VIRTUAL REALITY APPLICATION IN PROBLEM-BASED LEARNING EXPERIENCE: PROBLEMS AND FINDINGS

O. Shvetsova

Korea University of Technology and Education (KOREA, REPUBLIC OF)

Abstract

This research focuses on the 4th Industrial revolution and the Korean National Competency Standards. The aim of this research is to perform a comparative study of two university Management courses to present the difference between the effect of virtual reality (VR)-based teaching and problem-based learning (PBL) on teaching management. To achieve this goal, the author used the expert method, focus group interviews, and a comparative study. There are three hypotheses and four research questions on the relationship between teaching method and competency development. As a case study for this research, the author chose Korea University of Technology and Education and designed a survey to assess students' competencies. The participants are 2nd- and 3rd-grade university students. Quantitative data are collected from the interview forms developed by the researcher; qualitative data lre analyzed using the expert method and a comparative study. A significant difference was observed competency development in the VR class and that in a PBL class with a similar syllabus. Furthermore, it was noted that different teaching methods affect competency development in different ways; VR tools develop some competencies, but not all of them. Author found that VR tool requires appropriate teaching method and affects the student's ability to develop competencies.

Keywords: Virtual Reality; Problem-Based learning; competence model; student.

1 INTRODUCTION

Virtual Reality (VR) technologies have been rapidly recognized in construction Management education and training (CEET) programs because they are believed to effectively enhance the quality of such programs. A representative taxonomy of the visualization system for classifying types of VR was originally proposed by Chee, Y. [1] and Chen, C. et al. [2], and it describes how "virtual" and "real" are merged in different proportions to create a visualization environment. There are four different levels on the Reality–Virtuality (RV) continuum to be defined: Pure Real Presence, Augmented Virtuality (AV), Augmented Reality (AR), and Pure Virtual Presence. Strictly speaking, according to Bollinger L. et al. and Shin, D.-I., innovation technologies help to develop a competitive product; this is why, nowadays, VR is attracting much attention for improving communications in the professional workplace and other shared spaces [3–5].

Virtual and augmented reality (VR/AR) is becoming one of the tools of the electronic economy. VR/AR technology first captured its most successful market—the market of computer games, which is several billion dollars—as reported by Freeman C. [3]. When businesses understand all of the possibilities of VR/AR technologies, such technologies begin to be actively introduced to the business environment. VR/AR technologies in business are used for visualizing premises, product shelves, internal and hidden structures, and movement and comparing various spaces. Increasingly more business areas are incorporating virtual and augmented reality into their activities. It is used in construction, retail, investment, finance, education, etc., as discussed by Portelanc; Kovacs, G.; Kot, S. et al. [4].

VR/AR technologies are especially important in an educational environment. Education is increasingly moving to the Internet environment and becoming more distance-oriented. It is no secret that modern education requires the construction of an effective multi-level system of continuous education. The benefits and risks of e-education are presented in Table 1.

Table 1. Benefits and risks of the electronic form of education at University.

Area of investigation	Benefits	Risks	Examples
Infrastructure	Modernization of infrastructure	High costs	B (benefit): Modernization of infrastructure requires new equipment and modern technologies R (risk): Implementation of new equipment and modern technologies requires additional costs, time for establishing settings and personnel's adaptation
Innovation	Creation of innovations	Competition, quality of the service/product	B (benefit): Creation of innovations may lead Universities to new forms and methods of education that can be more flexible and market-oriented. Universities may invent new strategies: franchising or licensing R (risk): New innovations should be focused on market needs and industry standards; otherwise, they will not be successful. Innovations should provide relevant quality of product/service
Competency	Competency development	Competency assessment; matching Industry standards	B (benefit): Relevant competencies create new standards and skills, develop new teaching methods, and help to achieve organizational leadership R (risk): The competency model has some limitations—it must follow Industry standards; it should provide relevant requirements for the development level of individual competencies
Brand	University's brand expansion	Intellectual property and rights' risks	B (benefit): A university may expand its brand and improve its positioning strategy R (risk): Electronic and online educational market is a fast-cycle market, so competition may rise very quickly; it is necessary to protect know-how and innovations and arrange intellectual property rights
Customization	New customers and profit; market expansion	Unstable market preferences (risk of customization); health threats	B (benefit): University expands strategy (even globally), finds new markets, becomes more attractive to new customers R (risk): Customers' preferences are highly changeable, especially in different markets, so it is necessary to provide a differentiation strategy

Source: made by author.

Online training for company employees is becoming more common. However, not every company is ready to spend money on developing its own Learning Management System (LMS) platforms since it is cheaper to buy access to an already finished platform. This creates an additional market for e-learning courses for educational institutions.

