

A Metaverse Platform for Engineering Education: Case of South Korea

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Abstract - Recently, many countries are starting social distancing or lockdown measures in order to control the pandemic caused by COVID-19. At the same time, more and more attempts are made to solve the problem of engineering education break through the NFF education using teleconferencing platforms. However, in NFF education, there exists problems which have difficulty in recognizing nonverbal communication and giving feedback. Virtual Reality (VR) based NFF education has been presented to solve these problem, thus which has the various Metaverse platform (led to VR Class using). However, research for VR-based NFF education is insufficient. Therefore, in this paper, we propose a method for VR-based NFF education. For this purpose, a survey was conducted with students and teachers who took or conducted NFF education or VR-based NFF education in South Korea. Based on the survey results, we proposed the essential elements for VR-based NFF education and methods to achieve them.

Index Terms - Virtual Reality, Non-face-to-face (NFF) education, Face-to-face (FF) education, VR class, Metaverse

INTRODUCTION

Many countries are starting social distancing or lockdown in order to control the recent pandemic caused by COVID-19. The above-mentioned situation made typical face-to-face (FF) education has been disrupted, and thus non-face-to-face (NFF) education using various teleconferencing platforms have been increased to solve it. For example, according to a study analyzing traffic at Polytechnic University of Turin in Italy, more than 600 online lectures have been conducted every day after the COVID-19 Pandemics, and external traffic has increased by 2.5 times [1]. Peking University in China offered a total of 2,613 undergraduate online courses and 1,824 graduate online courses [2]. In addition, a study of students aged 18 or older around the world found that 80.7% of 30,383 subjects said they experienced cancellation of FF courses and online courses instead [3].

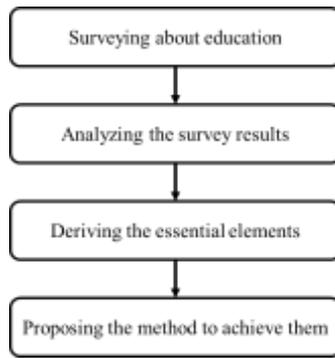
Also, Virtual Reality (VR) based NFF education has been presented to solve the NFF education's problem of reality and interaction, and this is currently most commonly used in the VR Class format using the Metaverse platform. For example, a study [4] conducted project of student leadership development during COVID-19 pandemics in Metaverse platform. Also, in the medical field, practice was conducted through virtual simulations, including clinical scenarios, for medical students or nurses [5-6].

As such, VR-based NFF education was conducted to replace practice classes that cannot be conducted due to COVID-19 pandemics. However, research for VR-based NFF education is insufficient. Therefore, in this paper, we propose a method for VR-based NFF engineering education. For this purpose, a survey was conducted with students and teachers who took or conducted NFF engineering education or VR-based NFF engineering education in South Korea. In addition, through the survey results, we proposed the essential elements for VR-based NFF engineering education and methods to achieve them.

METHOD

This section describes a method for deriving the essential elements for VR-based NFF education and methods to achieve them. A study was conducted with the procedure shown in Fig. 1. The total number of teacher survey was 27 (male: 22, female: 5), consisting of teachers or education officials.

FIG.1: RESEARCH PROCEDURE



The survey on teacher consisted as follows:

- Experience on NFF and VR-based NFF teaching
- Intentions to use VR-based NFF teaching in near future
- Problems when conducting NFF education or VR-based NFF education
- Requirements for VR-based NFF education

The total number of student survey was 100 (male: 59, female: 41), consisting of KOREATECH students in South Korea.

The survey on student consisted as follows:

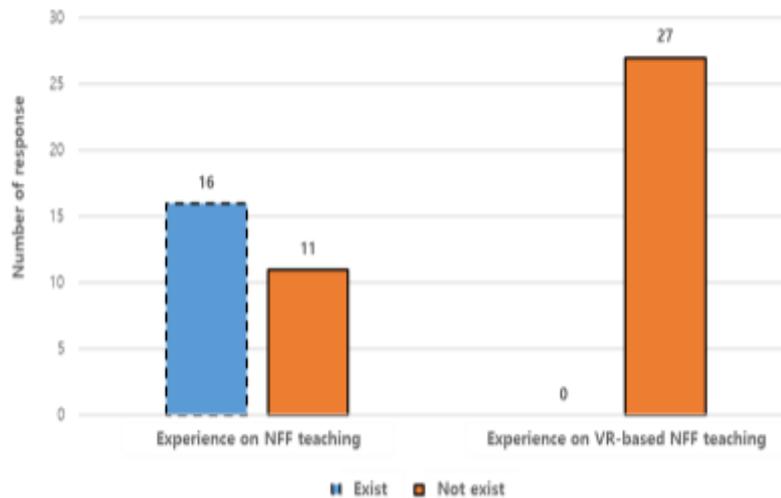
- Experience on NFF and VR-based NFF studying
- Intentions to use VR-based NFF studying in near future
- Problems when taking NFF education or VR-based NFF education
- Requirements for VR-based NFF education

RESULT

3.1 Analysis on teachers' survey

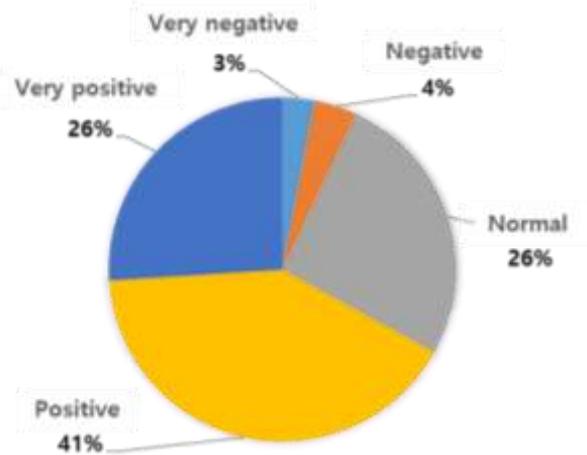
The results of the questions asking about experience on NFF and VR-based NFF teaching are shown in Fig. 2. More than half of teachers said they had experience in NFF education, and it was found that NFF education has become popular now. However, in the case of VR-based NFF education, it was found that there were no experiences. This showed that VR-based NFF education still needs more environment to be established as a general education method.

FIG.2: EXPERIENCE ON NFF AND VR-BASED NFF TEACHING



Also, the responses to the question asked about intentions to use VR-based NFF teaching in near future are shown in Fig. 3. Positive responses were 67% and negative responses were 7%, and they showed that teachers be willing to conduct VR-based NFF education in the future.

FIG.3: INTENTIONS TO USE VR-BASED NFF TEACHING IN NEAR FUTURE



The responses to the questions asked about problems when conducting NFF education or VR-based NFF education are shown in Table 1. At this time, there were no teachers who conducted VR-based NFF education, so there was no response. The main problems using NFF education included the difficulty of interaction, the absence of realism, and the difficulty of practice classes. In order for VR-based NFF education to widely used, the problems of NFF education mentioned in the above need to be solved. Finally, the responses to the requirements for VR-based NFF education are shown in Table 2. As a result, to conduct using VR-based NFF teaching, infrastructure, teacher's capability to control it, and convenience of VR environment must be supported. Also, VR-based NFF education environment should be established at an available level of cost.

TABLE 1. PROBLEMS WHEN CONDUCTING NFF EDUCATION OR VR-BASED NFF EDUCATION

Type	Problems
NFF teaching	<ul style="list-style-type: none"> · Difficulty of communicating · Difficulty of answering in detailed manner · Difficulty of identifying the status of student
VR-based NFF teaching	-

