A STUDY ON THE EDUCATIONAL EFFECT OF MIXED REALITY IMPLEMENTATION EXPERIENCES: FOCUSED ON THE PROGRAMMING TASK VALUE OF ELEMENTARY SCHOOL STUDENTS

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ABSTRACT

Mixed Reality (MR) is one of promising technologies in the 4th industrial revolution era. The purpose of this study is to let elementary school students experience directly programming of MR implementation and to examine how educationally the task value of programming is effective. To achieve that, 100 elementary school students were divided into an experimental group (50 students) and a control group (50 students), and a preliminary questionnaire survey as pre-test was conducted for homogeneity test. With the same theme, MR implementation programming class was applied to the experimental group and general programming class was applied to the control group, ten times. After the experimental application, the two groups had post-test with the same questionnaire used in pre-test. To find the difference between the two groups, data were analyzed at the significance level of .05. As a result, the experimental group recognized the value of programming tasks more highly than the control group (t=2.009, P=.048). According to the analysis on the change in the programming task value between the groups depending on a class type, the control group recognized the programming task value in the same level as in the one before the class (t=1.446, p=.525), whereas the experimental group more recognized it than before the class (t=-2.327, p=.024).

Keywords: *Mixed Reality, Task Value, Programming Education, Scratch, Webcam*

1. INTRODUCTION

Garter, a global IT research enterprise, selected Virtual Reality (VR) and Augmented Reality (AR) as one of the Top 10 Strategic Technology Trends for 2017. According to the company, VR and AR is the technology to establish an advanced immersive virtual world in combination of various technologies, such as multiple mobile, wearable, and Internet of Things(IoT) [1]. Mixed Reality (MR), the theme of this study, includes the concept of AR and VR and comprehensively means the technology of mixing reality and virtuality. Today, global IT enterprises, such as Microsoft, Alphabet, and Facebook, research the MR. Its market scale continues to grow in the times of the 4th industrial revolution.

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In this study, elementary school students as the main character of the future society are asked to implement MR, and how this experience was effective educationally is examined. This is one of trials in the recent trend that computer science related course tries to be applied to public education in the world.

2. RELATED WORKS

2.1 Mixed Reality

MR as the technology of mixing reality and virtuality was first used by Milgram and Koshino(1994). MR can be classified into Augmented Reality (AR), Augmented Virtuality (AV), Virtual Reality(VR), and Virtual Environment(VE) depending on a level of mixture

of real world and virtual image. This classification is presented in figure 1 [2].
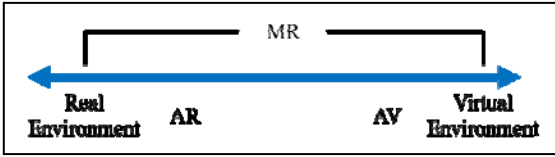

Figure 1: Virtuality Continuum(VC)[2]

As one of the classified types of MR, AR means all cases of augmenting a real world into a virtual image[2]. AV, which is closer to VE in terms of continuity, means that information of real world is added to a virtual image. In VR, a user is completely immersed in a virtual environment so that it is impossible to see real surroundings [3]. Of the three types, AR and VR are most widely used. Table 1 shows the comparison of the two types. Given all, AR means the environment where new information is added in a virtual space. VR means the indirect experience of a new circumstance with the background of totally different time and space in the condition where a real world is never visible..

Table 1: Comparison between Augmented Reality and Virtual Reality.

	Augmented Reality	Virtual Reality
Form	Reality + Virtuality	Virtuality
Relation with reality	-Augmented reality -Based on reality	-Replaced reality -A variety of indirect situational experience beyond time and space
Immersion	Relatively low	High
Device	Diverse sizes	A device enable to hide the whole sight, like HMD(head mounted display), is needed.

No. of available users	Concurrent use of multiple persons	Use by one

The interaction and immersion of MR enables a user to experience something which is hard to be experienced. Thanks to the feature, MR is widely applied to various areas, including military, medical service, game, advertising, broadcasting, and performance.