2 METHODOLOGY

2.1 Scope of research

The main research problem of this study may be recognized as difficulty in education process to meet the National Standard of competences development within the specific tools in teaching. It means that several factors affect student's competences development, such as teaching method; tasks; technology tool, etc. So, the best way to solve this problem is to compare different approaches, investigate all factors and find the best practical tool in education process for appropriate competences development.

The main goal of this research is to conduct a comparative study to present the difference VR-based teaching and traditional teaching in learning Technology entrepreneurship. To achieve this goal, the author created a survey of students' competencies. So, three hypotheses are proposed during the development of the survey:

- **H1.** *The VR class improves and develops core competencies in a basic Management course better than the PBL class;*
- **H2.** *The VR class does not improve or develop core competencies in a basic Management course better than the PBL class;*
- **H3.** *The VR class improves and develops only a certain scope of competencies in a basic Management course.*

Four research questions are established during the development of the survey to improve the clarity of the task:

1. How can competency be developed with VR?
2. How does VR focus on competency development?
3. Which teaching methods can influence competency development in a PBL class?
4. Which teaching methods affect competency development in a VR class?

2.2 Limitations of research

There are some limitations of this research:

- This research is based on a case study of one university (South Korea);
- The period of the survey is one semester (4 months);
- The scope of this survey is focused on the competency model of the 4th Industrial Revolution.

Virtual Reality (VR) is a technology that provides an interactive computer-generated environment, usually with a dynamically changing scenario in which one can see and move. VR simulates a user's physical presence in an artificially created world and allows them to interact with that virtual environment, as explained by Abatecola, G. et al. [5], [6]. Moreover, virtual reality plays an important role in the teaching process by providing interesting and engaging ways of acquiring information. It can help teachers to explain complex issues in light of its graphical nature combined with an explorative approach, physical interactions, and intuitive interfaces.

2.3 Structure of Research

The case study of Korea University of Technology and Education (hereafter referred to as KOREATECH) presents the difference VR-based teaching and traditional teaching in learning Technology entrepreneurship. The research team analysed the course syllabus for "Technology entrepreneurship" (case study method); identified the core competencies of students (expert method); discussed teaching methods (expert method); and interviewed two groups of students (one interview for the traditional class and another for the VR class). These interviews had three stages: the first stage was performed at the beginning of the semester; the second stage was after the mid-term exam, and the final stage was at the end of the semester (figures 1 and 2). A list of interview questions was prepared with the aim of showing the differences in the learning efficiency and academic performance of the student groups (comparative study method), and a retention test was conducted to compare how the students increased their knowledge and developed certain competencies.

A special VR application was developed for the "Technology entrepreneurship" class activity [7]. The VR application presents a business game, which is based on a case study (problem-based story). Students Ire instructed to watch and listen to the story for 7–8 minutes (3–4 different problems for different groups of students), after which that they received their role. For the decision-making process, they had to play their roles and solve the problem (develop the solution) in their case study [8].

2.3.1. Step 1 (Figure 1)

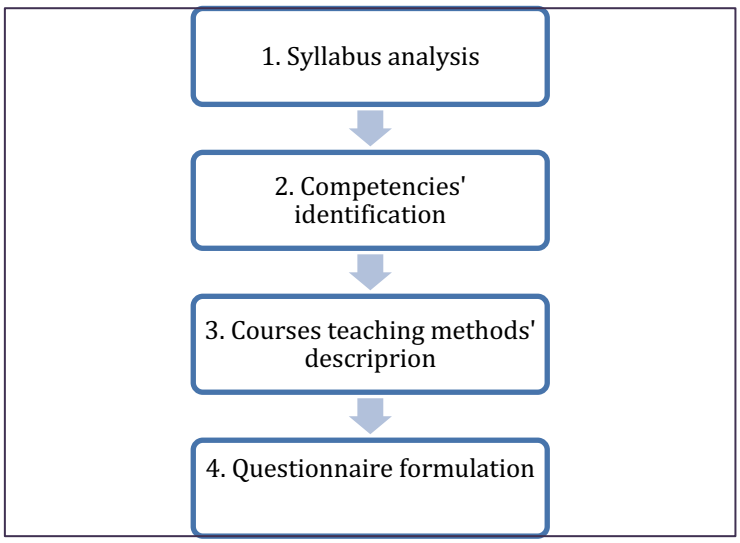

Figure 1. First step of research.

During the 1st step of the research, it was necessary to analyze the course syllabus to investigate competency and teaching goals. Afterward, the teaching methods Ire described, and the last effort was to create a questionnaire for students' feedback.

