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A Comparative Study on Learner Characteristics and Curricular Differences in Virtual Reality Education

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School teachers are actively carrying out Research on the application of realistic content. Virtual reality (VR) is one of the new tools in different school settings. Learners might have different grades of skills depending on their educational background: elementary, secondary, and university (prep teacher). Therefore, it is necessary to provide a VR curriculum suitable for each school level. For each school level, different curricular programs were created on how to produce VR. Education using them was conducted for 18 student teachers in college, 32 elementary school students (6th grade), and 5 middle school students (7th grade). The results of each school-level VR curriculum program were statistically analysed using questionnaires and follow-up interviews. For all school level learners, elementary school students tried to create topics they were interested in. Middle school students created content based on the topics related to learning and studying. Prep teachers preferred the topics related to field education and suggested the need for an additional training program on VR. In particular, most learners found it difficult to use Blockly, a coding domain. We hope that research in curricular programs regarding realistic content for different school levels, such as augmented reality (AR) and holograms (which are related fields of VR), will be studied in the future.

Key words: *VR production, VR coding, VR education, Cospaces, Blockly, SW education.*

Introduction

If IT-based programs are expected to be activated further in the future, how can VR-centred, realistic learning materials be created for learners in different school levels? We know that the content used by students becomes impactful when it is suitable to a learner's level (Sung and Jeong, 2019). It is necessary to build a curriculum for learning VR technology so that students can design and create content on their own (Thorsteinsson, 2013).

This study presents the VR curriculum for elementary school students, middle school students, and prep teachers to develop appropriate curricula for each school level. The purpose of this study is to provide systematic VR curricula by making comparative analyses of the characteristics of the learners from each school level.

Virtual Reality Adaptive Learning and Training

By definition, VR means a reality that does not exist but looks realistic on its surface (Plowman, 2019; Linowes and Schoen, 2016). Specifically, it refers to user interface technologies in which special devices involving human senses create the experience of realistic virtual spaces through software programs. Simply put, it is a world that is not reality.

Virtual Reality and Learning Effects

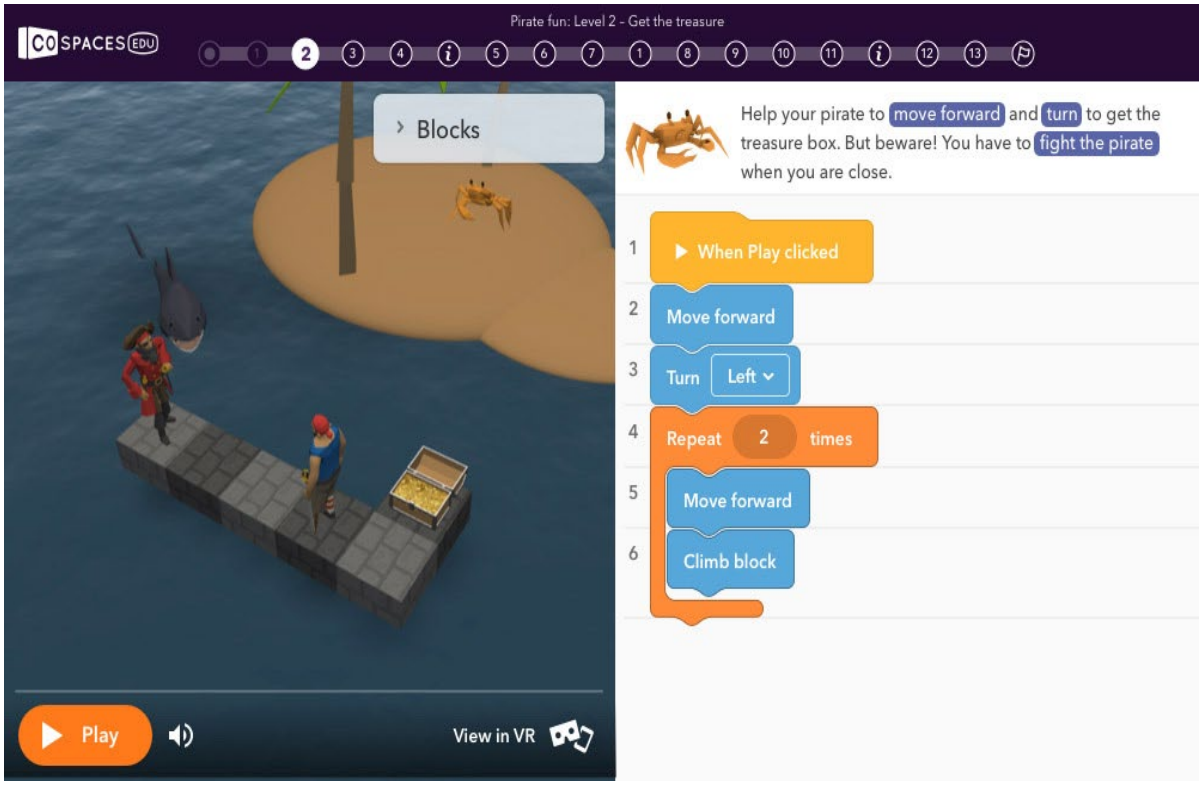
The ‘essential theory of learning’ was created by Edgar Dale, an American educator, who developed the ‘Cone of Experience’, also named the Learning Pyramid. Effective learning may be defined as 'active learning' (Charles et al., 2013). In other words, while people generally remember only 30% of what they read or listen, they generally remember 50% of what they see and hear through digital media and 90% of what they do, i.e. what they simulate, model, or experience in a lesson. If VR technology is applied appropriately in education, the ultimate goal of education could be maximised (Merchant et al., 2014).

