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DIDACTIC OPPORTUNITIES OF USING VIRTUAL VISUALIZATION TOOLS IN DEVELOPING STUDENTS' ACADEMIC AND DIGITAL ACTIVITIES

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Abstract

This article analyzes the didactic possibilities of using virtual visualization tools in developing students' academic and digital activities. The article identifies the impact of virtual visualization tools on the development of academic-digital competencies and the pedagogical prerequisites for their integration into the educational process.

Keywords

virtual visualization, academic-digital activity, didactic opportunities, digital education, interactive learning, simulation, differentiated education, motivation, educational process, digital competence, educational technologies

INTRODUCTION

The didactic possibilities of using virtual visualization tools in developing students' academic and digital activities play an important role in the new organization of the content, forms, and methods of modern education. This is because the process of acquiring knowledge in a digital educational environment is not limited to the reception of textual information; it combines multi-component cognitive activities such as vision, hearing, interactive action, analysis, and practical testing. Virtual visualization tools act as a didactic mechanism that ensures this process, bringing complex concepts into a visual, understandable, and controllable form.

LITERATURE REVIEW

The learning process organized through simulations is grounded in constructivist and active learning approaches. In particular, according to the experiential learning theory proposed by David Kolb, knowledge is formed progressively through direct experience, observation, analysis, and reflective thinking [1]. In line with this theoretical framework, the learner is not viewed as a passive recipient of information but rather as an active participant engaged in the learning process.

Virtual simulations provide an effective means of modeling this experiential learning cycle within a digital educational environment. In this context, students interact with various models, independently manipulate parameters, observe outcomes, and draw analytical conclusions based on their observations. As a result, the learning process shifts from a traditional reproductive approach to an active, inquiry-based, and problem-oriented learning model. This transformation contributes to the development of students' critical thinking, analytical reasoning, and decision-making competencies.

At the same time, the constructionist approach developed by Seymour Papert theoretically supports simulation-based learning mechanisms. According to this approach, knowledge is not transmitted in a ready-made form but is constructed independently by the learner through active, interactive, and creative engagement. Therefore, virtual simulations enable learners to act as active agents in the process of knowledge construction, fostering the development of their analytical thinking, problem-solving abilities, and reflective skills.

DISCUSSION

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One of the most important didactic potentials of virtual visualization tools lies in their ability to present educational content in a clear, illustrative, and cognitively accessible form. In higher education, many topics are associated with abstract concepts, complex processes, multi-stage mechanisms, or phenomena that cannot be directly observed [4]. In such cases, textual or verbal explanations alone are often insufficient to ensure effective understanding. Virtual visualization, however, enables the representation of complex content through diagrams, animations, 3D models, infographics, interactive maps, virtual laboratories, or simulations, thereby revealing the essence of knowledge more clearly. As a result, students develop a deeper understanding of the internal structure, functional relationships, and dynamics of the studied objects, phenomena, or processes. Another significant didactic value of these tools is their capacity to activate the cognitive learning process.

In traditional education, students often act as passive recipients of ready-made information, whereas virtual visualization tools transform them into active participants in the learning process. Students interact with models, manipulate parameters, observe outcomes, compare different scenarios, and draw conclusions based on their analysis. Such an approach shifts the learner's role from a passive observer to an active explorer, analyst, and decision-maker. In this regard, virtual visualization tools effectively support active learning, problem-based learning, and inquiry-oriented approaches.

Among the didactic potentials of virtual visualization, the concretization of abstract knowledge is of particular importance. This is especially relevant in disciplines such as mathematics, physics, biology, technology, engineering, medicine, and information technology, where many theoretical concepts pose challenges for students. For instance, internal physiological processes, the dynamics of mathematical functions, the step-by-step progression of physical phenomena, or the operational principles of technical mechanisms become significantly clearer through virtual visualization tools. This not only deepens understanding but also enhances long-term retention of knowledge and reduces the gap between theory and practice.

Furthermore, virtual visualization tools serve as an important factor in supporting independent learning and enhancing students' academic-digital activity. In a digital learning environment, students can interact with visual models and resources autonomously, revisit them multiple times, analyze their structure, and independently construct knowledge, thereby developing self-regulation, analytical thinking, and reflective learning skills.