In the education area, MR is recognized to have a high value in terms of application. According to Suh, Kim, Lee, and Lee(2007), the educational effects of MR are to promote the activity of obtaining a complicated concept and taking research activity through 3D virtual simulation connected with a real environment, to understand a phenomenon and facilitate immersion through the high presence of virtual contents, to improve learners' interaction through a tangible interface, and to enhance learners' control of learning contents[4].

Shelton(2003) researched AR based learning in a constructive approach. According to the researcher, AR based learning triggers a learner's active operating activity which helps a leaner design knowledge on its own. In addition, AR based learning brings about such educational effects as stimulation of active learning, promotion of constructive learning, implementation of intentional learning, offering of actual learning, and facilitation of collaborative learning [5].

2.2 Scratch Programming for Mixed Reality Implementation

Scratch is an educational programming language (EPL) that uses block-type commands for programming. Compared to text-based programming languages, Scratch reduces cognitive load and induces interest in learners and, therefore, is popularly used in the education field. While many studies discussed the educational effects of using Scratch, few concerned Scratch programming for implementing MR.

When connected with webcam, Scratch can implement simple MR through which users can write a program that enables interaction between their movement in real world and a virtual object.

To create MR, Scratch 2.0 and webcam are required and, among Scratch commands, video-related blocks in 'Events' and 'Sensing' are used. These video blocks detect and convert movements in the images received via webcam into values on a scale of 0 to 100, which are then used by the users for programming.

Table 2 describes video-related blocks in Scratch and their roles while figure 2 and figure 3 shows a sample project of Scratch programming implementing MR[6][7][8].
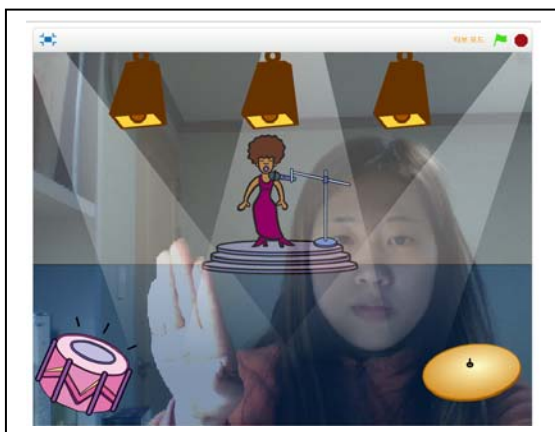

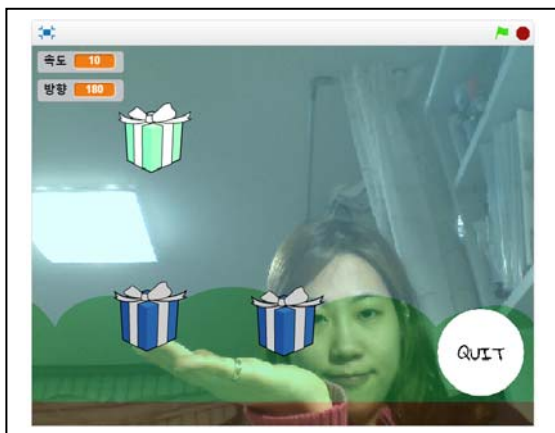*Figure 2: Scratch Project: Let's Make My Own Instrument[7]*

Figure 3: Scratch Project: Jumping on a Trampoline[8]

2.3 Task Value

The expectancy-value model explains the effects of cognitive elements that influence choices that are relevant to learners' achievement. Wigfield and Eccles(2000) argued achievement motivation of learners are determined by expectancy and value, with the former denoting expectation of success learners have and the latter subjective perception of value regarding a given task[9]. This value is represented by 'task value' and, according to the expectancy-value model, subjective task value influences achievement motivation. Figure 4 shows a diagram of the expectancy-value model.

Task value consists of attainment value, interest value, and utility value. First, attainment value(or importance) means the learner considers successful completion of the task to be important. Interest value(or intrinsic value) denotes the joy intrinsic to the task itself and that is, therefore, experienced while performing the task in question. By contrast, utility value is an extrinsic value that is related to the future goal that can be attained through the task[9][10]. In this study, the characteristics of elementary school students a study subjects were taken into account and two factors excluding attainment value were set as dependent variables.