Cospaces and Blockly

Cospaces is a web-based platform that makes it easy for users to create VR content. It also enables users to create 3D spaces using an internet connection. The current MAKER version is available free of charge and allows the creation of VR content with decent quality. Furthermore, its easy access allows users to create simple VR content by offering brief training sessions in which beginners or even elementary school students can learn. It also provides block coding for more advanced functions and can be used as an authoring tool for advanced computational thinking (Blockly coding, 2020).

Visual coding is also possible by utilising Blockly, which is a collection of libraries that converts blocks provided by Google in Cospaces into a user-defined source code (Figure 1). In Cospaces, Blockly can be used to create objects in virtual reality to respond to specific conditions or commands (Athawale et al., 2018).

Figure 1: Blockly in Cospaces



VR Curriculum for Each School Level

Research Subjects and Curricular Programs

The subjects of this study were thirty-two 6th graders, five 7th graders and eighteen student teachers in a teacher's college (Table 1). A VR authoring tool, Cospaces and its equipment, and Samsung Gear 360 (SM R-210) were utilised for this study to use a VR content creating program.

Table 1: The Education Status

Learner	period
Elementary school (6th grade)	2017.9. ~ 2017.12. 13 weeks
Male: 16, Female: 16	
Middle school (7th grade)	2017.5. ~ 2017.9. 9 times
Male: 4, Female: 1	
College (pre-service elementary teachers)	2018.3. ~ 2018. 6. 15 weeks
Male: 9, Female: 9	

Table 2 below shows the plans for each topic of the curriculum designed for a VR creating program (for elementary school students, middle school students, and pre-service teachers).

Table 2: Courseware Subjects by School Level in VR

Elementary school	**Middle school**	**College**
Subject 1: What is VR?		
Understanding the concept of VR: · VR that we know. · What do you want to make in VR? · Classification of reality, AR, and VR.	Know the technologies related to VR: · Cospaces preferences. · Features of Cospaces Foundation.	VR and VR Education: · Type of VR. · Using VR. · VR and IT.
Subject 2: Ready for VR		
Experience VR in a variety of environments: · VR experience with cardboard. · Experience 360 images. · Experience Gear 360. · Experience Google. Experience Creating my HMD: · What is the Google Cardboard? · Customise your own HMD. · Making my HMD. · Experience VR with my HMD.	Practice Cospaces: · Dealing with objects and figures. · Coding Cospaces (Blockly). Research design: · Preparing to create VR content. · Topic for VR content. · Making my HMD. · Experience VR with my HMD.	Coding Cospaces: · Features of Cospaces. · Join Cospaces. · Cospaces and curriculum. · Create and search objects. Explore Cospaces: · Knowing Cospaces configurations. · Dealing with gallery and my spaces. · Check the Cospaces menu. · Insert external image.

Subject 3: Create & Share VR Content			
	Dealing with preferences and spaces (object handling): · Adjusting size and position. · Connecting, copying, and deleting objects. · Utilising colour and opacity. Learning block coding: · Playing with Google Blockly. · Activate and move items. · Repeatedly moving. · Using functions. · Indication by information version. Dealing with scenes: · Adding, deleting, and naming scenes. · Using my VR with HMD. · Camera crashes and camera moves. Preparing my VR: · Organising functions for each scene. · Creating a story in VR. Creating VR exhibition works: · About topics to be covered in my VR. Participate in VR exhibitions.	Make VR content: · Creating VR content. · Modifying VR content. · Preparing for VR festival work entry. Announcement of VR content: · Present your work and exhibit it to the public. · Confirmation of missed activities. · Sharing my opinions. · Finalise my VR content production activities.	Practice Cospaces: · Control object attributes. · Using 360 camera, 360 images. · Insert images and music. · Add scenes and using the camera. Handling Blockly: · Move objects with Blockly. · Control scene with Blockly. Make VR content: · Erase and display objects. · Announcement of excellent work and sharing your opinions. · Make VR content for elementary school. · Make my VR content (focus on safety education). Announcement of VR content: · Discussion and sharing your content. · Modify my VR based on a friend's opinions.

