction for use in virtual reality and augmented reality, in the process of developing gameplay, and for modelling objects for educational purposes, the number of subjects emphasized [2, pp. 17–18].

Modern computer technologies allow create the simulators that include multimedia components – computer animation, audio and video effects, as well as virtual and augmented reality. The use of these tools enhances the sense of reality when working with the simulator and opens up new opportunities in the learning process. The augmented reality simulator’s information model is best depicted in terms of the process of sequential and cyclical accumulation of knowledge, highlighting the dynamics of virtual 3D space development as a constructive value of the simulator. The efficiency of using the simulator will depend, first of all, on the saturation of perception of knowledge throughout the action. The saturation of perception can be increased by creating a more capacious and realistic virtual 3D image of augmented reality.

Augmented reality when using such simulators imposes virtual objects, characters, filters or other effects on the surrounding world [27, pp. 4–5]. This is done by playing objects for the smartphone. To create such objects, three-dimensional modelling is often used to ensure the best integration of the object into the environment.

### **3.4 Design and visualization of training simulator**

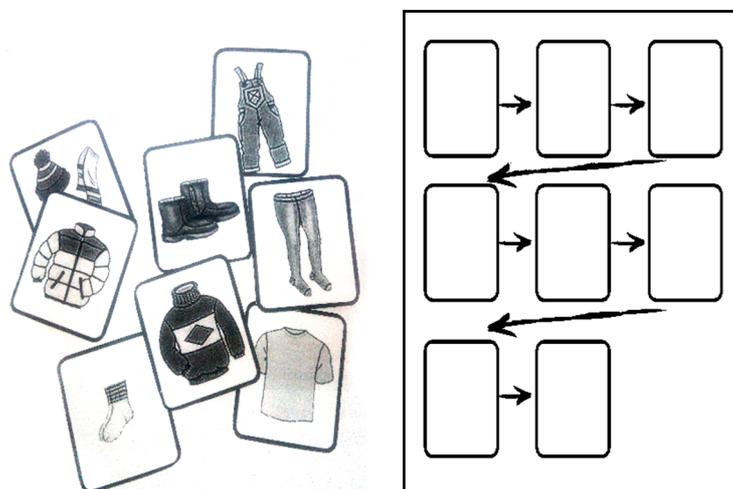
Nowadays, in connection with the relevance and effectiveness of the use of technologies of virtual and augmented reality for pedagogical purposes, the direction of pedagogical design of teaching aids based on virtual and augmented reality technologies has been determined. Despite the fact that augmented reality technology is really relevant and has several advantages over traditional learning, there are a number of problems in its implementation in education. The main problems with the introduction of augmented reality technology in education are the lack of ready-made tools [13]. In particular, this also applies to the school computer science course, in which augmented reality technology is more commonly used in the process of studying the section of computer science course “Computer Architecture” as the most illustrative [9; 29]. To develop a simulator with augmented reality, we chose the topic “Algorithms” of the school course in computer science. Consider a developed simulator to study the topic of algorithmization when studying a school computer science course. We define the developed simulator (by analogy with [6]) as an imitation learning tool, which is a specialized didactic complex of technical and software tools that implements the interaction of the student and the tools in the learning process. The simulator is

designed to develop and improve students' skills and abilities of logical and algorithmic thinking.

Augmented reality simulator to study the topic of algorithmization in the study of computer science course was developed in the Unity 3D development environment. Unity3D is a platform for computer games and applications development. Unity3D allows the creation of applications running on more than twenty different operating systems, including personal computers, game consoles, mobile devices, Internet applications and others [33]. The Unity3D program supports the Vuforia SDK. The Vuforia SDK is a software suite that includes augmented reality platforms and augmented reality software developer (SDK) tools to use AR technologies on mobile devices: tablets, smartphones and AR glasses for iOS, Android and UWP (Windows). The Vuforia SDK is integrated with the Unity3D game engine, which greatly facilitates the development of AR applications. Because AR reality technology is integrated by developers into most mobile operating systems, the mobile AR app supports Android 4.1.x and above, iOS 9 and above, and Windows 10 UWP. By default, Vuforia works with Image Recognition. Image recognition, also called Tracker Recognition or Image Tracking, is the process by which a software recognizes a predetermined image and renders certain content on top of it.

To model an assistant character based on the analysis and classification of 3D modelling tools [26, pp. 77–79] we used a graphical editor for three-dimensional Autodesk Maya modelling.

To perform the multi-level tasks, cards were prepared from which the student must assemble a flowchart that would fit the task. Cards are labels or tracker images that a student operates in the real world. Examples of cards are shown in the Fig. 1.

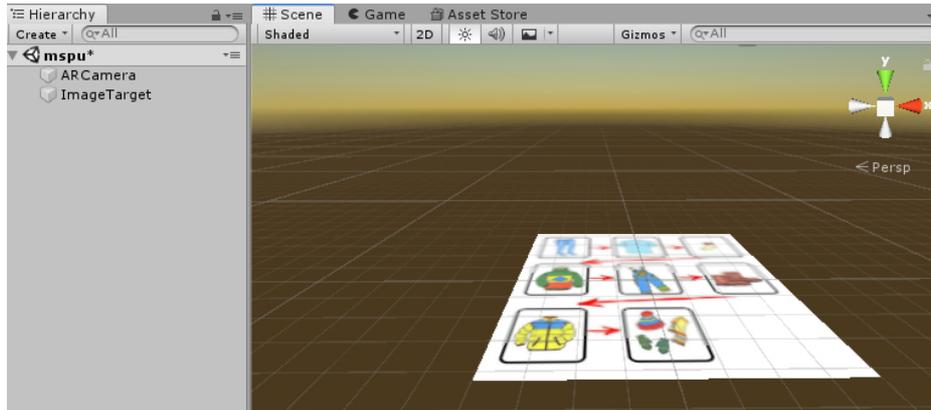


**Fig. 1.** Examples of tag cards for drawing flowcharts and a playing field

The next step in creating the program is to add the Image Target tag and ARcamera. ARcamera is a virtual camera that simulates the smartphone camera. There is also a

