MIND COURSE SUPPORT

LECTURE 4.VIRTUAL REALITY AS A NEW TREND IN MECHATRONICS ENGINEERING EDUCATION

Content

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1. OBJECTIVES OF THE LECTURE

This course aims to develop the general and specific skills of the students within the MIND project consortium. This course is one divided into two types of objectives, theoretical objectives as well as practical objectives. The theoretical objectives are those of producing, as well as of improving the understanding related to the concept of virtual reality as a modern way of learning and teaching. These theoretical objectives are related to the definition, identification of benefits and how they are used in different fields of education, such as mechatronics engineering.

Theoretical aspects focus on improving the learning experience of students and teachers by creating virtual models using different software platforms such as MATLAB / Simulink, Unity, in which students can practice and design different actions or models.

General objectives:

- Formation of notions related to the concept of virtual reality,

- Formation of ideas on the advantages of interactive learning methods,

- Understanding the relatively complex topics about learning with the help of virtual reality.

Specific objectives:

- To know the main devices with which they interact,

- Knowledge of the steps required to make virtual models,

- To create virtual reality models,

- To know how it works,

- To identify the causes of a possible malfunction.

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2. INTRODUCTION, VIRTUAL REALITY IN EDUCATION

The development of information technologies has changed the way people live. These innovative technologies have allowed people to carry out different activities in innovative and different ways, increasing productivi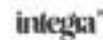ty, flexibility, comfort, etc. At the same time, these technologies have allowed the storage of large amounts of data, leading to the creation and access of information and knowledge in a much faster way. The access of more and more people to data, information and knowledge, has facilitated the increase of the standard of living of the people as well as the increase of the education level of the population. Education and even learning is greatly influenced by the motivation of individuals.

These information technologies can greatly increase motivation and implicitly learning through innovative technologies of teaching, learning, and evaluation. Motivation increases through the interactivity, dynamics and effects that the information technologies provide. The most interactive of these technologies are virtual reality (VR) and augmented reality (AR). These platforms simulate the true three-dimensional environment, the physical environment as a digital or virtual environment, offering the possibility to interact with the objects, giving the individual the possibility to acquire skills and competences for a complete learning. [Mon17].

In the education system, the introduction of information technologies is part of the modern component of education. This approach places the student at the center of the entire educational system, and to which all other components relate. In addition to this, the development of skills, competencies, critical thinking, communication, the expression of ideas and concepts freely by the student is encouraged [Ion01]. This approach is also called by Norman and Spohrer (1996), and student-centered methodology.

In countries such as Slovakia, studies have been conducted on the effects of traditional educational methods compared to modern ones. It has been found that traditional educational methods are perceived by students as lacking interactivity, monotonous, boring, which leads to a superficial or misunderstanding of the knowledge taught. All these disadvantages caused by traditional methods make learning ultimately unattractive to the

student. Another major consequence of traditional methods is the fact that it diminishes the motivation and development of the students [Mon17].
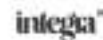
Information technology, as well as communication technology, are considered by the education system as one of the most important components in the progress of the learning process [Alc10]. Virtual reality or it is also called "Virtual Environments "is not a new technology per se but is formed by combining several technologies that have gradually developed over the years [Bou96]. These technologies are:

- Computer graphics/displays.

- human computer interfaces.

- Simulation.

The beginning of virtual reality technology was given in the 1980s, which had a head-mounted display along with a suit that was connected to the computer. That model had the same role it plays today, namely, to mimic the 3D environment [Phi14]. Before reaching the virtual reality of today, before 1980, different models were built, such as the mechanical flight simulator built by Edward Link in 1929 to prepare pilots for flight. Another invention that contributed to the development of virtual reality was that of Morton Heilig, who developed a multimodal experience display system and received the patent in 1960 [She02]. A significant discovery was made between 1970-1985, at the University of North Carolina, when Sutherland and his students were able to improve computer graphics and explore 3D rendering of objects, following this technology to be improved between year 1986-1992 [Jen02].

