Virtual Reality and its Technologies in Education – Our Experiences

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***Abstract*—At our department, students can study virtual reality technologies and their problematic (Department of computers and informatics, Faculty of Electrical Engineering and Informatics of Košice - DCI FEEI TU of Košice). Study of virtual reality technologies is divided into two parts. First part focus on theoretical knowledge and second part focus on practical knowledge. This paper presents practical exercises during which students earn practical experiences about virtual reality technologies (3D scanning, augmented reality, head-mounted display, 3D displays and 3D printing). This paper also presents our experiences and students' feedback to this education.**

***Keywords*—virtual reality, virtual reality technologies, education, augmented reality, head-mounted display, 3D displays, 3D printing, 3D scanning**

I. Introduction

Virtual reality (VR) technologies (such as 3D displays, 3D cameras or 3D printers, etc.) have become an everyday part of our lives. At DCI FEEI TU of Košice, students can study virtual reality and its technologies. This study is focused on the acquirement of theoretical knowledge and practical experiences about 3D computer graphics, virtual reality and its technologies. On practical exercises students work with the latest virtual reality technologies (e.g. augmented reality, 3D scanning or 3D printing) and create content for them (such as anaglyph pictures or 3D models). For education purposes it is also important to know what students know about virtual reality and its technologies to correctly adjust lessons to the students' knowledge and to the needs of practice.

This paper presents our experiences and students' feedback to this education and is organized as follows. Section 2 presents virtual reality technologies that students learn about and work with. Section 3 presents what students learn on practical exercises. Section 4 shows our experiences with the education of VR. Section 5 summarizes information presented in the paper.

II. Virtual Reality Technologies

A. 3D Scanning

3D scanner is a device that analyzes a real-world object or environment to collect data on its shape and possibly its appearance (i.e. color). There are several types of 3D scanners, which differ in the technology used for obtaining a data. They can be divided into two main categories: *contact* and *non-contact* scanners.

Contact scanners require a physical contact with the object being scanned. Non-contact scanners use radiation to acquire required information about objects. They are of two basic types: *passive* and *active* [1].

B. Augmented Reality

There are several definitions of augmented reality (AR) [1]. One was given by Ronald Azuma in 1997. Azuma's definition says that Augmented Reality: combines real and virtual, is interactive in real time and is registered in 3D.

Another one was given by Paul Milgram and Fumio Kishino: Milgram's Reality-Virtuality Continuum. Continuum is visualized as line that is between reality and virtuality (Fig. 1).

C. Head-Mounted Displays

A head-mounted display (HMD) is a display device, worn on the head (or as part of a helmet), that has small display optic in front of one (monocular HMD) or each eye (binocular HMD). HMD are used in virtual reality and augmented reality applications. Another classification of HMDs is based on how the user sees real world. This classification divides HMDs into two categories: *immersive* and *see-through*. See-through HMDs have two subcategories: *video see-through* and *optical see-through*.

D. 3D Displays

3D displays use several technologies to create 3D image. Each technology has its advantages and disadvantages. There are several types of 3D displays [3]: holographic displays, volumetric displays (swept-volume and static volume displays) and stereoscopic displays (passive, active and autostereoscopic).

E. 3D Printing

3D printing is a form of additive manufacturing technology where a three dimensional object (3D model) is created by laying down successive layers of material. 3D printers are generally faster, more affordable and easier to use than other manufacturing technologies. 3D printers offer developers the ability to print 3D models for visualization, testing or direct parts creation.

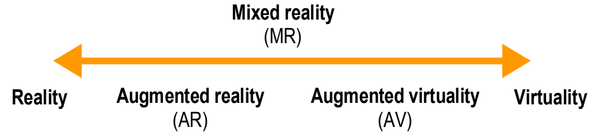

Figure 1. Visualized Milgram's Reality-Virtuality Continuum

III. Modeling and Visualization Using Virtual Reality Technologies

Creation of a 3D model for visualization needs a lot of effort. Everything begins with collecting of information and analysis (preparation phase). When the data are prepared 3D model creation begins (modeling phase). A check of model for errors comes after 3D digital model creation (verification phase). The visualization of the final model is the last step. This process is depicted in Fig. 2 [4]. Students learn about each step on practical exercises, where they create and visualize 3D models. Also students learn how to work with virtual reality technologies and how to use them to improve 3D model creation and visualization process.

Practical exercises are divided into these sections:

- 3D model creation,
- 3D scanning,
- 3D visualization,
- 3D printing.