2.3.2 Step 2 (Figure 2)

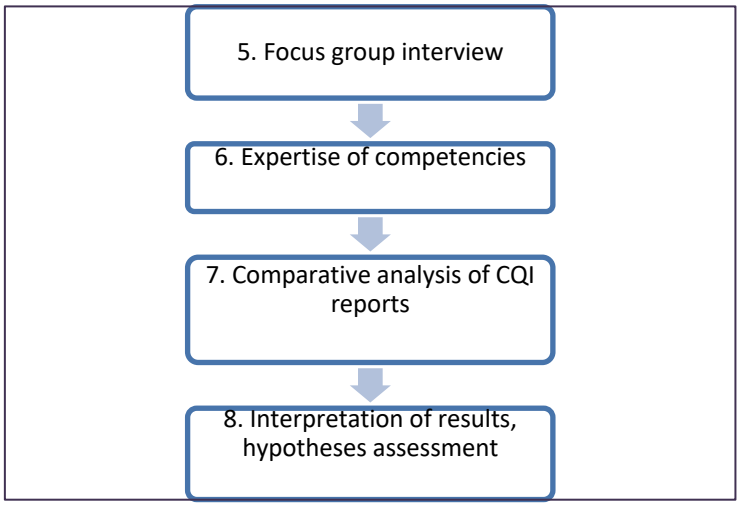

Figure 2. Second step of the research.

During the 2nd step of the research, it was necessary to arrange the focus group interview with relevant students (who attended the class); after that, with the help of individuals with expertise on competencies, the results from the interviews Ire compared with the answers in the Channel Quality Indication (CQI) reports. The last effort was to analyze the results of the survey and assess the hypotheses.

2.4 Research Methods

This study is based on three research methods:

1 Expert method;

2 Focus group interview;

3 Comparative study.

Expert method helps to investigate and rank all the factors; focus group interview helps to collect the data; comparative study helps to manage findings and make the decisions.

3 RESULTS

I chose the focus group interview method for data collection because it has several advantages:

- it is a face-to-face method;
- it uses a moderator (the Professor can hold this interview);
- it uses a fixed location and group (KOREATECH University, Mechanical Management Department, one classroom);
- questions from an unexpected area (VR, for example) can be used;
- the period of the interview process is fixed (3 times during 1 semester).

The participants are picked from the School of Mechanical Management (KOREATECH), and all of them are students of the second grade. I interviewed two groups of students: one group was from the PBL class of "Technology entrepreneurship" with a total of 62 participants (53 males and 9 females); another group was from the VR class of "Technology entrepreneurship" with a total of 51 participants (39 males and 12 females). They interviewed 2 "Technology entrepreneurship" classes: one PBL class and one VR class. The developed questionnaire was the same for both groups of respondents. The structure of the interview process is presented in table 2.

Table 2. Structure of interview.

PBL class "Technology entrepreneurship"			VR class "Technology entrepreneurship"		
Participants	Moderator	Period	Participants	Moderator	Period
62 (53+9)	HRD	1st stage: at the beginning of semester; 2nd stage: after mid-term exam (middle of semester); 3rd stage: at the end of semester (after final exam)	51 (39+12)	Professor	1st stage: at the beginning of semester; 2nd stage: after mid-term exam (middle of semester); 3rd stage: at the end of semester (after final exam)

Note: author's elaboration.

An example of the interview questions is provided in Appendix B. The interview was held three times during one semester: the 1st stage was at the beginning of the semester; the 2nd stage was after the mid-term exam (middle of the semester); the 3rd stage was at the end of the semester (after the final exam). There are 44 questions in total, and they are divided into 8 different areas related to the competency model. Students had to answer only those questions which contributed to the evaluation of the most important competencies for the "Technology entrepreneurship" course. I introduced the students to the competencies and their meanings during the interview procedure:

- Competency 1. Interdisciplinary fusion. All questions are related to the interdisciplinary correlation of this course with other courses. I ensured that the students understood the scope of the course.
- Competency 2. Troubleshooting. All questions help to understand whether students are able to recognize the problem and find ways to solve it.
- Competency 3. Communication. All questions are focused on communication activities and cooperation within a group. Students present their opinion on which type of decision-making process (individual or group) is more convenient for them.
- Competency 4. Study map. All questions are based on course materials, teaching methods, and goals. So, I checked whether students understand everything, whether they can use the material, and which teaching method is the most attractive to them.
- Competency 5. Challenging practice. These questions are focused on academic and technical skills and understanding the project's trajectories.

- Competency 6. Practical application. This pool of questions is related to the market area, practical skills, and self-development.
- Competency 7. Human relationship. These questions help to check the student's understanding of the human features of a project in the Technology entrepreneurship area.
- Competency 8. Major foundation. This pool of questions is focused on major knowledge and technical deep learning.

