



# Virtual Reality in Education – Can Mining Be Learnt Virtually?

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## Abstract

*Virtual reality (VR) is increasingly used in education. Therefore, it is also a modern tool supporting the process of educating future miners and professional development of employees in the industry. VR technology allows for realistic representation of the mining environment, machinery and technological processes, which allows for safe training without the need to be in real excavations. Thanks to simulations, it is possible to practice operating procedures, responding to emergency situations and occupational health and safety rules. The use of VR increases the effectiveness of teaching, improves the understanding of complex processes, and reduces the risk of accidents and training costs. Virtual reality is also conducive to learning through experience, which has a positive effect on the engagement and consolidation of knowledge by training participants. The discussed project, codenamed HoloGEM, is an educational solution offering mining-related content in the form of an e-learning platform, where one of the solutions is the use of virtual reality.*

**Keywords:** HoloGEM, mining, education, virtual reality

## 1. Introduction

Contemporary education is undergoing dynamic changes resulting from the rapid development of information and communication technologies and growing expectations regarding the effectiveness and attractiveness of the education process. Traditional teaching methods, based mainly on theoretical messages, are increasingly proving to be insufficient in the face of the need to develop practical, analytical and creative competences. In response to these challenges, innovative teaching tools are gaining more and more importance, among which virtual reality (Virtual Reality – VR) occupies a special place.

Virtual reality is a technology that allows the user to immerse themselves in a three-dimensional, computer-generated environment with which they can actively interact. Thanks to the use of specialized goggles, controllers and educational software, it is possible to simulate real or hypothetical situations in a realistic and engaging way. In the educational context, VR creates new opportunities for knowledge transfer, allowing pupils and students not only to observe the phenomena discussed, but also to experience them directly.

The use of virtual reality in education is justified by the theory of experiential learning, according to which active participation in the cognitive process is conducive to better memorization and understanding of the material. VR enables the visualization of complex processes, structures and dependencies that can be difficult to represent in traditional teaching, such as physical, chemical, biological or technological processes. In addition, this technology allows for repeated exercises and adjustment of the learning pace to the individual needs of the user.

The use of VR is often associated with Augmented Reality (AR). The difference is that Virtual Reality (VR) is an artificial environment which is experienced through sensory stimuli

(such as sights and sounds) provided by a computer and in which one's actions partially determine what happens in the environment (Jerald, 2015; Scavarelli et al., 2021), while Augmented Reality (AR) allows the user to see the real world, with virtual objects superimposed upon or composited with the real world. Therefore, AR supplements reality, rather than completely replacing it (Azuma, 1997). The combined form of both solutions is often referred to as Mixed Reality (MR).

## 2. Advantages of VR

Virtual Reality (VR) has made significant inroads into both the consumer and professional sectors. As VR has matured as a technology, its overall practicality for use in education has also increased. The progress of VR in educational research and classroom practice can be evaluated through three key questions regarding benefits, challenges and current applicability (Lege and Bonner, 2020). The stimulation in interest is one of the crucial benefits. Modern visualization solutions allow to arouse much more attention and interest among students (Costa and Melotti, 2012; Tai et al., 2020; Velez, 2017). Particular benefits have been observed in vocabulary learning (Chen, 2016; Madini and Alshaikhi, 2017; Parmaxi and Zaphiris, 2015).

Virtual reality also allows you to reach an environment that is not normally accessible to a student. Therefore, it also allows you to virtually encounter threats, the heavy industry zone and places that are difficult to access in practice. Thus, it allows you to gain knowledge in a field that is empirically inaccessible to the average student. The advantages of this approach have been discussed in many publications (Błażauskas et al., 2017; Elmqaddem, 2019).

Another benefit is spatial learning in virtual environments. Memories can be stored in sequential locations based within a mental image called memory palaces. Such an ap-



Fig. 1. Title screen  
Rys. 1. Ekran tytułowy

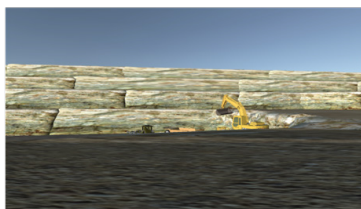


Fig. 2. Scenario – Open Pit Mining  
Rys. 2. Scenariusz – Górnictwo Odkrywkowe



Fig. 3. Scenario – Underground Mining  
Rys. 3. Scenariusz – Górnictwo Podziemne

proach has been presented, among others, in scientific studies (Krokos et al., 2019; Pollard et al., 2020).

