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ENHANCING EDUCATIONAL QUALITY THROUGH VIRTUAL REALTY

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Abstract: Technology development today have great impact on education. Usage of modern tools became imperative for increasing the comprehension of learning materials. In area of product development, CAD/CAM/CAE software have big role in achieving the learning outcomes. The next step represents the software combination with Virtual Reality (VR). In such environment students can achieve better understanding of product design elements. This paper provides the insight of the role of Virtual Reality in education in area of Industrial design.
Key words: virtual reality, education, product development, virtual prototype.

INTRODUCTION

Technology development today has a strong impact on education, and the use of modern digital tools has become imperative for improving the comprehension of learning materials. In the area of product development education, understanding complex product structures, assemblies, and functions represents a significant challenge when only traditional teaching methods are applied. Conventional approaches based on lectures, technical drawings, and screen-based CAD models often limit students' ability to fully visualize and interpret product design elements.

CAD/CAM/CAE software plays an important role in supporting learning outcomes by enabling students to create, analyze, and modify digital product models. Through these tools, students gain knowledge about geometry, materials, manufacturing processes, and performance analysis. However, interaction with these models is still mostly limited to two-dimensional displays, which can reduce spatial understanding and make it difficult to interpret complex assemblies and internal components.

The next step in the development of educational tools for product development is the integration of CAD/CAM/CAE software with Virtual Reality (VR). In a VR-based learning environment, virtual prototypes can be experienced in an immersive and interactive manner [1,2]. Students are able to observe products at real scale, explore assemblies from different perspectives, and inspect internal structures that are not easily accessible in physical or screen-based models. This immersive visualization significantly improves the understanding of product design elements and their relationships within the overall system.

Virtual Reality also supports better understanding of virtual prototypes and assembly by allowing students to interact with them dynamically. Components can be assembled and disassembled, mechanisms can be observed in motion, and functional behavior can be analyzed in a realistic environment. Such interaction helps students identify design issues at early stages, such as poor accessibility, interference between parts, or ergonomic limitations. As a result, students develop a more comprehensive understanding of the product development process and the importance of design validation before physical prototyping. On Fig. 1 the different applications of Virtual Assembly prototyping is shown [3]

Fig.1. *Different applications for virtual assembly simulation in prototyping [3]*

Furthermore, the use of VR in education provides active and experiential learning [4]. Instead of passively observing models, students actively explore and evaluate virtual prototypes, which demandes engagement and knowledge retention. This approach also reflects modern industrial practice, where virtual prototyping and digital validation play a key role in reducing development time and costs. [5]

MATERIAL AND METHODS

Example of VR implementation for education

Technology development today has enabled the application of Virtual Reality (VR) as an effective tool in education, particularly in the area of product development and virtual prototyping. In order to achieve a realistic presentation and detailed analysis of a developed 3D model, the insertion and visualization of the model were performed using the eDrawings software environment combined with VR equipment (Fig. 2). This process was carried out in the laboratory of the Higher Technical College of Applied Sciences in Zrenjanin.

Fig. 2. *HTC Vive Cosmos virtual headset*

VR equipment used in this case study shown on Fig. 1. has the following characteristics shown in Table 1:

Table 1. *Basic specifications of the HTC Vive Cosmos VR headset*

Display (type/size)	Two LCD RGB displays, 3.4 inches per panel
Resolution	1440 × 1700 pixels per eye, total 2880 × 1700 pixels
Refresh rate	90 Hz
Field of view (FOV)	Approximately 110 degrees
Tracking	Inside-out tracking using 6 cameras; no external base station required for basic use
Recommended room scale	Minimum ~2 m × 1.5 m for room-scale mode
Supported connections/ports	DisplayPort 1.2, USB 3.0 / USB-C for data and power; proprietary port for modifications (mods)
Interpupillary distance adjustment (IPD)	Yes, IPD adjustment available
Audio	Built-in on-ear headphones, integrated microphones
Design/comfort	Flip-up front section (display can be lifted like a visor), suitable for users who wear glasses
Weight	Approximately 702 g