A. 3D Model Creation

In this section students learn how to create 3D models, which are used in 3D visualization (using 3D displays) and in 3D printing. As 3D modeling applications are used Google SketchUp [5] and Blender [6]. During practical exercises students learn:

- 3D modeling basics,
- how to create model using photos, sketches or blueprints,
- how texture created 3D models
- how to set up scene for rendering of single image or entire animation

B. 3D Scanning

In this section students learn how to manipulate and work with 3D scanner Leica ScanStation 2 [7] - e.g. finding the right scanning position, setting the best parameters for scanning or joining multiple point clouds together. Students also learn how to use scanned data to speedup their 3D model creation. Students working with mentioned 3D scanner are shown in Fig. 3.

C. 3D Visualization

3D visualization section is divided into four subsections where students work with:

- **anaglyph images** – this subsection teaches students how to correctly create left and right image of selected real object (scene) for subsequent easy creation of anaglyph image.
- **autostereoscopic 3D display Philips WOWvx [8]** – in this subsection students learn which method this display use for 3D content displaying (2D-plus-depth) and how to create content for this autostereoscopic 3D display.
- **virtual reality system** – in this subsection students acquire theoretical and practical knowledge about 3D virtual reality system that combine together 3D displaying system (passive stereoscopic system using INFITEC technology [9]) and position tracking system (InterSence IS-900 SimTracker [10]) to create immersive VR environment. Students also learn how to create content for this VR system with 3D modeling applications (Google SketchUp or Blender) and 3D scanning.
- **augmented reality** – this subsection teaches students how AR works and how to create content for AR applications. Fig. 4 shows student working with augmented reality system that use for displaying see-through HMD NVIS nVisor ST 60 [11].

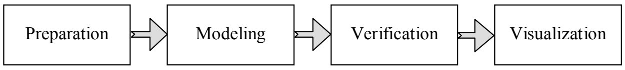

Figure 2 Modeling and visualization process

Figure 3 Students working with 3D scanner

D. 3D Printing

This section teaches students how 3D printing works and how to manipulate with 3D printer 3D Systems ZPrinter 450 [12], how to prepare 3D models for printing and how to finalize printed models. For printing students use their 3D models which were created in SketchUp or Blender.

More details about VR systems and 3D interfaces with which students work (learn about) at [13].

Figure 4 Student working with augmented reality system

IV. Teaching Virtual Reality – Our Experiences

It is important for us to know what students know about VR problematic and what they think about virtual reality education at the DCI FEEI TU of Košice. For this purpose were created two questionnaires. 64 students of the Virtual reality systems (SVR) course participate in this survey. The first questionnaire (given to the students at the start of a semester) had three questions and was focused on the current knowledge of students about VR technologies. The second questionnaire (given to the students at the end of the semester) had also three questions. Its purpose was to determine students' satisfaction with the quality of the SVR course. Questionnaire also focused on the students' satisfaction with the VR systems and equipment with which they work during the semester and their ideas how these VR systems and equipment can be improved.

A. Questionnaires at the Start of Semester

Questions in the questionnaire:

- Q. 1: Do you know how following 3D interfaces work?
- Q. 2: With which 3D interfaces have you met?
- Q. 3: Where have you met 3D interfaces from the question n. 2? (possible answers: home, school, shop, friend and other)

Questionnaire focus on these 3D interfaces: 3D scanners, data gloves, head-mounted displays, walk simulation interfaces, position tracking, 3D displays, 3D cameras, augmented reality, 3D printers and touch screens.

Results obtained from the questionnaire are shown in the following table (Tab. 1) and figures (Fig. 5 - 7). Names of the individual 3D interfaces in figures were changed to numbers (see column 1 in Tab. 1) to clarify the representation of the obtained results.

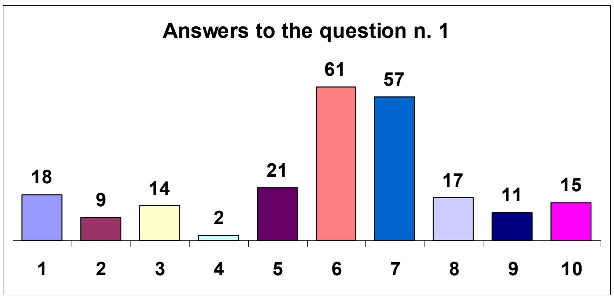

Figure 5 Graph of the answers to the question n.1

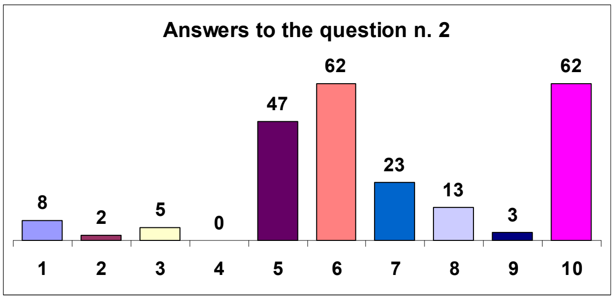

Figure 6 Graph of the answers to the question n. 2

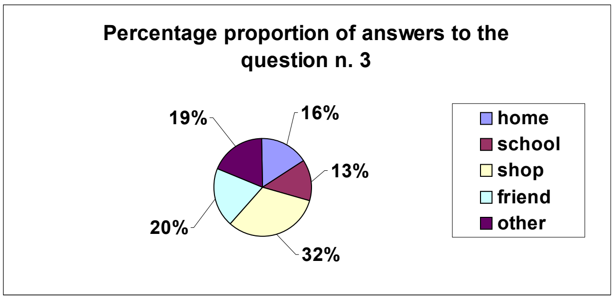

Figure 7 Graph of the percentage proportion of the answers to the question n. 3

TABLE I. Results Obtained from the Questionnaire (Start of the Semester)

