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VIRTUAL REALITY IN THE CONTEXT OF COMPETENCE AND KNOWLEDGE ACQUISITION

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Purpose: The main objective of the study is to present a scenario of classes using selected virtual reality applications. The specific objectives include (1) presenting students' perceptions and feedback on the use of VR applications supporting the training of gantry crane operation and warehouse processes, and (2) identifying the knowledge and competencies developed during VR-supported classes in the case of gantry crane and warehouse simulator applications.
Design/methodology/approach: This article develops an author's classes scenario using virtual reality (VR) technology, including simulations of a gantry crane operator's work and warehouse processes. Qualitative methods were used for the analysis, based on reports, reviews, and observation sheets prepared by students during the course, as well as the results of a survey conducted using the Mentimeter tool.
Findings: The research has shown that virtual reality has the potential to enable students to acquire theoretical knowledge and practical skills in gantry crane operation and warehouse processes in a safe, controlled environment. Analysis of student reports and opinions confirmed that VR technology supports the development of both hard technical skills and soft cognitive, personal, and social skills. Furthermore, the Mentimeter survey results showed that students perceive VR as a modern, engaging educational tool with a wide range of applications beyond entertainment.
Research limitations/implications: The main limitation of the study is its implementation on a relatively small sample of students from a single field of study, which hinders the full generalization of the results. Furthermore, the analysis relied primarily on qualitative reports and participant opinions, which may result in subjective assessments. However, the results indicate the need for further research into the broader application of VR in education and the verification of learning outcomes in the long term.
Practical implications: Practical implications arise from the potential use of virtual reality as a tool supporting the teaching process in the education of engineers and managers. The classes scenario demonstrate that VR allows students to safely and engagingly acquire knowledge and technical and social skills essential in today's labor market. Implementing similar solutions can contribute to improving the quality of practical education and better preparing graduates for work with modern technologies.
Social implications: The social implications of research indicate that the use of VR in education fosters the development of collaboration, communication, and collaborative problem-solving skills. This technology can also increase the accessibility of practical experiences for individuals who, in real-world settings, would not be able to safely interact with specific

machines or processes. More broadly, VR supports the development of digital competencies across society, which is important in the context of industrial transformation and the development of a knowledge-based economy.
Originality/value: The article addresses the issue of using virtual reality to acquire competence and knowledge by students (using the example of the Management and Production Engineering course). It presents author's short classes scenarios (with tasks for students) using VR and conducts a discussion on competences and knowledge that can be acquired thanks to VR-assisted classes. In addition, students' opinions on VR are presented: in the task reports, students were to indicate, among other things, what they learned and how they assessed individual training and VR applications.
Keywords: virtual reality, VR training, VR goggles, classes scenario, competences, knowledge.
Category of the paper: Research paper.

1. Introduction

Knowledge is one of the fundamental key resources of society and the whole economy in the modern world. Effective generation, transfer and general management of this important non-material resource is the foundation for individual and organizational development. Gradual gaining of knowledge is vital for employees, managers, and the organization. The ability to acquire, process, and apply data and information (and, based on them, knowledge), determines innovation and competitiveness. New employees are expected to know technology, digital solutions and have skills in the human-machine relationship (operation of new technical means, software, digital programs, data analysis tools and methods etc.). An example of one such evolving technology is virtual reality (VR). The ability to operate and use VR can be the X-factor, providing an advantage as well as enhancing learning and training, for new, often young, employees.

The modern job market places increasingly higher demands for university graduates. Virtual reality opens new opportunities in teaching (Li et al., 2020; Marks, Thomas, 2022), vocational training (Fussell, 2020; Fussell, Truong, 2020) , and the development of practical skills (Dubiel et al., 2025; Van Wyk, De Villiers, 2009). VR enables the creation of immersive learning environments in which learners can safely and realistically experience situations that are difficult to replicate in traditional settings (Grabowski, Jankowski, 2015). The use of such tools in the teaching process enables not only the acquisition of theoretical knowledge but also the development of technical (Stecuła, 2019), cognitive (Tichon, 2006), social (Howard, Gutworth, 2020), and personal competencies (González-Mendívil et al., 2020). The use of virtual reality can be found at various stages of education and vocational training. In the literature, there are papers that concern the use of virtual reality in primary school (Hui et al., 2022; Laine et al., 2023), secondary school (Bogusevschi et al., 2020; Keller et al., 2018), higher education (Fabris et al., 2019; Marks, Thomas, 2022; Stecuła, 2023) and also in professional work in various professions (Mwangi, Tanaka, 2025; Saraswat et al., 2025).