The time of the pandemic, which dominated education in the period 2020-2022, caused a sharp increase in the use of educational techniques. Virtual reality also fulfills its task in this regard, enabling virtual walks without the need to leave home. This has been highlighted and noted by many Authors (Ball et al., 2021; Rezaldi et al., 2025)

Therefore, it can be said that virtual reality will allow:

- Maintaining engagement and interaction: During the pandemic, many students struggled with isolation and a lack of interaction. VR can help to bridge this gap by providing a shared virtual space in which learners can collaborate and socialise, thereby mimicking the dynamics of a physical classroom. Platforms such as VRChat, AltspaceVR and ENGAGE XR have already proven effective in fostering community in virtual settings (Scavarelli et al., 2021).
- Ensuring access to practical learning: For subjects requiring hands-on learning, such as medicine or engineering, VR provides realistic simulations that replicate laboratory experiments or surgical procedures. Research by VHIL showcases how VR can be used to train medical students in emergency response scenarios without risking real lives, making it an invaluable tool during pandemics when physical interaction is limited (Dunleavy et al., 2009).
- Expanding Global Access: Although equitable access to technology remains challenging, VR hardware

is becoming increasingly affordable. By leveraging partnerships with tech companies, educational institutions could distribute VR headsets to underserved populations, thereby ensuring continuity of education. Such initiatives could prevent the widening of the education gap observed during the pandemic (Samala et al., 2025).

- Fostering empathy and global awareness: VR education can foster empathy by enabling students to 'walk in someone else's shoes'. Studies by VHIL have shown that VR experiences, such as simulating a refugee's journey, can cultivate a deeper understanding of global issues. This is a critical capability during pandemics, when global collaboration and empathy are essential (Bertrand et al., 2018).

### 3. Threats and challenges

The main threat and challenge in the use of virtual reality is the lack of educational skills of teachers in this area. Thus, it is necessary to train teachers to use modern IT tools and to equip school and university laboratories with appropriate equipment to take full advantage of the experiences offered by virtual reality (Scavarelli et al., 2021). An undoubted opportunity to implement this type of solutions in the education system is the increasing availability of VR devices and their lower prices.

Another threat is the potential adverse health effects. Some people experience health problems when they come into contact with VR, especially if it is long-lasting and abundant in li-

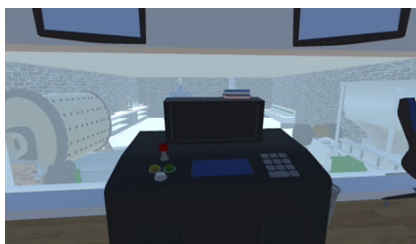


Fig. 4. Scenario – Mineral Processing

Rys. 4. Scenariusz – Przeróbka Surowców Mineralnych



Fig. 5. Scenario – Mineral Processing

Rys. 5. Scenariusz – Przeróbka Surowców Mineralnych



Fig. 6. Scenario – Health and Safety at Work

Rys. 6. Scenariusz – Bezpieczeństwo i Higiena Pracy

ght effects. In such cases, the use of these solutions in everyday education is not advisable (Smutny, 2023). The use of VR also requires a specific usable area. Too little space can result in physical injuries. Therefore, it is necessary to properly prepare the environment where users will use VR (Wang et al., 2024).

Of course, the most important thing is the quality of the content offered. In addition to a good quality visual message, it is important that the content offered is as close as possible to the real experience. Developing clear guidelines and standards for creating high-quality VR content is essential to address these issues. Collaboration between developers, educators, and subject matter experts is crucial to ensure that VR experiences are engaging and pedagogically sound. Furthermore, continuous assessment and feedback mechanisms are necessary to improve VR content, ensuring its learning experiences remain relevant, up-to-date, and aligned with educational goals (Antón-Sancho et al., 2024).

#### 4. Availability

The availability of VR has increased significantly over the past years. The combination of VR and AR has provided new educational opportunities and increased the attractiveness of the presented content. Many platforms have been created around the world using these solutions, also drawing on the content offered by artificial intelligence. The mix of this content attracts young people's attention and makes them interested in new topics that traditional forms of education do not attract them to. In the world, you can clearly see where the use of VR dominates. Based on global reports and analyses of scienti-

fic publications, it can be concluded that the countries where VR has gained the most popularity are primarily China, South Korea, Australia, the USA, Taiwan, and in Europe Greece, Finland, the United Kingdom, Germany and the Netherlands (Brodny et al., 2023; Samala et al., 2025). In Poland, this technology is also gaining popularity (Ignaciuk, 2023). It is worth paying attention to its use in e-sports, rehabilitation, or various types of training. It also indicates a positive attitude of students towards VR as a teaching tool in the classroom, which aroused greater interest in the topic and engagement in the class than lessons conducted using traditional teaching methods (Aubrey et al., 2018). These observations confirm that the change in the way of teaching from a teaching method to an engaging educational experience is an important value of this technology. Remembering content using virtual reality is more effective than using screen technologies, e.g. a computer or tablet (Crogman et al., 2025).