Over time, it has been tried to define virtual reality by different authors who have succeeded better or worse in capturing all aspects of virtual reality. For example: Howard Rheingold 1991, defines virtual reality (VR) as "An experience in which a person is surrounded by a three dimensional computer-generated representation, and is able to move around in the virtual world and see it from different angles, to reach into it, grab it, and reshape it." [How91], [Car93]. Another example of defining virtual reality is given by Bertol (1997) describes VR as "A computer-generated world involving one or more human senses and generated in real-time by the participant's actions." [Dan97].

Virtual reality systems are composed of the following elements: users, computers, hardware and software. Within the virtual systems there was a division into two general categories: *Immersive Virtual* and *Non-Immersive*.

Immersive Virtual: Immersive virtual reality systems are those where the individual is surrounded "immersed" in the virtual world. The user has a helmet mounted on his head that gives him the feeling that he is in the natural environment. As a disadvantage, immersive systems are more expensive due to software and hardware complexities than non-immersive systems. Also, these systems need high computing power to function optimally [Jen02].

Non-Immersive: Non-immersive virtual systems are also called desktop systems because they are PC based*.* In non-immersive virtual reality systems, viewers are not totally "immersed" in the virtual world. The difference between the two is that in the non-immersive virtual reality the head-mounted helmet is replaced with a desktop screen. In this type of reality, the user watches and interacts with the image that is played by a PC on a screen [Car93], [Bou96].

Speaking of the educational field and the integration of virtual reality in the educational process, it is possible to bring the real three-dimensional environment into the classroom of the students [Mar05], [Years 98]. For this it is important to define the pedagogical domain, thus, according to Mortimer (1999), pedagogy is defined as: "Any activity carried out consciously by one person, in order to improve the learning of another". Pedagogy is also called the art of teaching science, which aims to improve the learning process [Mic04]. The need to use modern teaching and learning methods in which students become active participants in the learning process, but not only passive, is an important aspect for the educational system [Alc14].

Following are some examples of implementing modern student-centered methods using virtual reality at the College of Architecture and Design at the University of Science and Technology in Jordan, which has implemented a virtual reality model for building construction courses. Technology in Jordan, which has implemented a virtual reality model for building construction courses. The authors developed software to be able to use immersive and non-immersive virtual reality in building construction (BC \ VR software). They chose a 2D model

of a house structure that they initially transformed into a 3D model with the help of the AutoCAD computer-aided design program, then inserting it into the Unity program to be able to create the virtual reality model of the building structure (fig. 1).
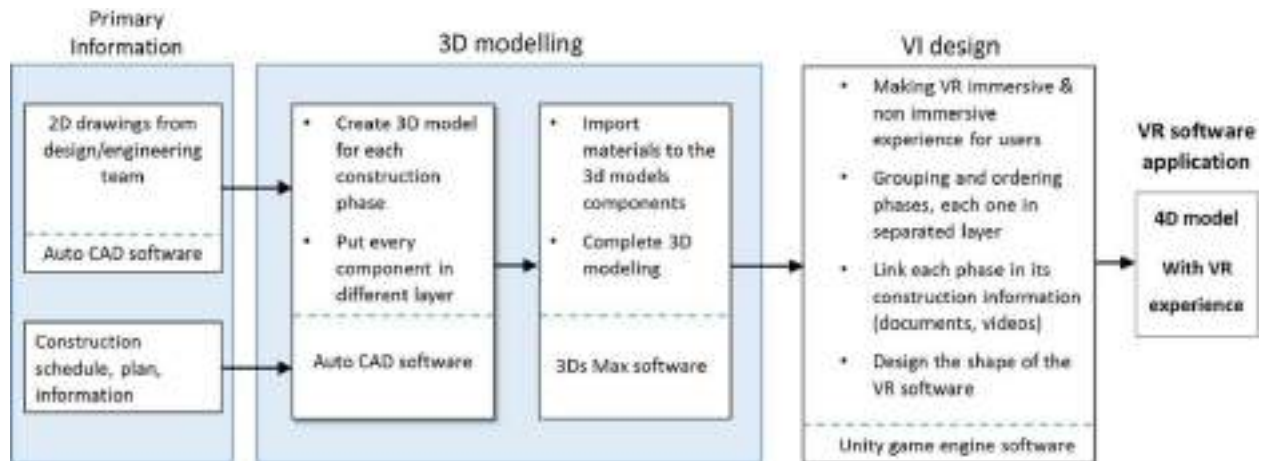

Figure. 1 The process of generating the BC / VR software [Ahm19]

- The conclusions of this study showed that the implementation of virtual reality in education is a modern and essential method in changing the teacher-centered methodology into a student-centered one.
- The students' reaction was a positive one, expressing their desire to move from traditional to modern methods based on virtual reality, in which students are actively involved in the process of accumulating knowledge.
- Virtual reality can also be used in other courses in the field of construction or architecture [Ahm19].