The article addresses the issue of using virtual reality to acquire competences and knowledge by students (using the example of the Management and Production Engineering course at the Faculty of Organization and Management of the Silesian University of Technology). The author will present and discuss practical examples of how to conduct classes using virtual reality. Then, she will indicate the competences and knowledge that can be acquired thanks to VR-supported classes. The author will present short scenarios of classes (with tasks for students) using VR and will lead a discussion on the competences and knowledge that can be acquired. The other part of the article will present students' opinions on virtual reality. Students had to indicate what they learned from given classes supported by virtual reality and how they assessed individual training and VR applications. They provided this information in reports from individual tasks. The author shows the competences and knowledge that can be acquired during VR-supported classes in the context of the contemporary market. Currently, future employees are increasingly required to have competences and knowledge in the field of operating modern technical means, working with digital products or solving problems related to the human-machine system.

2. Research materials and methods

The article addresses the issue of using virtual reality to acquire competence and knowledge by students. The author presents scenarios of VR-assisted classes with specific tasks for students and discusses the competences and knowledge that can be developed through such activities. In addition, the article includes students' perspective and feedback on VR-supported classes.

The main objective of the study has been formulated as follows:

- to present a scenario of classes using selected virtual reality applications.

The specific objectives include:

- presenting students' perceptions and feedback on the use of VR applications supporting the training of gantry crane operation and warehouse processes,
- identifying the knowledge and competencies developed during VR-supported classes in the case of gantry crane and warehouse simulator applications.

The developed scenario is original (author's). The classes, conducted according to the developed scenario, were held as part of the Management and Production Engineering program at the Faculty of Organization and Management of the Silesian University of Technology. Two VR applications developed by EpicVR were used for the classes: a gantry crane simulator and a warehouse simulator. Both applications provide teaching materials allowing students to acquire technical and organizational knowledge, as well as develop practical skills in a safe, digital environment.

The classes were organized as a team-based activity. Students (17 people) were divided into small groups, each assigned specific teaching roles: VR Explorer, Report Engineer, Reviewer, and VR Observer (optional role). Each group prepared two (or optionally three) documents: a report, a review, and an observation sheet. The documents were prepared in Word format (saved as PDFs) and distributed via the Platforma Zdalnej Edukacji (PZE).

The article also presents students' responses to general questions about VR that did not directly relate to the applications being tested. The questions were: (1) "How would you describe virtual reality?" (2) "What can we use virtual reality for (despite entertainment)"? Responses were collected using the Mentimeter tool, and the results were presented in the form of word clouds, which enabled the identification of participants' dominant associations and opinions.

3. The concept of classes using virtual reality

This chapter presents two scenarios for classes using selected VR applications. These applications include:

- gantry crane,
- warehouse simulator.

The first part of the chapter describes each of the mentioned applications. Then, an authors' classes scenario utilizing these applications is presented. Such classes are taught in the Management and Production Engineering program at the Faculty of Organization and Management at the Silesian University of Technology. The proposal to utilize virtual reality and the above VR applications in classes is proprietary and has already been implemented in classes for the first time in the spring semester of the 2024/2025 academic year.

3.1. Characteristics of VR applications

Gantry crane

Gantry crane application was developed by EpicVR company. It is a simulation of the profession of a gantry crane operator. A person using VR headset is placed in a virtual cabin of a gantry crane. In the cabin there is a panel with control elements (buttons, manipulators). In addition to the cabin, the application also shows the hall space with many elements and loads. This application is used for training in the basic operation of the machines. The trainee can perform various operations: lifting, lowering, shifting the load horizontally, and moving the crane along the track. Subsequent application modules vary the load size and the height of the operator's cabin. The trainee can perform various maneuvers: lifting, lowering, shifting the load horizontally, and moving the crane along the track. Subsequent application modules vary the load size and the height of the operator's cabin. The user progresses through the training stages, starting with checking the technical condition of the device, through lifting and transporting the load, and finally responding to hazardous situations. Figure 1 presents the view from the cabin.

Figure 1. The exemplary view from the gantry crane VR application developed by EpicVR.
Source: author's photo based on (EpicVR, 2019).