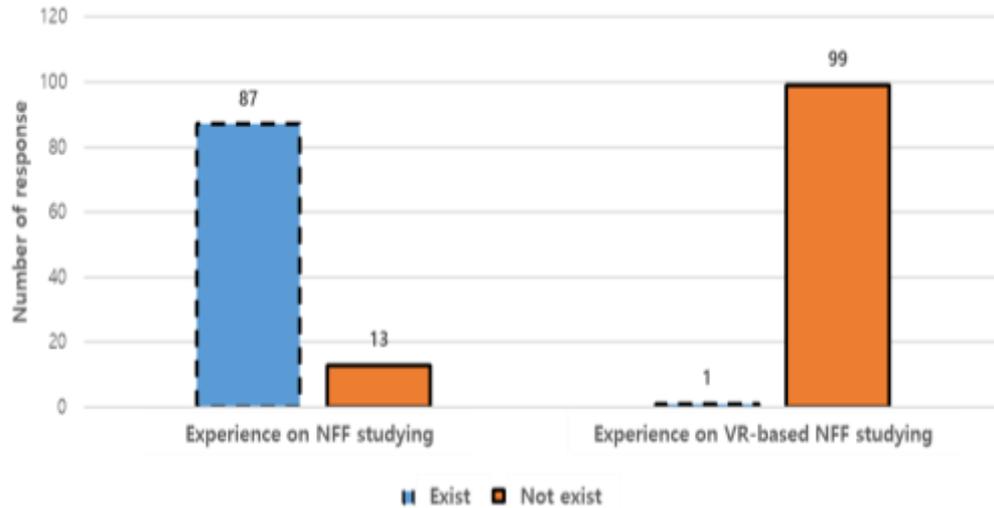
TABLE 2. REQUIREMENTS FOR VR-BASED NFF TEACHING

Requirements
<ul style="list-style-type: none"> · Student-centered education · Small amount of teaching · Infrastructure establishing (ex. safety and communication device) · Teacher's capability · Feedback · Reasonable cost · Conducting extra practice education · Improvement on VR environment manipulation · Improvement on fatigue for students and teachers

3.2 Analysis on students' survey

The results of the questions asking about experience on NFF and VR-based NFF studying are shown in Fig. 4. 87% of students said they had taken NFF education, but 99% of students said they had no experience in taking VR-based NFF education. This also showed that VR-based NFF education has very low accessibility for students.

FIG 4: EXPERIENCE ON NFF AND VR-BASED NFF STUDYING



Also, the responses to the question asked about intentions to use VR-based NFF studying in near future are shown in Fig. 5. Unlike teachers, negative responses (55%) were higher than positive responses (45%). However, additional surveys of whether they were willing to study using VR-based NFF, if the disadvantages of NFF were solved, showed that only 34% responded negatively (Fig. 6). Therefore, if disadvantages of VR-based NFF were solved, VR-based NFF can become widely used

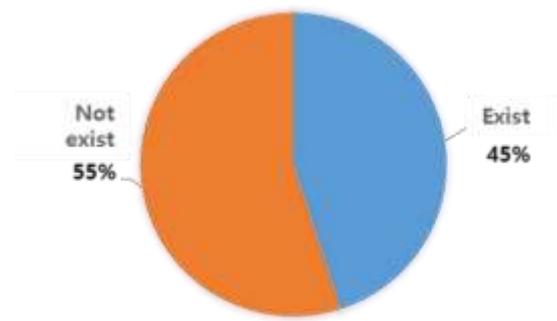


FIG 5: INTENTIONS TO USE VR-BASED NFF STUDYING IN NEAR FUTURE

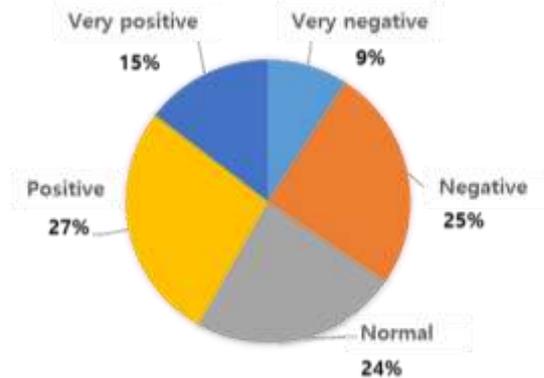


FIG 6: INTENTION TO USE VR-BASED NFF STUDYING AFTER NFF'S DISADVANTAGES ARE SOLVED

Also, the problems when taking NFF or VR-based NFF education, and requirements for VR-based NFF education are as shown in Table 3 and Table 4, respectively. Similar to the teachers' survey, there was a response that infrastructure, convenience and accessibility of the VR environment must be supported. In addition, many students said that there should be a necessity of conducting education with VR, and it seemed that education content should fully utilize the advantages of VR.