In the case of elementary school curriculum, such subjects as social studies, art, and Korean language are relevant to ICT. The lack of regular class time is known as one of the most urgent problems in IT subjects in Korea. Elementary curriculum needs to supplement 'creative experience activities' to offer better IT classes to elementary students. They could add such activities as decorating HMD, exhibiting VR, and sharing their opinions.

In the case of secondary school curriculum, five students from middle school (i.e. the gifted group in IT) had an extra class in which they could focus on the advanced features of virtual reality content production (controlled by block coding). They could learn about the properties

of objects and figures of Cospaces more closely and in more detail than the elementary school group.

As for college level curriculum, lessons for pre-service teachers were designed on a weekly basis. Virtual reality content output was produced in terms of educational topics. It was also possible to have time for learning tools, for example, dealing with a 360-degree digital camera and using video taken on the spot in class. In addition, the existing content of virtual reality was analysed in order to develop something useful for elementary school students in the future. Their output products were tested, and feedback was necessary for improvement.

VR Output Comparison and Implications for Each School Level:

VR Education for Elementary School Students

A survey on the learning effect of VR education in elementary school students was conducted in the categories of knowledge, attitude, and practice area (Table 3).

Table 3: A Questionnaire of Elementary School Students' Cospaces

Knowledge Area
K1. You can use virtual reality to provide information. K2. Virtual reality is used only for certain studies. K3. Virtual reality shows content only to me. K4. When virtual reality is generalised, reality is not fun. K5. Virtual reality equipment has only the equipment worn on the head.
Attitude Area
A1. It is better to play with virtual reality than to meet friends. A2. I am worried that I am addicted to virtual reality. A3. Virtual reality can help with learning. A4. I want to provide my friends with information to develop virtual reality content. A5. I want to use virtual reality often.
Practice Area
P1. If you need to stop virtual reality, you can stop using it. P2. Do not use virtual reality when you are with family or friends. P3. I am using virtual reality to study. P4. I used virtual reality for classes and performances. P5. It has become customary to spend a lot of time using virtual reality.

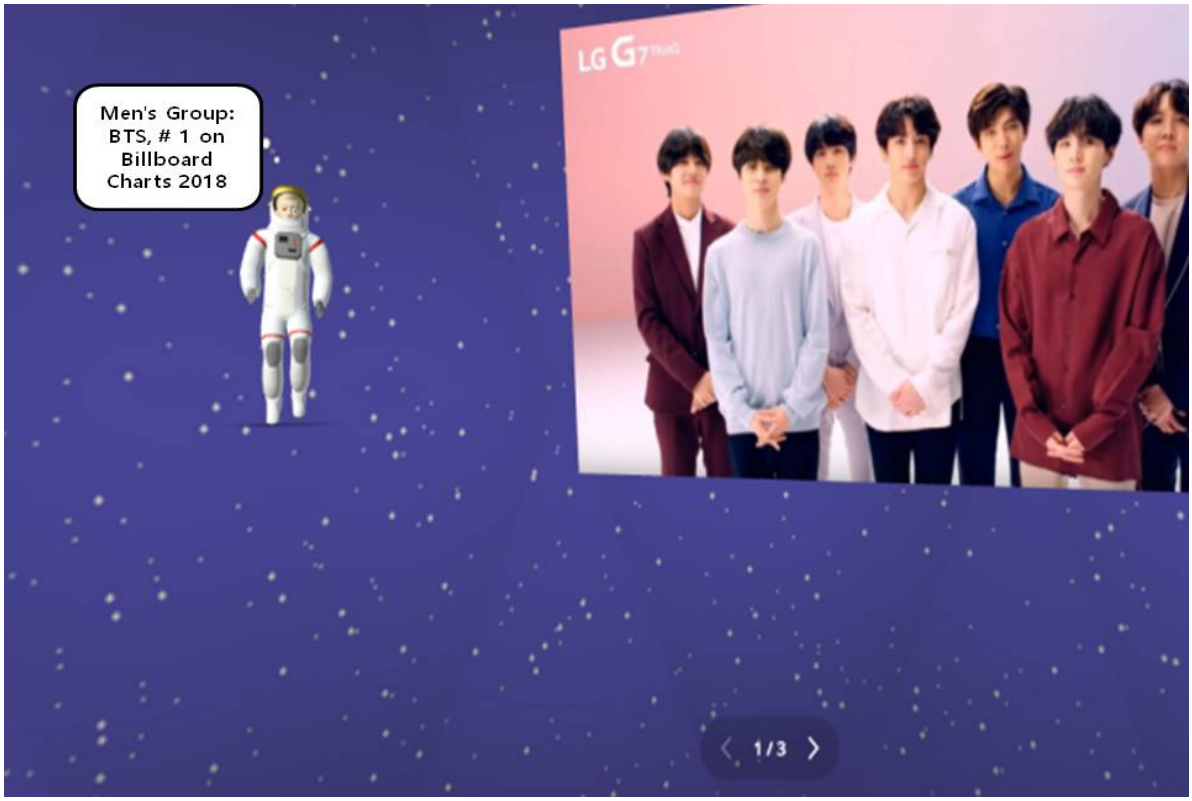
For the changes before and after the experimental program, they answered a question: 'If you have any VR equipment at home, for what purpose are you using it?'. The items 'for