Warehouse simulator

Warehouse simulator application was developed also by EpicVR company. The person using this application takes on the role of a warehouse worker, their task is to familiarize themselves with the order completion procedure. The trainee performs the following activities: retrieving packages from the belt, scanning the package, scanning the package contents (products), checking the order and its completion, repacking the package, filling empty spaces of the package with protective paper, sealing the package with tape, affixing labels, adding a waybill, operating the computer, handing over the finished package. Figure 2 presents the view from the Warehouse simulator VR application.

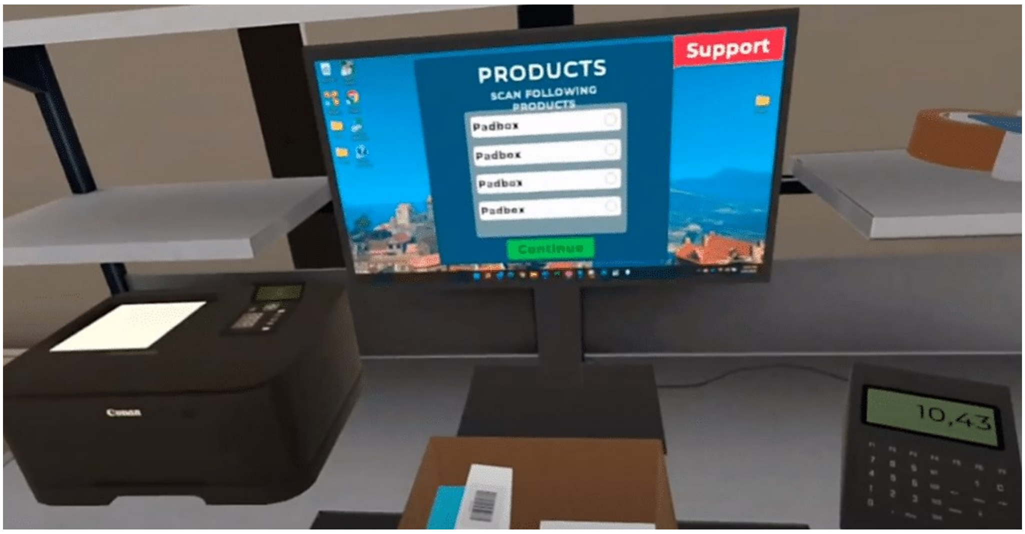

Figure 2. The exemplary view from the Warehouse Simulator VR application developed by EpicVR. Source: author's photo based on (EpicVR, 2022).

3.2. Classes with the use of VR applications scenario

Classes using the above-mentioned virtual reality applications are conducted in the Management and Production Engineering program. Students are to be divided into groups of a few students. Each group receives instructions according to which they must perform the task. The most important points of the instructions include the following:

- students need to choose different roles from 1 to 4 (role 4 is optional). Roles include:
  - Role 1: VR Explorer.
  - Role 2: Report Engineer.
  - Role 3: Reviewer.
  - Role 4 (optional): VR Observer.
- depending on the number of people in the group, more than one person may play one role.
- each student performs their tasks according to their role. The appropriate individuals (roles) prepare the report, review, and observation sheet. The report, review and observation sheet should be prepared in a Word document format (saved as PDF) and sent to the PZE platform (by the end of the given lab session).

The VR Explorer puts on VR goggles and undergoes virtual reality training. Their task is to familiarize themselves with the mechanics of a given application. In the case of the first application, the student has to get to know how to operate (properly use) a gantry crane and then move a load in the first module. In the case of the second application, the student becomes familiar with logistics and warehouse activities. The task is to complete an order (including checking/verifying, packaging, labelling, marking, and dispatching etc.).

The Report Engineer is responsible for preparing a report on the construction and operation of the gantry crane (in the case of the first application) and the order picking process (in the case of the second application). Observing the VR training and using other materials / sources (e.g., personal knowledge, articles, manuals, the internet, etc.), the Report Engineer develops a document containing:

- description of the gantry crane's construction with names of all parts and components (students can also prepare figures),
- a detailed description of the operation of the machine and the purpose of its use.

The Reviewer is responsible for preparing a review that evaluates the training:

- what can be learned during the training (minimum 5 elements) and to what extent?
- can the application be used for:
  - training future gantry crane operators (application 1) / warehouse logistics employees (application 2)? Yes/No + justification.
  - training current gantry crane operators (application 1) / warehouse logistics employees (application 2)? Yes/No + justification.
  - assessing professional predispositions for a given job? Yes/No + justification.
  - other purposes – what…? Yes/No + justification.
- evaluation of the application:
  - to what extent is the application realistic?
  - to what extent is the application useful?
  - what did you like most?
  - what did you like least?
- Recommendations: what is missing and what needs improvement?