In the previous article, virtual reality was implemented in the formal, institutional educational environment. It is important to test the performances of virtual reality and in the informal, non-institutionalized educational environment, more precisely in companies.

To this end, Ms. Monica Dávideková et al, from Comeniu University, has produced a scientific article to determine the effects of virtual reality on employee education in Slovakia. In this article in the form of a survey, the emphasis has been placed on the modern method by using virtual reality. The quantitative research was carried out in the form of a
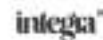
questionnaire and sent to companies from the private and state environment. 100 responses were generated by companies from various fields of activity, such as: energy, finance, tourism, transport, education, government, IT, production, health, services, the majority being in the tertiary sector (73%). From the results of the questionnaire, 34% of the answers say that the education of the employees is carried out by the self-education method and denotes the major method by which employees are trained in companies in all the sectors tested.

It is true that in this article, as well as in the specialty literature, companies mainly use traditional methods of training employees. These methods have their disadvantages and shortcomings in acquiring the skills so necessary for employees to meet the challenges in companies. A possible alternative to traditional methods is the introduction of virtual reality as a modern and active method in developing employees' skills, close to reality. Both in the specialized literature and in this article, virtual reality fits very well in the areas where it is necessary to simulate certain processes that would normally be difficult for individuals to learn. As an example, would be the field of health, production, air transport, ICT, transport, as well as the simulation of possible critical situations. The results of the study showed that the traditional methods of training employees are perceived as time consuming, boring, which leads to a superficial understanding or misunderstanding of knowledge, which makes learning perceived as unattractive. Virtual reality helps develop skills to solve workplace problems, develops creative and critical thinking, improves the learning process, and increases employee motivation [Mon17].

According to the researchers, virtual reality in education is an effective way of learning. According to their research, they came to the conclusion that virtual reality has benefits and is a better method than traditional methods, especially for children [Gre17], [How18]. Another educational aspect that virtual reality can improve is that of social aspects. Research from VR-SCT, which focused on improving social skills as well as social cognition, has shown through measurements that virtual reality brings improvements to individuals at the social and emotional cognitive level. This consisted of creating 10 different scenarios, in which the individual will meet new people and interact with them. The individual was forced to interact with each person, resolve a conflict, negotiate and simulate an interview for a job [Jen18].

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Another study in which virtual reality represented a beneficial element was the study conducted by Kandalaft M. R. et al., which focused on cognitive behavioral therapy (CBT) to reduce anxiety. This was done with the help of immersive VR technology, in which individuals were introduced to a "blue room", where they could see 360˚ without the need for glasses and being able to move around the room. Assisting people was done by a psychologist who helped them with the treatment part. Each participant was introduced to different scenarios at a higher or lower level of complexity depending on the individual's comfort state. The results showed that 8 out of 9 participants had positive results, and 7 out of 9 had higher confidence [Kan13].

Today, there are many variants of immersive virtual reality headsets on the market, from different manufacturers and with different structures. Some examples of VR headset companies include: *Samsung GearVR*, *Google Cardboard*, *HTC Vive*, *Facebook Oculus Rift*, *Sony PlayStation VR* (fig. 2), [Mye07].