I used an evaluation scale of five grades as possible answers:

1 -2 = Very negative/Totally disagree
2 -1 = Negative/Disagree
3 0 = Not sure/So-so
4 1 = Good/Agree
5 2 = Very good/Exactly Agree

Based on the expert method, I received the following summarized results:

1 Syllabus analysis. Most of the topics are focused on technical and communicative skills. Three main teaching methods are used: VR, programming, and testing. The course description is the same for the PBL class and VR class; also, these two classes have similar goals.
2 Competency identification. Eight main competencies Ire investigated (from a total of fourteen) that are necessary to develop in the "Technology entrepreneurship" course: interdisciplinary fusion; troubleshooting; communication; study map; challenging practice; practical application; human relationship; major foundation. All of these competencies have an average score of more than 3.5 points.
3 Teaching methods' evaluation. From analysing the results, I found that virtual reality was the most effective for developing competencies. It ranked 1st with 170.14 points from the evaluation.

Questionnaire formulation. On the basis of competency identification, I created 44 questions (around 5–7 for each competency) and provided a five-point scaled evaluation system for the answers.

Now, let us compare the overall results among the 3 stages (1st, 2nd, and 3rd interviews) (table 3). I submit the most representative answers (those with the highest percentage) in each column. The minus sign indicates a negative answer, and the plus sign indicates a positive answer.

Table 3. Comparative study of 3 interview stages (PBL class and VR class).

Competency	PBL class results, %			VR class results, %		
	1st interview	2nd interview	3rd interview	1st interview	2nd interview	3rd interview
1.Interdisciplinary fusion	-27%	+26%	+30%	-25%	20%	+27%
2.Troubleshooting	+33%	-28%	-26%	+29%	+32%	+39%
3.Communication	-30%	-30%	+25%	-22%	20%	+19%
4.Study map	+31%	+34%	+38%	+25%	+26%	+30%
5.Challenging practice	+27%	+29%	+29%	+25%	+29%	+36%
6.Practical application	-27%	-25%	+26%	+29%	+32%	+32%
7.Human relationship	+30%	+33%	+29%	+32%	+25%	+29%
8. Major foundation	-35%	-26%	+25%	-24%	+24%	+25%

Note: author's elaboration.

I compared the results of the two classes from 3 stages of the interview process and understood that different competencies could be developed with different methods of education. However, four competencies ("Interdisciplinary fusion", "Communication", "Challenging practice", and "Major foundation") are highly developed in the VR class, and the results changed from negative answers to positive answers during the survey. I suggest that VR application has a more positive effect on these competencies than other teaching tools and materials.

4 CONCLUSIONS

Through this research, I investigated the impact of different teaching methods on students' competency development; the effect of VR training in class was analysed. The CQI (Channel Quality Indication) report is an important element of the teaching process in Korean Universities. It has a significant impact on the Professor's teaching system performance because students complete class evaluations at the end of the semester. There are two types of CQI reports: periodic (for general classes) and aperiodic (for special cases, for example, short lectures). In our survey, I refer to the periodic CQI report. I still have an open question: are the results of the focus group interview correlated with the results of the CQI report at the end of the academic semester? This means that I should investigate the impact of competency development in the VR class on the results from the CQI report. In this case, I can achieve more specific results by using data from different trajectories of the survey (students' interviews; CQI report analysis; National Competency Standards).

The survey was based on a case study of Korea University of Technology and Education. The author used several research methods, namely, the expert method, focus group interview, and comparative study. The participants Ire 2nd- and 3rd-grade university students. The quantitative data Ire collected through the interview forms developed by the researchers; the qualitative data Ire analysed through the expert method and a comparative study. A significant difference was observed competency development in a VR class and a PBL class with a similar Syllabus. Moreover, it was noted that different teaching methods affect competency development in different ways, and VR tools develop some competencies, but not all of them.

The main results of this research are:

1 Different teaching methods have different effects on competency development in Management education;

2 Hypothesis 1, "The VR class improves and develops core competencies in a basic Management course better than in the PBL class", is not proved through this study.

3 Hypothesis 2, "The VR class does not improve or develop core competencies in a basic Management course better than in the PBL class", is not proved through this study.

4 Hypothesis 3, "The VR class improves and develops only a certain scope of competencies in a basic Management course", is proved through this study.

5 There is a more positive tendency to develop competencies in the VR class than in the PBL class;

Four competencies ("Interdisciplinary fusion", "Communication", "Challenging practice", and "Major foundation") Ire highly developed in the VR class, and the results changed from negative answers to positive answers during the semester, according to the survey. I suggest that VR application can affect these competencies more than other teaching tools and materials.

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