By loading the 3D model into the eDrawings software, it became possible to analyze the model in a virtual environment and gain a more comprehensive understanding of its structure and functionality. After opening the desired model file, the software enabled further interaction and preparation for VR visualization.
Once the virtual reality module was activated, the model of the robotic arm was displayed in its real dimensions and from multiple viewing angles (Fig. 3). This approach provides a significantly better understanding of spatial relationships within the assembly compared to classical 3D visualization on a computer screen. One of the most important functionalities within the VR environment is the Explode option, which allows the assembly to be decomposed into individual components (Fig. 4). In this way, each part of the robotic arm can be observed separately, enabling detailed inspection of shape, size, and position in relation to the overall structure.

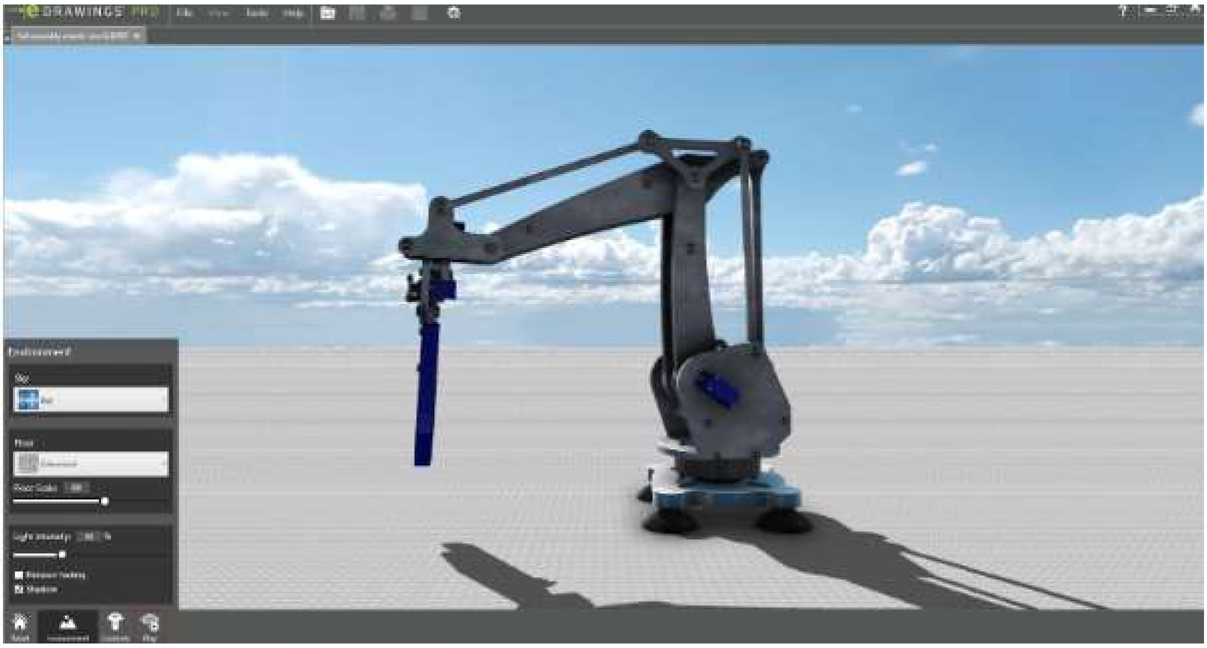

Fig. 3. *Display of robotic arm in VR environment*

Fig. 4. *Exploded view of robotic arm in VR environment*

An additional advantage of VR visualization is the possibility of interacting with individual components by virtually “grasping” them (Fig. 5), which creates a realistic perception of the product and improves comprehension of assembly logic. The software also allows annotations to be written directly on the model, enabling visual marking of critical components, adding comments, and proposing design modifications. This feature significantly improves team communication, as all observations and suggestions can be clearly shared within the same virtual environment.