Figure 2. VR headset examples

The advantages of virtual reality in education

The advantages of virtual reality in the educational process are many, but, an essential advantage is to provide a high level of learning. The main advantages of this technology in education are:
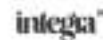
- It offers the students a complete learning, similar to the one in real life, the students can learn complex concepts much easier by this method than by the traditional methods.
- It changes the vision of educational institutions, so that they can pay more attention to improving the way of learning, than to focus on students' grades.
- It offers students the possibility of individualized learning, focused on their real needs, in an open and positive learning environment.
- The educational institutions, where, in order to prepare the students, a dangerous environment was necessary for the students, through virtual reality this danger is eliminated.
- It offers people with disabilities the chance to participate in the didactic activities.
- Low cost, compared to expensive and bulky equipment, as well as easy monitoring and recording of learning sessions [Pan10].

2.1 Competence development through modern methods

To understand the purpose of modern methods in the learning process, a comparison will be made between traditional and modern methods. For this, an analysis of the specialized literature in the field of education sciences will be carried out. According to Dumitru 2001, Marcu 2003 and Ionescu 2001, the main features of traditional methods are:

- The communication between student and teacher is one-way.
- The pupils and students are regarded as objects in the educational process, being passive receivers of information.
- In the traditional educational process, the focus is on acquiring abstract theoretical knowledge by the student.
- The evaluation by traditional methods is based on the reproduction of knowledge.
- By approaching traditional methods, the motivation of the extrinsic student is stimulated.
- It establishes a rate of assimilation of the knowledge that is compulsory for each student.

Instead, modern methods represent an interactive approach that is focused on the accumulation of competencies and abilities. Modern methods are characterized by:

- The student is positioned in the center of the system, thus becoming the subject of education.
- Use of informational methods in the educational process.
- Learning is based on problem solving and critical thinking development.
- In modern methods, different learning styles and rhythms are addressed.
- It stimulates intrinsic motivation.
- The relationship between teacher and student is open, democratic and based on respect and collaboration [Mar03], [Dum01], [Ion01].
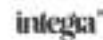
3. Virtual reality in mechatronics

Virtual reality within manufacturing systems, within Industry 4.0, represents a great opportunity to create a new way of preparing the production [Kov16]. In manufacturing, virtual reality can be of great help in:

- In the design phases for product visualization and analysis.
- Platforms where customers can interact with the finished product of the company.
- Improvement of manufacturing processes
- Monitoring of technological processes from a distance, etc…

These are just a few examples of possible uses of virtual reality in Industry 4.0. There are many types of virtual reality equipment on the market, with different features and specifications. Usually, the better the immersion of the equipment, the more complex the virtual reality device is. Before implementing these technologies, it is necessary to carry out cost assessments and calculations as well as the benefits that this investment would bring in the next period. Achieving a high degree of immersion makes it possible to train employees in an environment closer to the real environment, finally the employee will be better prepared for that position. Another aspect is the much faster changes in technologies that require continuous updating of the scenarios through reprogramming, which leads to extra effort and time. Another category of people, more conservative, considers virtual reality harmful to

human health, some of them felt nausea after a certain time, so we must find a variant so that the interaction between technology and man is as friendly as possible. The most important devices needed to create a virtual 3D environment are:

- Head Mounted Display

- 3D Mouse

- Gloves

- Cave

- Video camera and shadows

- Space Ball

- Voice recognition

- Biological sensors [Vas19].

The authors Matsas E, et al. have created a virtual reality platform of a factory in which new employees are trained on the production line together with robots, focusing on safety aspects in the workplace. The authors used in this research a combination of equipment, Oculus Rift and Kinect, to which they added sounds to the robot's movements to make the training as immersive as possible. The results showed that the people trained in this way had a lower rate of injury in their activity in production.

It is certain that virtual reality systems, within industry 4.0, will need to be flexible in adapting to industry changes. In industry 4.0 and beyond, an important component is the creation of a risk assessment method. In this context, virtual reality was used to perform evaluations and tests [Mak15], [Büt17].

To create different virtual environments used in Industry 4.0, there are several software variants on the market that can be used for this, each with its advantages and disadvantages. For example, Martin Němec et al. has made several scenarios in the fields of medicine and industry using the combination of software Unreal Engine 4 and Unity 3D, but which has the disadvantage that it requires a lot of programming work [Něm17]. Second Life and OpenSim are two software platforms that have long been used to create virtual reality. These two platforms were created mainly for educational use and especially for learning (fig. 3). These two platforms have the advantage that they are easy to install and maintain [Chr13].