The VR Observer is responsible for preparing an observation sheet. Their task is to analyze the behavior of the VR trainee. Through this task, the student identifies and learns to understand the impact of virtual reality on people. Observations and analysis should include:

- reactions,
- emotions,
- reflexes,
- sensory responses (reactions to sounds in the application, reactions to visual effects, concentration, engagement, etc.),
- reactions to stress during training,
- human-VR relations,
- communication,
- coping with difficulties during training,
- other elements.

Figure 3 presents the photo of students performing tasks in accordance with the developed lesson scenarios using VR.

Figure 3. Students performing tasks according to the developed classes scenarios using VR.
Source: author’s photo.

4. Students’ Perception of Classes Using Virtual Reality

This chapter presents an analysis of reports prepared by students after classes conducted using virtual reality technology. These reports contain their observations, opinions, and assessments of the usefulness of selected VR applications – a gantry crane simulator and warehouse process simulations. Reports were prepared by 17 students. This analysis is complemented by the presentation of the results of a study conducted using the Mentimeter tool, which allowed for a broader perspective on the perception of virtual reality and its potential applications beyond entertainment.

4.1. Students' perception of gantry crane operator VR training

The virtual reality crane simulator provided students with an opportunity to learn about the specifics of operating this type of device in a safe and controlled digital environment. Students indicated that the simulation allowed them to become familiar with both the structure of a cabin crane (bridge, track, hoist, operator's cabin, and control system) and the practical aspects of operating the transport mechanism. Using VR goggles and controllers reproducing control levers, they were able to assume the role of an operator tasked with lifting and moving loads between designated points while maintaining safety guidelines.

Most participants emphasized the high degree of realism of the application – both in terms of the hall's workspace and the dynamics of load movement. The immersive nature of the experience was highlighted, including the ability to look around the operator's cabin, use a camera, and observe the surroundings in 3D. Visual realism, intuitive controls, and interactivity were among the most highly rated elements in the reports.

At the same time, several reports pointed to difficulties in judging distances in the VR environment, which initially hampered precise maneuvering. Participants also noted that initial control attempts were chaotic for many and required adaptation to the new interaction environment. However, over time, coordination and movement fluidity improved, and users gradually gained proficiency and confidence in operating the virtual crane.

Students unanimously noted that the VR training allowed them to develop manual dexterity, hand-eye coordination, spatial orientation, and transport route planning. Reports also highlighted reflections on developing responsibility and awareness of the importance of occupational safety regulations. The exercises provided knowledge of the crane's structure and mechanics, as well as practical experience in its operation – without the risk of damage to the equipment or health hazards.

Student reviews indicate that the app is primarily effective as an introductory and teaching tool, aimed at those beginning to learn how to operate crane equipment. It can be effectively used in the training of future operators and in academic teaching, where it provides an attractive alternative to traditional methods.

Students also provided suggestions for improvements to the app. These included:

- expanding the app to include emergency situations,
- improving the depth visualization system,
- implementing force-feedback technology to enhance haptic feedback,
- integrating the VR module with theoretical content, such as occupational health and safety.

In summary, students rated the VR crane operation app positively as a teaching tool that provides an engaging introduction to the topic of crane control. Its immersive qualities, realism, and learning safety were particularly appreciated. Although the tool has limitations in terms of advanced training, its potential for developing basic technical and manual skills is very high.

4.2. Students' perception of virtual warehouse simulation

The Warehouse simulation application allowed students to practice the complete order picking process in a warehouse environment. The simulation covered the entire workflow: from picking a package from the conveyor belt, through scanning and labeling, to actual packaging, filling any empty spaces with protective materials, sealing, and handing the package over for shipping. Participants had access to virtual devices and tools such as handheld barcode scanners, boxes, packing tape, fillers, label printers, and a computer with an order processing system. This allowed them to become familiar with both the technical aspects of warehouse operations and the logical sequence of actions necessary to successfully complete the logistics process.

Students indicated that the application allowed them to learn a great deal about order picking and collaboration in an interactive and practical way. The most frequently mentioned issues included:

- operating the equipment used in the order picking process (scanner, labeling machine, packaging tape),
- knowledge of packaging and securing procedures,
- following the logic and sequence of actions in the logistics process,
- workstation organization and movement ergonomics,
- scanning and labeling goods according to standards,
- teamwork and communication with other participants.