educational content' and 'watching 360-degree videos' increased. On the other hand, the item 'for playing games' and 'watching 360-degree photographs' decreased. Furthermore, for the question 'what is the reason for using VR equipment?', the answer 'for curiosity' showed a decrease, and the answer 'for studying' showed an increase (Nam and Kim, 2018).

The longer elementary school students created virtual reality content, the more concentrated and focusing they were on the work. In addition, they boasted about the content they made to their friends around them, or they made corrections while receiving feedback from fellow students. Thanks to the experience of creating virtual reality content, they were able to observe active communication generation among their friends as the project was being completed.

The characteristics of VR content created by elementary school students are mainly related to their interests, such as introducing their favourite characters and celebrities. The main function of Cospaces used by them included making speech bubbles, loading images and inserting objects. The main functions used in Blockly coding were simple, such as activating buttons, switching scenes, and changing properties (sizes, etc.), as seen in Figure 2.

Figure 2: BTS Introduction VR Made by Elementary School Students



VR Education for Middle School Students

A similar type of survey on the categories in Cospaces and Blockly coding was conducted by some middle school students (gifted students). They experienced some VR education in elementary school days, but they needed to learn and improve their present skills in using the functions of Cospaces (Nam and Kim, 2018). Students who were not highly motivated to communicate or collaborate with their friends were encouraged to. The results of individual observations of 5 students are shown in Table 4.

Table 4: The Questionnaire & Answers of Middle School Students' Cospaces

Q1. What was the most difficult feature in Cospaces?
#1: I was sorry that I could not use various objects in the free version, and the camera movement was inconvenient.
#2: The point of view was inconvenient when producing the work, which made it difficult to do fine work. Above all, the workspace seems small.
#3: Create object.
#4: Adjust screen.
#5: In the free version, there were not many objects available.
Q2. What did you like about using Cospaces?
#1: Cospaces has the advantage that anyone can easily make VR and check the modified content linked with a mobile phone.
#2: It is easy and simple to use with a little learning.
#3: Easy.
#4: Beginners can easily create virtual reality.
#5: You can create various viewpoints by using the camera function.
Q3. Did you find it hard to code using Blockly?
#1: When dealing with flat figures or photographs, it was difficult to attach them completely to the object wall.
#2: It was hard to code in a different way because there was no block of functionality that would make it appear invisible in Cospaces.
#3: Naturalising movement.
#4: There was nothing difficult.
#5: Create variables.

The VR curriculum is more familiar to middle school students, most of whom are computer users, (more so than elementary school students). Therefore, the curriculum that was made related to topics of learning. Three students created historical, event-related content and one student created school violence prevention content. The students replied that they wanted to imagine and construct historical events through content that cannot be otherwise visualised. The other student also answered that the intention of creating such content was to make

content related to school violence prevention indirectly so that friends could experience it realistically.

Middle school students were unconvinced that the program called Cospaces is free. They were very curious to see that the changes they made in Cospaces were immediately visible on mobile devices. Since they were familiar with coding by using Blockly, they answered that it was not difficult to give commands with Cospaces. Regarding the strengths of Cospaces, they said 'various viewpoints can be created by using a camera'. Regarding the weaknesses of Cospaces, they complained, 'there are not many objects, and it is hard to do fine work due to inconvenient viewpoints.'

