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DESIGNING AND ORGANISING THE PEDAGOGICAL PROCESS BY MEANS OF AUGMENTED REALITY TOOLS

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Abstract. The article analyses augmented reality (AR) as a means of designing and organising the pedagogical process in teacher-training institutions and general education schools. The author clarifies the place of AR within the reality–virtuality continuum, describes marker-based and markerless approaches, and considers their didactic functions: visualisation of abstract concepts, enhancement of learning motivation and support for collaborative activity. Drawing on systematic reviews and meta-analytic data, the study shows that AR has a positive effect on learning outcomes provided that cognitive load is carefully managed. As a practical result, a six-step algorithm for creating AR-based learning materials and a set of design principles for AR lessons in pedagogical disciplines are proposed, together with recommendations for preparing future teachers to use the technology.

Keywords: augmented reality, mixed reality, didactic visualisation, AR learning materials, lesson design, cognitive load, teacher training, digital pedagogy.

INTRODUCTION

The rapid spread of smartphones and tablets has created conditions under which technologies that recently required expensive equipment can now be used in an ordinary classroom. Augmented reality is one of the most accessible of these technologies: it requires only a mobile device with a camera and a suitable application. The strategy “Digital Uzbekistan – 2030” sets the task of introducing digital technologies into all levels of education and developing digital skills among teachers and learners [1]. Implementing this task requires not only technical infrastructure, but also a methodology that explains how new tools should be integrated into the teaching process.

For pedagogical disciplines, AR is interesting for two reasons. First, it can be used directly in university courses to make abstract pedagogical concepts more tangible. Second, future teachers must themselves learn to design AR-based lessons for their pupils, which turns the technology into an object of professional training. However, many students and practising teachers perceive AR as a complicated tool that requires programming skills, and its didactic potential therefore remains underused. This article aims to substantiate the methodological principles of designing and organising the pedagogical process with the help of AR tools.

LITERATURE REVIEW

The classical definition proposed by R. Azuma describes augmented reality as a system that combines real and virtual objects, operates interactively in real time and registers virtual content in three-dimensional space [2]. P. Milgram and F. Kishino placed AR on the reality–virtuality continuum, between the fully real environment and the fully virtual one, and introduced the broader concept of mixed reality [3]. This position explains the main pedagogical advantage of AR over VR: the learner does not lose contact with the real classroom, the teacher and classmates, so that digital content enriches rather than replaces social interaction.

H.-K. Wu and colleagues identified the key educational affordances of AR, including learning content in three-dimensional perspectives, ubiquitous and collaborative learning, a sense of presence and immediacy, and the visualisation of the invisible [4]. A systematic review by M.

Akçayır and G. Akçayır confirmed that AR most often contributes to better learning achievement, higher motivation and more positive attitudes, while also noting difficulties such as usability problems, technical failures and the extra time students need to get used to the applications [5]. A meta-analysis by J. Garzón and J. Acevedo found a moderate positive effect of AR on students' learning gains across different levels of education [6].

At the same time, the effectiveness of AR is constrained by the limits of human working memory. J. Sweller's cognitive load theory and R. Mayer's principles of multimedia learning suggest that excessive, poorly coordinated visual and audio elements reduce rather than increase learning [7; 8]. J. Bacca and co-authors also pointed out that most AR studies focus on science and engineering, while applications in the humanities and in teacher education remain comparatively rare [9]. This gap determines the relevance of the present study.

METHODOLOGY

The research is based on a theoretical analysis of scientific literature on augmented reality in education, a comparison of available AR authoring tools in terms of their suitability for teachers without programming experience, and pedagogical modelling. The modelling method was used to develop an algorithm for creating AR learning materials and a set of principles for organising AR-supported lessons in pedagogical disciplines.

RESULTS AND DISCUSSION

From a technical point of view, two main approaches to AR can be distinguished. Marker-based AR is activated when the camera recognises a predefined image, such as a picture in a textbook, a QR code or a printed card. Markerless AR places digital objects onto real surfaces using the device's sensors and does not require special images. For school and university practice, the marker-based approach is usually more convenient, because it links digital content to specific printed materials and is easy to organise in a classroom. Free or low-cost platforms such as Assemblr EDU, CoSpaces Edu and Merge Cube allow teachers to create simple AR scenes without writing code.

In pedagogical disciplines AR performs several didactic functions. Its visualising function makes it possible to turn abstract categories, for instance the system of didactic principles or the structure of the educational process, into interactive schemes. Its motivational function arises from the novelty and interactivity of the content. Its communicative function is realised when pupils work with AR objects in pairs or groups and discuss what they see. Interpreted in this way, AR can be regarded as a modern continuation of the principle of visual instruction that J. A. Comenius formulated in the seventeenth century [10].

The analysis allowed the author to formulate an algorithm of six steps for creating AR-based learning materials, which is presented in Table 1.

Table 1. Algorithm for creating AR-based learning materials

Step	Content of the teacher's activity	Result
1. Goal setting	Defining the learning outcome the AR material should support	Measurable lesson objective
2. Content selection	Choosing information that genuinely benefits from visualisation or interactivity	List of AR elements
3. Trigger selection	Choosing markers (textbook page, card, QR code) or a markerless scene	Linked printed and digital components
4. Content creation	Producing 3D models, short videos or audio using an authoring tool	Ready AR scene

5. Piloting	Testing the material on different devices and with a small group of learners	Corrected version of the material
6. Evaluation	Analysing learners' results and feedback after the lesson	Decision on improvement or wider use

When organising an AR lesson, it is important to observe several principles. The principle of didactic necessity requires using AR only where it adds something that cannot be achieved by simpler means. The principle of time limitation suggests that work with AR content should be a distinct phase of the lesson, followed by discussion, so that interaction with the screen does not displace interaction between people. The principle of minimal cognitive load implies that each AR scene should contain only the elements necessary for the task and that text, images and sound should be coordinated [7; 8]. Finally, the principle of equal access means that the teacher must plan pair or group work so that pupils without personal devices are fully involved.