Analysis of the observation sheets revealed that most students reacted naturally to events in the virtual environment, indicating a high level of immersion. In the initial phase of the training, there were some adaptation difficulties – chaotic movements, disorientation, and frustration resulting from unsuccessful attempts to complete tasks. However, over time, participants learned the logic of the process and demonstrated greater fluency.

Emotions accompanying the training were varied – curiosity, engagement, and satisfaction after completing tasks dominated. Short-term symptoms of stress and frustration also occurred, for example, during labeling or when system errors occurred. It was noted that students treated virtual objects as if they were real – they lifted packages, backed away during sudden movements, and intuitively gestured while manipulating objects. This indicates a strong sense of presence in the VR environment.

Students rated the app as highly realistic and useful in the learning process. Particularly appreciated were:

- the intuitive nature of the app and the opportunity for practical "learning by doing",
- the realistic representation of warehouse procedures,
- the engaging nature of the exercises and the need to maintain concentration,
- the ability to repeat tasks multiple times without the risk of material damage.

Students unanimously emphasized that the application has broad application potential in training future and current warehouse workers. It can also be useful in assessing candidates' professional aptitudes, implementing new logistics processes, testing workstation ergonomics, and simulating emergency situations.

Recommendations for the application's development included:

- introducing emergency modules (e.g., damaged packages, system errors),
- expanding packaging scenarios to include various product types and working conditions,

- adding a multiplayer mode enabling collaboration in VR,
- developing analytical tools for detailed assessment of participant performance (response time, precision, ergonomics),
- optimizing the interface and personalizing difficulty settings.

In summary, students' perceptions of the Warehouse Simulation application were positive. The simulation provided them with practical knowledge of logistics processes, developed technical and organizational skills, and experienced working in a realistic VR environment. Despite these limitations, participants rated the tool as effective, engaging, and promising in the context of modern vocational education in logistics.

4.3. Students' perception of virtual reality

To gain a broader picture of virtual reality perception, students were asked two general questions, not directly related to the specific applications used during the course. The questions were:

- How would you describe virtual reality?
- What can we use virtual reality for despite entertainment?

The interactive Mentimeter tool was used to collect responses. Students provided their responses individually using mobile devices, and the results were presented in a word cloud format. This approach allowed for a quick visualization of the dominant concepts and associations among participants.

Referring to the first question "How would you describe virtual reality?", student responses indicated that VR is primarily associated with innovation, modernity, inspiration, and closeness to reality. Recurring associations also included terms such as exciting technology, enhancing knowledge, fun, fresh, amazing, and mind-blowing. Students perceived VR as both educational (good for learning, helps with understanding) and emotional – related to providing new experiences (new experiences, provides insights, and opens horizons). Terms related to specialized simulations, such as emergency training, special forces training, and the phobia killer, also emerged. Overall, VR was described as a modern, attractive tool with potential in various areas of life. Student responses are presented in Figure 3.

Figure 3. Student responses to the question "How would you describe virtual reality?" collected using the Mentimeter application.

Source: author's photo.

In the second question, "What can we use VR for (despite entertainment)?", students indicated a very wide range of VR possibilities. Applications related to education and training were particularly common in the responses, including occupational safety, cooking training, firefighters training, surgical simulation, for doctors' practice, overcoming fears, and self-defense training. Numerous references were also made to industry and logistics: shaping production, production monitoring, manufacturing processes, materials assembly, process optimization, as well as applications in architecture (architecture models), tourism (tourism, experience before travel), and medicine (medication, health care). The potential use of VR in critical scenario analysis (analysis of critical scenarios), military training (space and military), and even digital marketing (digital marketing). The results show that students perceive virtual reality as a technology of the future, combining educational, industrial, and medical benefits. The answers in the word clouds prove that they associate VR not only with entertainment, but also with practical applications in professional, educational and social contexts. Student responses are presented in Figure 4.

Figure 4. Student responses to the question "What can we use VR for (despite entertainment)?" collected using the Mentimeter application.

Source: author's photo.