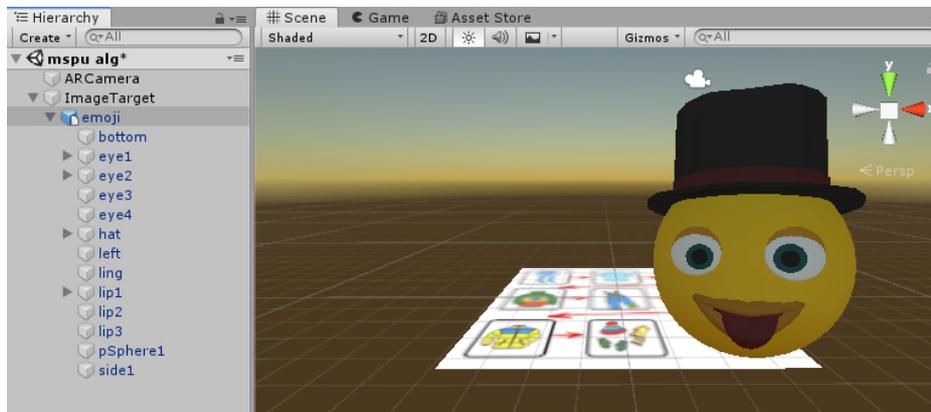
prefab Camera managing game stage Unity. ImageTarget is an image tag. The result of adding a label to the project scene is shown in the

Fig. 2.



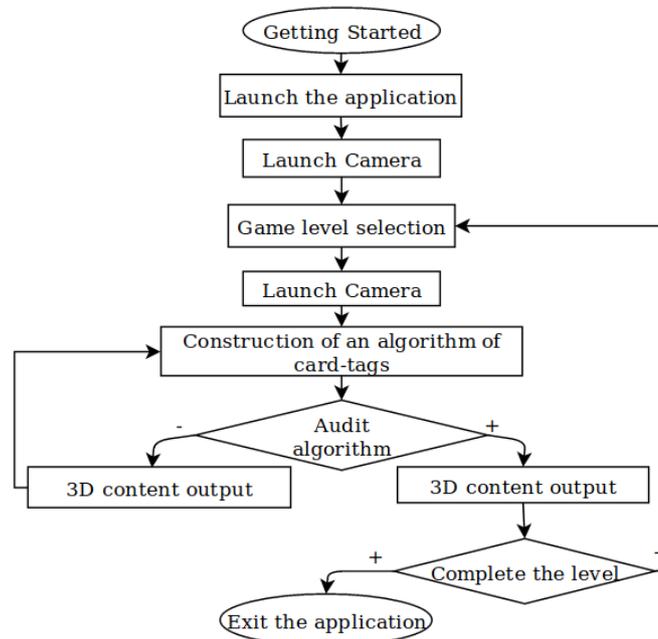
**Fig. 2.** Placing a label on the Unity stage

Next, a 3D object of the helper character with emotion is added to the scene, which will correspond to the faithful almost wrong decision of the task. The result of adding an object to the scene is shown in the Fig. 3. After all the labels and objects were placed on the Unity stage, the project was saved in apk-format for further testing on an Android smartphone.



**Fig. 3.** Adding a 3D object to the Unity scene

The result is a mobile augmented reality application that is used as a simulator for studying the computer science course on “Algorithms and Performers”. To use the bottom app, a student must have a smartphone or tablet on the Android platform. The algorithm of the application is shown in Fig. 4.



**Fig. 4.** The algorithm of the application

After starting the application is initialized mobile camera, after which the user selects an educational level. After selecting the required educational level, the user goes to the game levels directory. Then the level at which the user builds a chain of card tags starts. If the chain is constructed correctly, a positive 3D character appears on the screen, if not – the 3D character reports that the algorithm is incorrectly constructed and the level needs to be redone. After completing the level, the user can continue the game to the next level, or shut down the application.

Thus, by pointing the camera of the smartphone to the solution of the problem on the topic of algorithmization, the student sees the reaction of the assistant character, which illustrates the correctness of the solution of the problem: the emotion of sadness corresponds to the wrong solution of the problem, while the joy illustrates the correct solution.

The survey, conducted among parents of pupils who participated in the project activity using an augmented reality simulator, showed the following results. Parents appreciated such educational experience. Parents expressed a positive attitude towards using mobile devices for learning purposes. The thought of using mobile devices has changed from negative to positive or at least neutral in the process of participating in a project. All parents noticed increased interest in children, increased motivation to learn new material. Many parents have used links to the right programs and engaged with their child outside the institution. The overall result of the project activity was satisfied with both teachers, children, and parents, who expressed their willingness to participate in such activities in the future.

## 4 Conclusions and prospects for further research

We have analysed scientific and methodological sources for determining the effectiveness of using educational simulators. The analysis of modern approaches, covered in foreign and domestic sources on the experience of using augmented reality in educational simulators, is conducted. Described is a developed educational simulator with augmented reality, aimed at studying the topic of algorithmization in the school course of computer science for children of primary school age. The augmented reality simulator will help teachers, tutors, and even parents to increase the effectiveness of learning a computer science course on the topic of algorithmization. Further research prospects are aimed at expanding the educational tasks of the simulator and the development of playing cards, as well as the experimental verification of the effectiveness of using the developed software product in the conditions of basic and complete general secondary education.

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