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Figure 3 OpenSim virtual reality platform [Vas19]

The Sansar platform (fig. 4), from Linden Lab, is an improved platform on the graphics and immersion side. The disadvantage of this platform is that a PC with high specifications is required [Vas19].
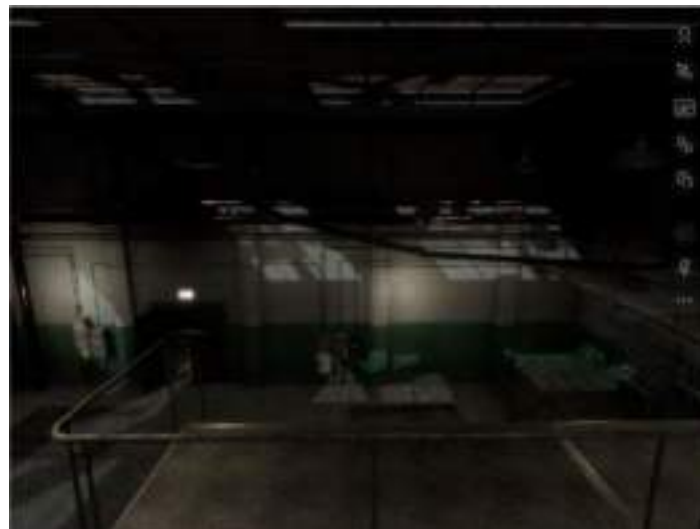

Figure 4 Sansar platform [Vas19]

Vasiliki Liagkou et al. I propose two solutions for training the employees of SMEs through virtual realities using two different platforms, namely Unity and OpenSim. The Unity platform offers better image quality and thus the animations are more realistic (fig.5). The Unity platform also offers the possibility of interacting with objects that respect the laws of physics as well as lighting and audio sources.
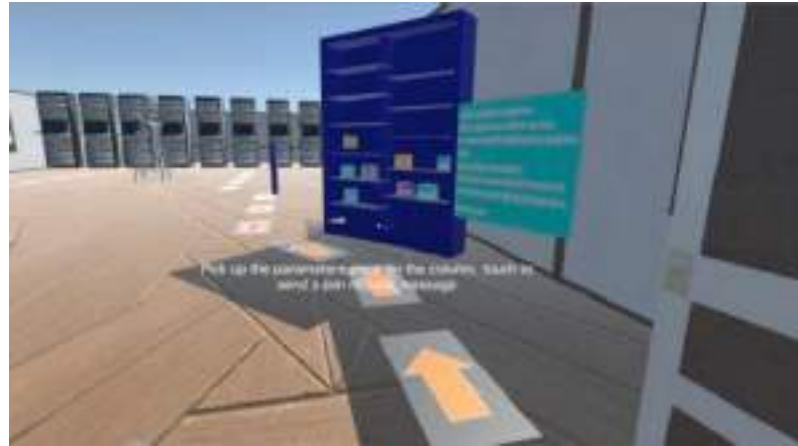
Figure 5 Model of VR in Unity [Vas19]

The Unity platform has a limited number of free modules that can be used, the rest being possible to use them only if purchased. In the case of more complex VR environments the cost of the application can increase greatly. Upgrading the environment in Unity is more difficult than in the OpenSim platform. To be able to change the VR environment in Unity you need to write program lines in C#. Within the Unity application, the user can interact with the elements around him, and the interface is a simplistic and easy to use.

For OpenSim, creating a virtual environment is less expensive than creating a virtual model in Unity. This is because the OpenSim platform is an Open Source platform. Updating VR environments in OpenSim is a pretty easy procedure, so an SME operator could do it, the same thing in Unity requires more effort. The virtual environments realized in OpenSim have the disadvantage that the quality of the VR experience is not sufficiently realistic compared to Unity (fig.6) [Vas19].