	Question n. 1	Question n. 2	Question n. 3				
			home	school	shop	friend	other
3D scanners **(1)**	28,13%	12,50%	0,00%	12,50%	0,00%	0,00%	0,00%
Data gloves **(2)**	14,06%	3,13%	0,00%	3,13%	0,00%	0,00%	0,00%
Head-mounted displays **(3)**	21,88%	7,81%	0,00%	7,81%	0,00%	0,00%	0,00%
Walk simulation interfaces **(4)**	3,13%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Position tracking **(5)**	32,81%	73,44%	14,06%	20,31%	29,69%	21,88%	9,38%
3D displays **(6)**	95,31%	96,88%	28,13%	35,94%	89,06%	29,69%	84,38%
3D cameras **(7)**	89,06%	35,94%	7,81%	0,00%	29,69%	10,94%	9,38%
Augmented reality **(8)**	26,56%	20,31%	4,69%	0,00%	9,38%	6,25%	7,81%
3D printers **(9)**	17,19%	4,69%	0,00%	4,69%	0,00%	0,00%	1,56%
Touch screens **(10)**	23,44%	96,88%	76,56%	23,44%	95,31%	92,19%	40,63%
Average value	35,16%	35,16%	13,13%	10,78%	25,31%	16,09%	15,31%

Evaluation of the results obtained from the questionnaires:

- Q. 1: Most known 3D interfaces are 3D displays (95.3%) and 3D cameras (89%). Least known 3D interfaces are walk simulation interfaces (3.1%).
- Q. 2: Most students have met with 3D displays (96.9%), touch screens (96.9%) and position tracking (73.4%). Approximately 36% of students have met 3D cameras. 20% of students met augmented reality. Other interfaces have less then 10%.
- Q. 3: Most students have met with 3D interfaces at shop (32%). Worst percentage has school (only 13%).

B. Questionnaires at the End of Semester):

Questions in the questionnaire:

- Question n. 1: Rate VR systems and devices with which you have met in the LIRKIS laboratory. (4 – best, 0 – worst)
- Question n. 2: How would you modify / improve VR systems and devices in the LIRKIS laboratory?
- Question n. 3: What would you add, change or remove from SVR course?

VR systems and devices in the LIRKIS laboratory: stereoscopic VR system (INFITEC) – **(1)**, Philips WOWvx (2D-plus-depth) – **(2)**, stereoscopic system (anaglyph) – **(3)**, 3D display LG (light polarization) – **(4)**, Microsoft Surface 1.0 – **(5),** AR system with HMD – **(6)**, 3D scanner (Leica Scanstation 2) – **(7)**, 3D printer (ZPrinter 450) – **(8)**.

Results obtained from the questionnaire are shown in the following tables (Tab. 2 - 3) and figure (Fig. 8). To evaluated results from the questions 2 and 3 was used SWOT analysis. Names of the individual 3D interfaces in the figure were changed to numbers (see previous paragraph) to clarify the representation of the obtained results.

Evaluation of the results obtained from the questionnaires:

- Q. 1: Best average rate gain system for autostereoscopic 3D visualization (3.68). Worst average rate gain stereoscopic displaying system using anaglyph technology (1.58).
- Q. 2 and 3: Suggestions obtained from students were used for the improvement of SVR course and created VR systems.

V. Conclusion

This paper was divided into two parts. In the first part of this paper were presented practical exercises during which students earn practical experiences about 3D computer graphics, VR and their technologies. Experiences and knowledge earned during these lessons help students to better understand problematic of 3D computer graphics, VR and its technologies.