In a digital environment, students can independently interact with presented visual models or interactive resources, revisit them multiple times, analyze their structure, and draw their own conclusions. This process contributes to the development of self-regulation, monitoring of learning progress, information selection and analysis, as well as reflective thinking skills. As a result, virtual visualization tools evolve beyond being merely explanatory instruments used during classroom instruction and become effective didactic platforms that support students' independent learning activities. Another significant advantage of these tools lies in their capacity to facilitate individualized and differentiated instruction.

Since each student differs in terms of learning pace, cognitive style, and educational needs, uniform textual or verbal explanations are not equally effective for all learners. Virtual visualization tools address this challenge by enabling the presentation of content in multiple formats: some students may better understand through animations, while others may prefer схематic representations, tables, or interactive models. In this way, the learning process becomes more learner-centered. This is particularly important when working with students of varying levels of preparedness, within inclusive education contexts, and in designing individualized learning trajectories.

From the perspective of motivation, virtual visualization tools also offer substantial pedagogical benefits. For representatives of the digital generation, dynamic, visually rich, interactive, and user-responsive learning resources are significantly more engaging than traditional text-based materials [3]. Such forms of presentation foster a positive attitude toward

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learning content, sustain attention, and enhance intrinsic motivation to learn. In this context, both the aesthetic and functional qualities of visualization tools play a crucial role. When selected appropriately, they stimulate emotional engagement, cognitive interest, and creative thinking in students' learning activities.

Moreover, virtual visualization tools effectively bridge the gap between theoretical knowledge and practical application. Students often encounter difficulties when attempting to apply theoretical concepts in real-life situations. Virtual laboratories, digital models, and simulations provide opportunities to observe how theoretical knowledge operates in practice. Through virtual experimentation, students can model various scenarios, observe the consequences of errors in a safe environment, and apply their knowledge to solve practical problems. Consequently, learning progresses from a reproductive level to a more applied and creative level, enhancing both understanding and competence development.

Another important didactic potential of virtual visualization tools lies in their ability to provide immediate feedback and support reflection. Through interactive systems, students can instantly see the results of completed tasks, identify their mistakes, and correct them in a timely manner. This contributes to the continuous improvement of the learning process. At the same time, instructors are able to monitor at which stage and on which topics students experience the greatest difficulties, allowing them to adapt pedagogical interventions accordingly. Thus, virtual visualization tools perform not only explanatory functions but also serve as effective means of monitoring, диагностика, and corrective support.

The impact of virtual visualization tools on academic-digital activity is also reflected in the development of students' digital competence. In the process of using such tools, students acquire skills in working with digital interfaces, visually analyzing information, creating digital content, engaging with interactive platforms, and effectively utilizing electronic resources. This enhances not only their performance within the educational process but also their competitiveness in future professional activities. From this perspective, virtual visualization tools act not only as supportive instruments for academic learning but also as educational resources that foster digital literacy.

CONCLUSION

In conclusion, the didactic potential of virtual visualization tools in developing students' academic-digital activity is extensive and multifaceted. These tools enable the presentation of learning materials in a clear and accessible manner, activate cognitive processes, concretize abstract concepts, support independent learning, facilitate individualized and differentiated instruction, enhance motivation, bridge the gap between theory and practice, provide immediate feedback and reflection, strengthen interdisciplinary integration, and promote the development of digital competence. Therefore, virtual visualization tools can be considered one of the most effective didactic means for fostering students' academic engagement, cognitive independence, and digital culture in modern higher education.

However, when applying virtual visualization tools, it is essential to adhere strictly to the principle of didactic appropriateness. Any visual tool should be employed not merely because of its technological novelty, but because it effectively addresses specific pedagogical objectives. Otherwise, excessive visual elements or unnecessary interactivity may distract students' attention, increase cognitive load, and hinder the achievement of core learning goals. Consequently, the effectiveness of virtual visualization tools depends on their coherent integration with learning objectives, content, instructional methods, and assessment systems.

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