Figure 6 Model of VR in OpenSim [Vas19]

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In the article written by RaúlCrespo, it relies on the benefits of virtual reality to provide a new way to teach students the operation and handling of the Mitsubishi Movemaster RV-M1 robot. For this application, the author used the Unity software platform, and as the hardware used the Oculus Rift immersive VR headset. After the students have programmed the robot in the virtual environment, the program will be validated on the physical robot. The operating diagram of the entire process will be exemplified below in Figure 7.
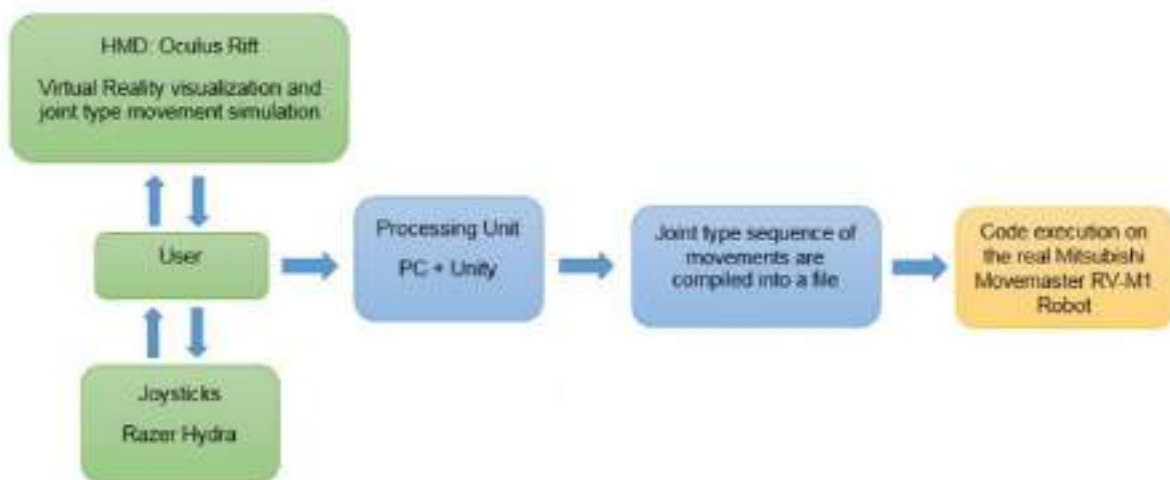

Figure 7 Function diagram [Rau15]

Software and hardware were needed to make this research possible. The elements that made up the hardware part are:

- Oculus Rift immersive virtual reality headset,

- Razer Hydra Joysticks to manipulate every joint of the robot,

- Mitsubishi Movemaster RV-M1 Robot.

And as software have been used Unity platform:

- Oculus SDK,

- Sixense SDK,

- Denford Robot Communications,

- Unity 3D,

- Sketch-Up and Blender,

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- Takohi Inverse Kinematics,

- APEX Game Tools.

After the 3D modeling of the Mitsubishi Movemaster RV-M1 robot was done, the files were imported into the Blender program with the "dae" extension, and where the robot's joints were connected. The files from Blender were imported into Unity with the "fbx" extension. The physical robot together with the 3D robot in the United program are shown below (fig.8).
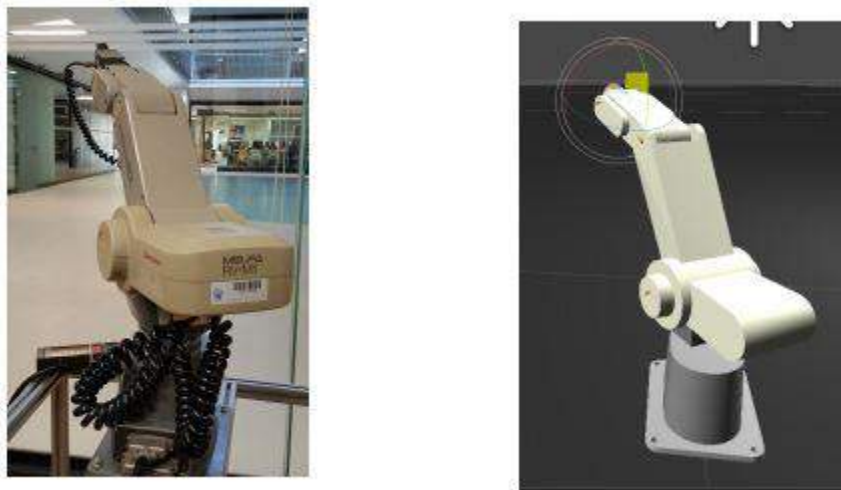

Figure 8 Real robot and 3D robot in VR [Rau15]

The results of this research conducted on a group of students showed that students who used virtual reality managed to successfully complete the learning module in a shorter period of time, while those who used the robot failed to complete the module for studying [Rau15].