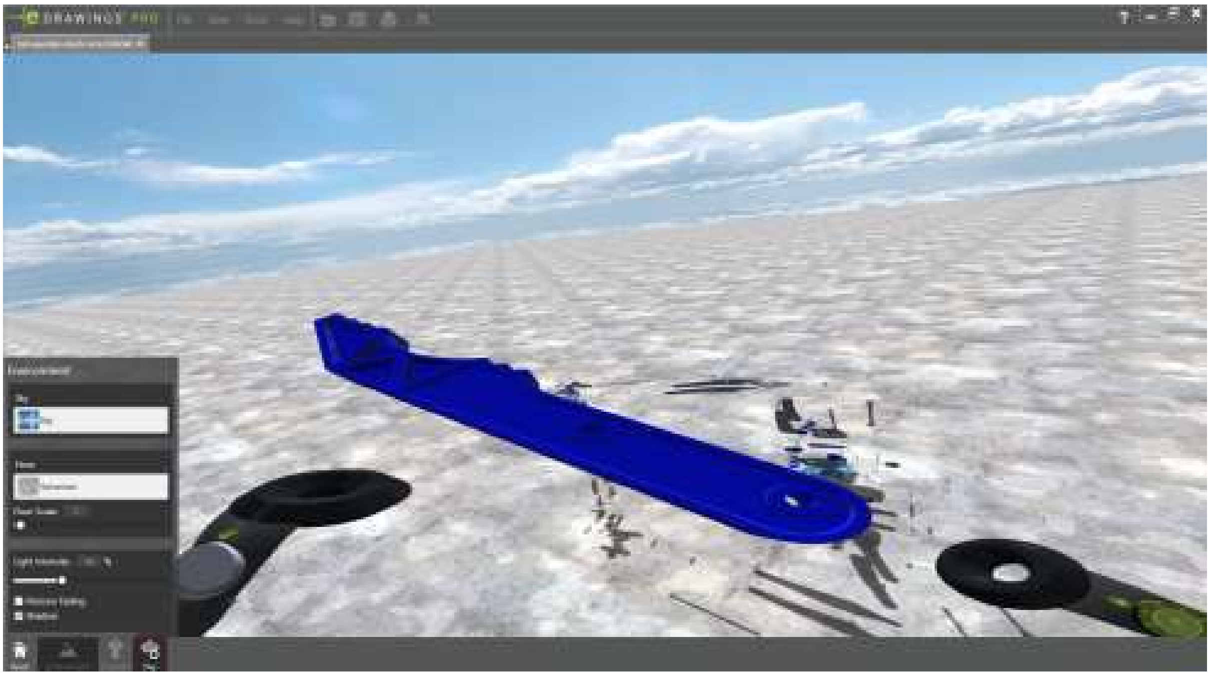

Fig. 5. *Interaction with individual parts*

Furthermore, eDrawings offers additional tools that enhance model verification and analysis, such as dimension measurement (Measure), sectional views (Section view), and various display controls (Fig. 6). These functionalities support precise evaluation of product geometry and improve both individual and collaborative work in educational and engineering practice.