TABLE 3. PROBLEMS WHEN TAKING NFF EDUCATION OR VR-BASED NFF EDUCATION

Type	Problems
NFF studying	<ul style="list-style-type: none"> · Concentration decline due to large amount of education · Difficulty of interaction · Difficulty of feedback · Decline on sense of presence · Concentration decline · Limited practice due to lack of hands-on practice experience · Difficulty of feedback in practice · Difficulty of team activities
VR-based NFF studying	<ul style="list-style-type: none"> · Low quality of education than FF education due to concentration decline

TABLE 4. REQUIREMENTS FOR VR-BASED NFF STUDYING

Requirements
· High realistic and immersive content
· High quality content
· High readability content
· Manipulation convenience
· Low fatigue
· Device environment that can fully utilize VR
· No system errors
· High accessibility
· Convenient interaction
· Quarantined safety
· Necessity of conducting education with VR
· VR writing accessible in real world

3.3 Essential elements for effective education

In this section, we derived the essential elements for VR-based NFF education through the result of survey in section 3.1 ~ 3.2. Also, VR/AR safety guidelines [7] were referred to minimize safety issues in VR environments where education is conducted. To draw the essential elements for VR-based NFF education, followings are considered:

- Problems when conducting/taking NFF education or VR-based NFF education
- Requirements for VR-based NFF education
- VR/AR safety guidelines

As shown in Table 5, a total of seven essential elements for VR-based NFF education were derived from above the three items. Finally, we proposed the methods to achieve the essential elements as shown in Table 6.

TABLE 5. ESSENTIAL ELEMENTS FOR VR-BASED NFF EDUCATION

	Essential elements	Main Consideration	Detailed contents
1	Effective/realistic interaction	Difficulty of interaction between students and teachers	①
2	Effective feedback	Absence of real-time or detailed feedback	
3	High immersion	Lack of presence	
		Concentration decline	
4	Realistic practice	Difficulty of practice lack of hands-on environment	
5	Student-centered education	Need for student-centered education	
6	Selectable environments based on infrastructure and cost	Infrastructure establishing	
		Reasonable cost	
7	Education time under 30 minutes	Requiring at least 10 minute of rest after 30 minutes of VR content	③
		Concentration decline due to large amount of education	①

TABLE 6. METHODS TO ACHIEVE THE ESSENTIAL ELEMENTS

	Essential elements	How to achieve
1	Effective/realistic Interaction	<ul style="list-style-type: none"> · Using various I/O tools between contents and students · Identifying student's concentration using eye-tracking tools · Checking the education progress in real-time by motion information and education videos of students
2	Effective feedback	<ul style="list-style-type: none"> · Using tactile/physical feedback methods · Feedback in detailed manner through motion information and education videos of students · Sharing results and mutual feedback among students using memo function in the education timeline
3	High immersion	<ul style="list-style-type: none"> · Using the story in VR content and the role of students · Education contents experience using VR content

4	Realistic practice	<ul style="list-style-type: none"> · Using VR contents that are implemented like the real world · Practice through virtual equipment and virtual object manipulation · Practice with an actual working step
5	Student-centered education	<ul style="list-style-type: none"> · Procedure for student's VR adaptation process · VR content experience for theoretical knowledge acquisition · VR content experience for practical knowledge acquisition
6	Selectable environments based on infrastructure and cost	<ul style="list-style-type: none"> · Using applicable VR contents in various environments · Pre-check the student's environment when instructional design
7	Education time under 30 minutes	<ul style="list-style-type: none"> · Reducing education time through pre- education

CONCLUSIONS

Many countries are starting social distancing or lockdown in order to control the recent pandemic caused by COVID-19. To solve the problem of engineering education disruption cause by social distancing or lockdown, VR-based NFF engineering education using metaverse platform is being conducted. However, research for VR-based NFF education is insufficient. Therefore, in this paper, we proposed the essential elements for VR-based NFF education and methods to achieve them. To this end, we conducted survey on NFF education and VR-based NFF education for teachers and students in South Korea. Based on the results of this survey, we derived seven essential elements for VR-based NFF engineering education (Table 5): 1) Effective/realistic Interaction, 2) Effective feedback, 3) High immersion, 4) Realistic practice education, 5) Student-centered education, 6) Selectable environments based on infrastructure and cost, 7) Education time under 30 minutes.

Also, as shown in Table 6, we proposed the methods to achieving each the essential elements. It is expected that engineering education could be more effective if the essential elements and methods obtained from this study are applied to VR-based NFF engineering education.

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