Commonly used Cospaces functions by middle school students include using library objects, entering texts, changing backgrounds, inserting 360-degree images, changing object properties, showing an information window, and grouping objects. Applied Blockly coding showed the completion of content using various functions, such as scene changes, object rotation, information-board display functions, and path following (Figure 3).

Figure 3: History VR Created by Middle School Students

VR Training for Pre-Service Teachers (College Students of the Teaching Profession)

The curriculum for college students studying to be preparatory teachers for elementary school teachers was carried out over 15 weeks in regular classes. Before and after the training of the experimental group, Keller's ARCS model was used to compare the influence of motivation on learners (Table 5).

Table 5: The Questionnaire of Pre-Service Teachers' Cospaces

Attention Area
A1. Is Cospaces technology amazing? A2. Would you like to talk more about Cospaces in your topic? A3. Was the virtual reality provided in the class interesting and varied?
Relevance Area
R1. Do you think the VR features you learned in class will help in the future? R2. Did you think you need the VR features you learned in class? R3. Would you like to use the course face function for VR production?
Confidence Area
C1. Do you think it is easy to learn by starting the easy task and learning the features of Cospaces? C2. Do you think you need to create your own virtual reality after learning the features of Cospaces? C3. Do you think you can use Cospaces to create and to control virtual reality content?
Satisfaction Area
S1. Creating virtual reality content using the Cospaces features learned in class is a daunting task. S2. If you create virtual reality content using Cospaces, you will hear compliments from friends and teachers. S3. It would be helpful if you used Cospaces space as an educational and learning resource for the elementary curriculum.

For the level of satisfaction from learning, 70% of them showed positive opinions in response to the question ‘Do you want further education training about virtual reality?’ The scores of attention, relationship, confidence, and satisfaction showed 80% in the Likert 5-point evaluation of learners’ opinions on VR training, which implies a high achievement level (Kim, 2017).

Moreover, in the analysis before and after the experiment on the general tendency of prep teachers, many 'science' courses were selected as the most suitable subjects for VR education.

50% of them also expressed that there are difficulties for students when they feel ‘more time is required' for creating VR content. As a special feature of VR subjects involving the prep teachers, the study created safety education content for each means of transportation with the educational theme of traffic safety suitable at schools. Elementary school-level animation characters were generally used, and a story was inserted to create intriguing questions and rewards for students by adding game elements (Nam and Kim, 2018).

The functions commonly used by the college students (prep teachers) included adding a speech bubble, inserting an object, displaying an information window, adding an image and description to the information window, changing object properties, inserting an image, and inserting music. Applied Blockly coding includes moving objects, showing or hiding objects, switching to the next scene, triggering an event when touched, playing simultaneously, and activating an object. Furthermore, 2015’s revised Korean curriculum for applying the existing virtual reality content to the field education for creating useful virtual reality content in elementary education was presented. It showed interests in analysing strengths and weaknesses in the education of VR content as well.

Pre-service teachers produced content materials for safety education in terms of different types of transportation based on the topics of traffic safety (Figure 4). Again, they included animation characters that elementary school students liked very much, and utilised a story with game elements to reward them. Moreover, they delivered additional information about safety-critical systems emphasised by the information display function.

Figure 4: KTX Safety Education VR Game Made by Pre-Service Elementary Teacher

Conclusion

This study compared and analysed the effects of curricular programs using virtual reality content creation adjusted for different school level learners. For elementary school students, middle school students, and college students, the virtual reality authoring tool Cospaces and the equipment, Samsung Gear 360 camera, were used for the study.

Depending on the school level, there were clear differences in concentration time in the created output, the subject of the content, and the time spent on creating the objects. Elementary school students tried to create a topic related to them (a topic of interest). Middle school students were interested in how useful the technology would be for learning and for friends. Prep teachers (college students) first prioritised the practicality of the technology for elementary school students. College students spent the most time creating content, followed by middle school and elementary school students.

All learners were highly interested in the VR content-creating program and answered that it is practical and useful. However, the majority of them found coding with Blockly very challenging. Learners felt that the distribution of VR content to the existing creators in our society increased their curiosity about VR technology. They were highly motivated to go for and create various forms of content. However, they were negative regarding the learning effect of VR technology.

Therefore, we have proposed different VR curricular programs, including appropriate subjects for each school level (from elementary school to university). Furthermore, more research on various forms of realistic content, such as AR and holograms (as well as VR), should be included in curricula for learners of different school levels.

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