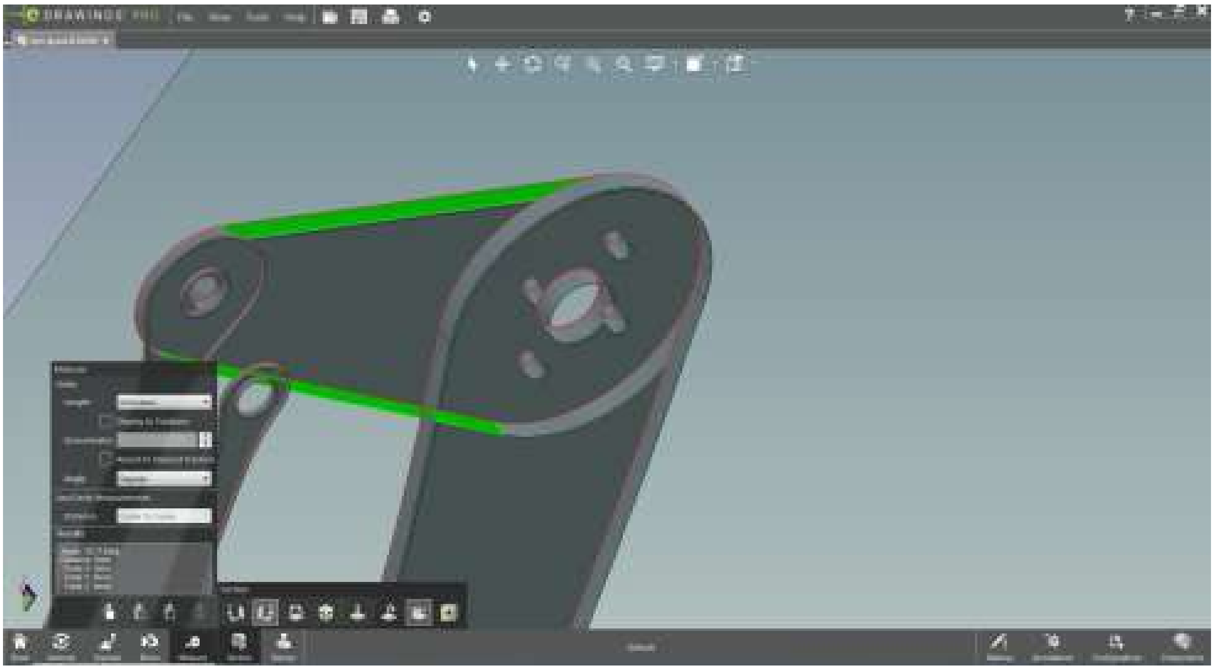

Fig. 6. *Display of additional tools in eDrawings*

RESULTS AND DISCUSSION

HTC Vive Cosmos headset provides high image resolution, a wide field of view, and inside-out tracking, which eliminates the need for external base stations and simplifies setup. Such characteristics make it suitable for educational use, 3D model inspection, virtual presentations, and assembly visualization. Although certain limitations exist, particularly in tracking precision under poor lighting conditions, the system provides sufficient performance for learning and product development analysis. Some of the advantages and disadvantages of this VR setup are:
Advantages:

- High resolution and image quality
- Simplified tracking using inside-out tracking with six cameras
- Comfort and ease of use with flip-up design
- Integrated audio system
- Flexibility and expandability through modular accessories

Disadvantages:

- Tracking issues in low-light conditions or when controllers are occluded
- Ergonomic limitations, including light leakage and maintaining optimal viewing position
- Controllers require AA batteries
- Relatively high price compared to some competitors

With the usage of eDrawings, the model was transferred directly into the virtual environment, where it could be observed from all directions and analyzed in a realistic manner. The VR module enables users to manipulate individual parts, rotate them in space, observe sectional views, and measure distances, angles, and radii. This level of interaction significantly improves understanding of the virtual prototype and allows students to better comprehend the structure, functionality, and design logic of the product.

CONCLUSION

Virtual reality have important role in improving educational processes, especially in the area of product development. Traditional teaching methods, based mainly on lectures, technical drawings, and screen-based CAD models, often limit the understanding of complex assemblies and product structures. Although CAD/CAM/CAE software significantly contributes to achieving learning outcomes, its integration with Virtual Reality represents a further step in improving the educational process.

The application of VR enables students to experience virtual prototypes in an immersive environment, where products can be observed at real scale and analyzed from multiple perspectives. As shown in this paper, the use of VR in combination with eDrawings software provides a better understanding of spatial relationships, assembly logic, and functional characteristics of product designs. Interactive features such as exploded views, manipulation of individual components, and measurement tools contribute to clearer interpretation of product design elements and early identification of potential design issues.

VR-based visualization supports active learning and increases student engagement, leading to improved comprehension of virtual prototypes. Although certain limitations of the applied VR equipment exist, the system provides sufficient performance for educational use and product development analysis.

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