5. Acquired knowledge and competences

Classes using virtual reality technology enabled students to develop both theoretical knowledge and practical competences that are directly relevant to the requirements of the modern labor market. Knowledge gained during the task of simulating the work of a gantry crane operator includes the following:

- gantry crane constructure,
- operational principles of lifting and moving load mechanisms,
- safety procedures applicable to working with handling equipment,
- requirements for compliance with basic occupational health and safety regulations when operating an overhead crane,
- the logic of carrying out transport operations (e.g., sequence of movements, load stabilization),
- possible hazards associated with incorrect operation of the device,
- methods of monitoring the work environment from the perspective of the operator's cabin (e.g., use of cameras),
- basic ergonomics for the operator in an industrial environment.

Competencies developed during the gantry crane operation simulation can be divided into hard and soft. Hard competences include the following technical competences:

- ability to precisely control a transport device in a virtual environment,
- ability to recognize and utilize crane structural components (track, bridge, hoist, cabin),
- planning a route and safe load transport,
- applying occupational health and safety principles in operational practice,
- operation and use of VR equipment, including the operation of controllers that represent control levers, interpretation of the user interface in a VR environment, the ability to adapt to an immersive environment.

Soft competencies include the following ones:

- cognitive:
  - developing spatial awareness in a 3D environment,
  - predicting the consequences of movements,
  - analyzing errors and modifying operational strategies,
  - quickly adapting to a non-standard control interface (VR instead of physical levers).
- personal:
  - patience and persistence in problem-solving,
  - resistance to initial difficulties associated with learning to operate the device,
  - building self-confidence in working with technologies,
  - reflection on the importance of a safety culture.
- social:
  - communicating and exchanging experiences during classes,
  - discussing mistakes and conclusions together,
  - collaborating in a group (during simulations and debriefing discussions).

Classes using a warehouse simulator allowed students to gain practical knowledge of:

- the order picking process in logistics (from receipt to shipment),
- operating warehouse tools (barcode scanner, label printer, packaging tape, computer with system),
- standards for marking, labeling, and securing packages,
- principles of organizing work at a picking station,
- product packaging procedures,
- ways to minimize the risk of damage to goods during transport,
- the importance of ergonomics in physical and digital work in logistics,
- the logic of warehouse management systems and the sequence of operations,
- the role of teamwork and communication in the logistics process,
- potential problems and errors (e.g., incorrect scanning, missing label, damaged product).

Competencies developed during warehouse simulation can also be divided into hard and soft skills. Hard skills include the following technical skills:

- the ability to operate tools used in the order picking process (code scanner, packing tape, label printer, computer with an ordering system),
- the application of principles of proper packaging and securing of shipments,
- knowledge of procedures for labeling, marking, and verifying goods,
- understanding the logic of the warehouse process and the sequence of activities in the supply chain,
- planning and organizing the workstation in accordance with ergonomic principles,
- operation and use of VR equipment, including the use of goggles and controllers in the process of interaction with virtual objects (scanner, packages, labels), and coordination of hand-controller movements in the simulation of manual activities.

Soft skills, in turn, include:

- cognitive:
  - quickly learning procedures and rules of operation in a virtual environment,
  - analyzing errors and implementing alternative picking strategies,
  - developing concentration and the ability to work under time pressure,
  - transferring knowledge from the virtual environment to real-world warehouse situations.
- personal:
  - coping with stress, such as that resulting from errors or difficulties,
  - patience and systematic execution of sequential tasks,
  - internal motivation and a sense of satisfaction from completing a task,
  - flexibility in adapting to new procedures or unexpected situations.
- social:
  - cooperation,
  - communication within a team,
  - learning through observation and mutual support,
  - exchanging knowledge and experiences when discussing results,
  - drawing conclusions together regarding the task.

6. Conclusions

The presented research focused on developing a virtual reality-based classes scenario. Examples included two applications: a gantry crane and a warehouse simulator. The article shows that virtual reality can be used at universities to teach students and let them acquire knowledge in a practical way and develop their competences, both hard (technical) and soft (cognitive, personal and social) competences. The positive reception of students is also a motivation for the further development of classes supported by virtual reality.

The article shows that virtual reality can be used at universities to teach students and let them acquire knowledge in a practical way and develop their competences, both hard (technical) and soft competences (cognitive, personal and social). The positive reception of students is also a motivation for the further development of classes supported by virtual reality.

From a labor market perspective, these findings are particularly significant, as they confirm the importance of VR in preparing students for work in a modern technological environment. Virtual reality can become a key element in the education of engineers and managers, supporting the development of digital competencies and practical skills needed in the conditions of Industry 4.0.

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