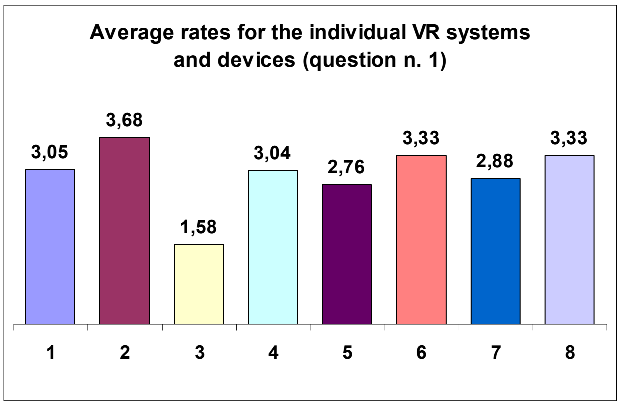

Figure 8 Graph of the average rates for individual VR systems and devices (question n. 1)

TABLE II. SWOT Analysis of the Answers to the Question Number 2

Strengths	Opportunities
- easy and intuitive interaction with VR systems - new technologies - easy and simple visualization of 3D models and other data - free VR engines and 3D modeling applications	- creation and modification of VR systems using students ideas - development of application that use 3D interfaces - simplification in the process of creation of new VR systems and devices (3D interfaces)
Weaknesses	**Threats**
- high price of 3D interfaces - HMD needs to be connected to the PC with cables - VR systems needs high computational power	- insufficient funds for purchase of new 3D interfaces - high price of the latest 3D interfaces - expansive repair of damaged hardware

TABLE III. SWOT Analysis of the Answers to the Question Number 3

Strengths	Opportunities
- large interest of the students in the problematic of VR (VR technologies) and 3D interfaces - satisfaction with the teaching of VR and 3D interfaces	- preparation of students for their future work with the VR technologies and 3D interfaces - increase of the teaching hours
Weaknesses	**Threats**
- fast interpretation of problematic dedicated to 3D modeling and Blender	- high price of the latest 3D interfaces - decrease of the teaching hours

In the second part of this paper were presented our experiences with the education of VR and its technologies. This part also presented students' feedback to this education. Two questionnaires were created to gain this feedback. This survey has shown these valuable information:

- Most known 3D interfaces are 3D displays (95.3%) and 3D cameras (89%). Least known 3D interfaces are walk simulation interfaces (3.1%).
- Most students have met with 3D displays (96.9%), touch screens (96.9%) and position tracking (73.4%). Approximately 36% of students have met 3D cameras. 20% of students met augmented reality. Other interfaces have less then 10%.
- Most students have met with 3D interfaces at shop (32%). Worst percentage has school (only 13%).

- Students are interested in VR problematic and want to learn about 3D computer graphics, VR and its technologies as much as possible.
- SWOT analysis shown strengths, opportunities, weaknesses and threats of VR education at DCI FEEI TU of Košice.

Information gain from this survey will be used to improve SVR course and whole education of VR at DCI FEEI TU of Košice.

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REFERENCES

[1] F. Hrozek, B. Sobota, R. Janošo: "Visualization with 3D Interfaces", International Scientific Conference on Computer Science and Engineering, CSE 2010, Proceedings of, vol. 1, no.1, pp. 328-335, September 20-22, 2010, ISBN 978-80-8086-164-3

[2] I. N. Durlach, S. A. Mavor: *Virtual Reality: Scientific and Technological Challenges*, Washington, D.C.: NATIONAL ACADEMY PRESS, 1995, 556 p., ISBN 0-309-05135-5

[3] S. Xu, C. M. Manders, T. Y. Odelia, P. Song: "3D display for a classroom", *Educational and Information Technology (ICEIT), 2010 International Conference on*, vol.2, pp. V2-316-V2-320, 17-19 September 2010

[4] B. Sobota, Š. Korečko, J. Perháč: "3D Modeling and Visualization of Historic Buildings as Cultural Heritage Preservation", *Proceedings of the Tenth International Conference on Informatics INFORMATICS 2009*, Herľany, Slovakia, Nov. 23. - 25., 2009, Košice, Elfa, 2009, 10, 1, pp. 94-98, ISBN 978-80-8086-126-1

[5] Google SketchUp homepage, http://sketchup.google.com/

[6] Blender homepage, http://www.blender.org/

[7] Leica ScanStation 2 homepage, http://hds.leica-geosystems.com/en/Leica-ScanStation-2_62189.htm

[8] Philipse WOWvx homepage, http://www.business-sites.philips.com/3dsolutions/home/index.page

[9] INFITEC homepage, http://www.infitec.de/index2.php

[10] Intersence IS-900 SimTracker homepage, http://www.intersense.com/pages/20/14

[11] NVIS nVisor ST 60 homepage, http://nvisinc.com/product.php?id=5

[12] 3D Systems ZPrinter 450 homepage, http://zcorp.com/en/Products/3D-Printers/ZPrinter-450/spage.aspx

[13] B. Sobota, F.Hrozek, Š. Korečko, Cs. Szabó: "Virtual reality technologies as an interface of cognitive communication and information systems", *2nd International Conference on Cognitive Infocommunications (CogInfoCom) 2011*, Budapešť, Maďarsko, 7.- 9. 7., Budapešť, Maďarsko, Budapest University of technology and Economics, 2011, pp. 1-5, ISBN 978-1-4577-1806-9