- *EXAMPLES*

3.1 VR examples using MATLAB

As an example, the Mitsubishi RV-2AJ serial robot was integrated into non-immersive virtual reality, this was done using the Matlab platform. This robot has a number of 5 axes of movement, and in order to be integrated in the Matlab programming environment, it was necessary to make the 3D model of the robot. The Mitsubishi RV-2AJ robot was chosen as a model for this example, but other types of robots can be used. After the 3D model of the robot is ready, the file is saved with the "VRML" extension. To manipulate the robot, in the Matlab platform a GUI with GUIDE is made, in the case of our application a GUI was made in which the "+" and "-" buttons were entered for each axis of the robot. In Figure 9, the robot is positioned in the "home" position. In order for the robot to reach the "home" position, a button called "HOME" has been inserted in the GUI application, and when pressed, the robot returns to the "home" position and all axis movements return to position 0.
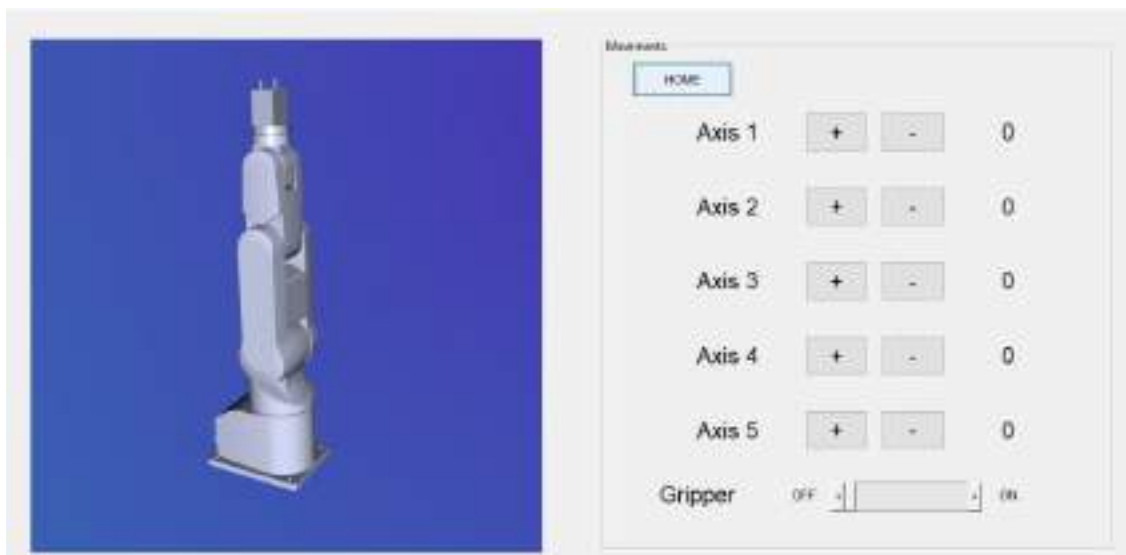

Figure 9 GUI application with the robot in the home position

The robot is equipped with a gripping device, which, in order to be activated, a slider has been inserted in the GUI application that has two positions: "ON" and "OFF".