#### 5. HoloGEM – virtual reality in mining.

The use of VR in the HoloGEM educational project went in the direction of e-learning. The time of the pandemic has definitely popularized the use of digital solutions in education. The HoloGEM project decided to develop a basic course in the field of mining, the aim of which was primarily to increase the attractiveness of the presented topic and change the negative image of mining among school and university youth. The future requires people with a broader, modern outlook, who are also familiar with the latest achievements in computer technology, not only in the field of education.

To achieve this, appropriate educational digital tools had to be developed, one of which is virtual reality.

In order to identify the educational needs in the field of teaching young people, especially in secondary schools, community interviews were conducted in the form of Focus Groups, i.e. with narrow groups of students directly interested. The study was conducted in rounds, and the questions asked were closely related to the content and forms of teaching related to mining and its derivatives. The same study was conducted in a group of teachers. As a result, both weaknesses and strengths of the current teaching system were identified, from which it was clear that the basic lack is the lack of practice. Due to the limited access of young people to the mines, including due to minors, students do not have the opportunity to come into contact with real working conditions and the resulting threats and challenges. Therefore, the development of VR scenarios in this area and their inclusion in the educational offer is very justified.

In cooperation between the project partners, VR scenarios were developed for all the offered sections of the course entitled "Introduction to Mining". They concerned underground coal mining, underground ore mining, open-pit mining, raw material processing, and occupational health and safety. In addition, a logic game in the field of Geology was also developed.

The course participant has the opportunity to choose a course with the use of a VR helmet (giving the full experience offered) and a version available to all computer users. Figure 1 shows the title screen with the logos of all content creators placed on the e-learning platform. Figures 2-6 present sample screenshots of selected scenarios offered to users of the platform.

It is worth noting that on the e-learning platform of the HoloGEM project, content is offered in four languages: Polish,

English, Portuguese and Turkish. In addition to VR content, presentations using artificial intelligence, a traditional e-book containing a lot of detailed information and various forms of verification of the state of knowledge (tests, logic games, etc.) were also used. They have been presented in more detail in other publications (Erarslan and Şahbaz, 2023; Erarsla, 2025; Niedoba et al., 2024; 2025). The whole is available free of charge on the Internet at <https://www.rimedia.unisa.it/hologem> (e-learning platform) and <https://fe.up.pt/hologem> (project website).

## 6. Conclusions

The educational offer requires constant corrections and upgrades. It cannot lag behind the development of IT and digitization. Young people expect modern solutions and only such solutions will attract their attention. In order to focus their attention on such a difficult topic as mining, it is necessary to skilfully present it and use the potential that lies dormant in this field of technical sciences. Along with modern forms of teaching, there is a chance that mining will regain its rightful position and attract young people back, regardless of its unfavorable image promoted in various media. Because, sooner or later, everyone will notice that without mining, no further economic development is possible, and products that are now a common good will simply not be able to be produced.

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### *Wirtualna rzeczywistość w edukacji – czy górnictwo może być nauczane wirtualnie?*

*Wirtualna rzeczywistość (VR) znajduje coraz szersze zastosowanie w edukacji górniczej, stanowiąc nowoczesne narzędzie wspierające proces kształcenia przyszłych górników oraz doskonalenia zawodowego pracowników branży. Technologia VR umożliwia realistyczne odwzorowanie środowiska kopalnianego, maszyn i procesów technologicznych, co pozwala na bezpieczne przeprowadzanie szkoleń bez konieczności przebywania w rzeczywistych wyrobiskach. Dzięki symulacjom możliwe jest ćwiczenie procedur eksploatacyjnych, reagowania na sytuacje awaryjne oraz zasad bezpieczeństwa i higieny pracy. Zastosowanie VR zwiększa efektywność nauczania, poprawia zrozumienie złożonych procesów oraz redukuje ryzyko wypadków i koszty szkoleń. Wirtualna rzeczywistość sprzyja także nauce poprzez doświadczenie, co pozytywnie wpływa na zaangażowanie i utrwalanie wiedzy przez uczestników szkoleń. Omawiany projekt o kryptonimie HoloGEM jest rozwiązaniem edukacyjnym oferującym treści dotyczące górnictwa w postaci platformy e-learningowej, gdzie jednym z rozwiązań jest zastosowanie wirtualnej rzeczywistości.*

**Słowa kluczowe:** *HoloGEM, górnictwo, edukacja, wirtualna rzeczywistość*