To show how the proposed algorithm and principles work together, a scenario of a seminar session for second-year students of the pedagogy programme was developed. The topic "Principles of teaching" was chosen deliberately: it is traditionally presented as a list of abstract statements that students memorise but rarely connect with real classroom situations. In the AR version of the seminar, each principle is linked to a printed card; when the camera of a smartphone is pointed at the card, a short animated scene appears, showing a classroom episode in which the principle is either observed or violated. The structure of the session is presented in Table 2.

Table 2. Scenario of an AR-supported seminar on the topic "Principles of teaching"

Stage	Teacher's and students' activity	Time
1. Introduction	The teacher states the objective and explains how to work with the AR cards; students form groups of three or four	5 min
2. Exploration	Each group scans its cards, watches the scenes and identifies which principle is shown and whether it is observed	15 min
3. Analysis	Groups fill in an analysis sheet: what the teacher in the scene did, what consequences followed, how the situation could be improved	20 min
4. Presentation	Groups present their conclusions; other groups ask questions and add examples from their school practice	25 min
5. Reflection	Students answer short questions on what was new and what remained unclear; the teacher summarises the key ideas	15 min

Several features of this scenario deserve comment. The AR scenes occupy only the exploration stage, while most of the time is devoted to analysis and discussion, which corresponds to the principle of time limitation. Each scene lasts no more than one minute and contains a single episode without background music or additional captions, so that students can concentrate on the pedagogical situation itself. Since the cards are printed and one device is enough for a whole group, the scenario does not depend on every student owning a modern smartphone. Finally, the scenes showing violated principles proved especially productive: students were more willing to argue

about mistakes than to describe correct examples, and the discussion naturally led them to formulate the principles in their own words.

The introduction of AR into the educational process is also accompanied by certain difficulties that the teacher should foresee at the design stage. The first group of difficulties is technical: applications may not run on older devices, recognition of markers deteriorates in poor lighting, and some platforms require a stable Internet connection. The second group is psychological and didactic. I. Radu, summarising a large number of studies, noted that AR content can capture learners' attention so strongly that they stop noticing the instructions of the teacher and the actions of their partners, and that poorly designed interfaces create additional usability problems [11]. The third group concerns the organisation of the lesson: the time needed to distribute devices, launch applications and solve unexpected problems is often underestimated.

These risks can be reduced by relatively simple measures. Materials should be checked in advance on the devices that will actually be used in class, and wherever possible scenes should be downloaded for offline use. It is advisable to prepare a printed or slide-based copy of the key content so that the lesson can continue if the technology fails. Clear rules of work, such as one device per group, fixed roles of the "operator", the "observer" and the "recorder", and a signal for returning to joint discussion, help to keep the attention of learners on the learning task rather than on the gadget.

An important element of designing the pedagogical process is evaluating the effectiveness of AR lessons. In our view, such evaluation should take into account at least three groups of indicators. Cognitive indicators reflect the quality of learning outcomes, for example the accuracy of students' explanations and their ability to apply concepts to new situations. Motivational indicators include interest in the topic, willingness to participate and the desire to continue working with similar materials. Organisational indicators describe how much lesson time was spent on technical operations and how evenly all learners were involved. Comparing these indicators with the results of lessons conducted without AR allows the teacher to decide on the basis of evidence rather than impressions whether the technology is justified for a particular topic.

The preparation of future teachers deserves particular attention. Students of pedagogical faculties often show interest in AR, yet feel unready to use it. This can be addressed by introducing practical tasks in which students create their own simple AR materials for school subjects, by analysing case studies of successful and unsuccessful AR lessons, and by organising joint projects with students of information technology. Such activities form not only technical skills but also the ability to make reasoned methodological decisions about when and how to use the technology.

The readiness of future teachers to use AR can be viewed as a combination of several interconnected components. The motivational component reflects a positive attitude towards digital tools and an understanding of their value for pupils. The cognitive component includes knowledge of the types of AR, its didactic functions and its limitations. The operational component covers the practical skills of finding, adapting and creating AR materials with authoring platforms. The reflective component manifests itself in the ability to analyse one's own lesson critically and to decide whether the use of AR achieved its purpose. Developing all four components requires that work with AR should not be confined to a single course on information technology, but should be distributed across methodological disciplines and teaching practice, where students can test their materials with real pupils.

CONCLUSION

Augmented reality is an accessible and pedagogically promising tool for designing and organising the educational process. By enriching the real environment with digital content, it preserves social interaction in the classroom and supports visualisation, motivation and collaboration. The effectiveness of AR, however, is determined by methodology rather than technology: clear goals, careful selection of content, control of cognitive load and equal involvement of all learners. The six-step algorithm and the design principles proposed in this article can be used by university lecturers and school teachers when developing AR-supported lessons. Promising directions for further research include the empirical evaluation of AR lessons in pedagogical disciplines and the creation of a bank of AR learning materials in the Uzbek language.

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