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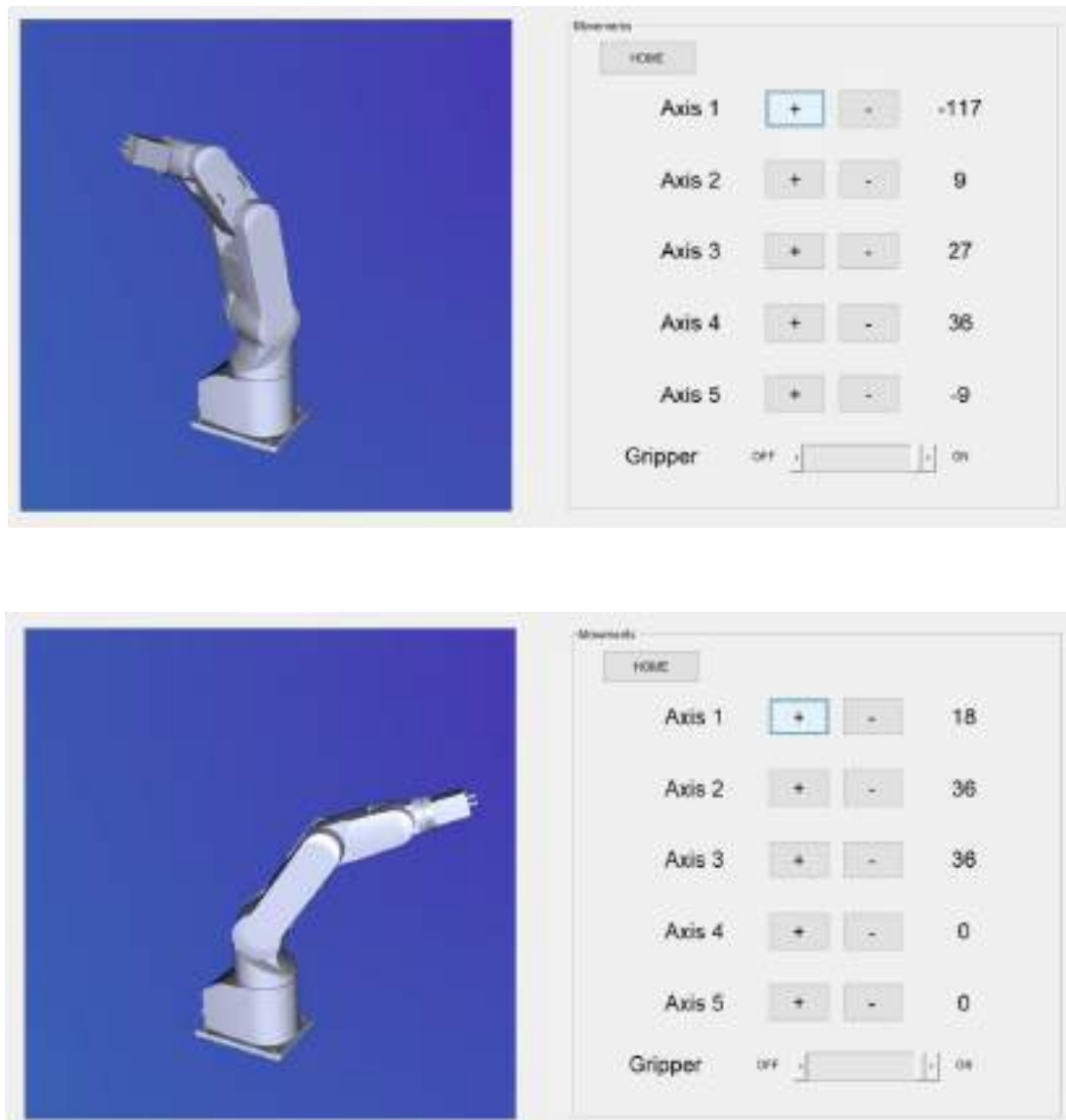Erasmus+ Programme
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Figure 10 The change of the robot position by operating axes 1, 2 and 3.

4. CONCLUSION

The lecture presents aspects regarding the virtual reality, students will learn about all hardware and software used in Virtual Reality (VR). Theoretical aspects focus on improving the learning experience of students and teachers by creating virtual models using different
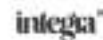
software platforms such as MATLAB / Simulink, Unity, in which students can practice and design different actions or models.

General objectives of the lectures were the formation of notions related to the concept of virtual reality, the formation of ideas on the advantages of interactive learning methods, understanding the relatively complex topics about learning with the help of virtual reality. The specific objectives were to know the main devices with which they interact, knowledge of the steps required to make virtual models, to create virtual reality models, to know how it works, to identify the causes of a possible malfunction.
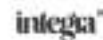
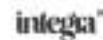Co-funded by the
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