This study looks into the value of programming tasks as the scale of the educational effects of MR implementation experience. The programming task value means a learner's subjective value for programming tasks. As of now, programming course is selected as a required one in many different countries. In order to keep such a mood and make possible 'sustainable programming education', learners should positively recognize the value of programming tasks. Sustainable programming education not only leads to raising IT talented persons effectively through specialized curriculum, but makes its position secured as a general and required course for all students.

As a related works, Song(2013) tried to structure the relationships among task value, academic burnout, learning satisfaction, and persistence in an e-learning course. As a result, task value had a negative impact on academic burnout, and positive impact on learning satisfaction and persistence[11]. And Bong(2001) separated task value into interest and usefulness, and tried to predict course performance and future enrollment intention. The findings were confirmed that there was a significant influence between each factors[12].

Johnson, Edwards, and Dai(2014) investigated changes in undergraduate students' task value and self-efficacy across an academic semester. As a result, task value and self-efficacy showed similar trajectories[13]. And Brown(2018) tried to find relationships between subjective task value and A-level achievement. In conclusion, there were positive associations between achievement and the attainment, intrinsic and utility value[14].

In research on programming, Burgin, Reilly and Traynor(2005) found that students who have high levels of intrinsic motivation and task value perform better in programming. In addition, they use more metacognitive and resource management strategies than low level students[15].

For another study, Yoon, Jang, Jeong, and Lee(2015) applied IT convergence learning to elementary gifted students and measured expectancy-value according to students' level. Consequently, advanced level students' expectancy-value score is higher than core level students' score[16].

3. METHOD

3.1 Research Hypothesis

This study tried to find how elementary school students' MR implementation experience influences their programming task value. Therefore, the study hypotheses were set up as follows:

RH1. Elementary students' experience of MR implementation programming will improve their value of programming tasks.

RH2. The group that experiences MR implementation programming will more highly recognize the programming task value than the group which has general programming experience.

3.2 Participants

In this study, 100 sixth-grade students of four classes at G Elementary School participated as subjects, and, according to their class, were divided into an experimental group and a control group. A pre-test was conducted for measuring task value of subjects, and the two groups were verified as being homogeneous. Table 3 shows subjects of the study

Table 3: Subjects of The Study

Group	Male	Female	Sum
Experimental Group	25	25	50
Control Group	26	24	50
Sum	51	49	100

3.3 Procedure

After the pre-test, the experimental group received 10 sessions of MR implementation Scratch programming class, and the control group 10 sessions of general Scratch programming class. The contents of the education were developed by using and modifying the program proposed by Kim and Lee (2017) according to the class settings[17]. Table 4 shows instructional design for the experiment.

Table 4: Classes Design

Session	Subject	Activities
1-2	First Meeting	Overview of the Scratch interface and the blocks Try simple operation of sprites
3-4	Today's Diary	Learn how to operate sprite and solve the simple problem Create and share students' own project
5-7	Run, Penguin	Demonstrate and overview the game Complete a partially finished game Reorganize and create students' own game
8-10	Catch the Mice	Demonstrate and overview the game Complete a partially finished game Reorganize and create students' own game

The classes were conducted twice per week for a total of five weeks. After the test, the same questionnaire used for the pre-test were used for conducting a post-test.

3.4 Measures

Items were taken from the programming task value scale[18] to assess students' task value regarding programming. It consists of a total of 13 questions, with 7 questions related to interest and 6 related to usefulness. The same questionnaire was used before and after the experiment. Participants indicated their response to each item on a 6 point scale ranging from 1(strongly disagree) to 6(strongly agree). The items of the questionnaire are shown in table 5.

Table 5: Programming Task Value Survey[19]

Factor	No.	Question
Interest value	1	I like programming.
	2	I am not interested in programming.
	3	Programming class is more interesting than other classes.
	4	I want to know more about programming.
	5	Solving a problem for programming is interesting.
	6	Programming is a pleasant theme to study.
	7	I want to learn programming more time.
Utility value	8	Programming is worthwhile.
	9	Knowledge about programming is not helpful to solve a problem that will occur in the future.
	10	Contents in programming class will be helpful to me.
	11	Learning programming is helpful in my everyday life.
	12	Compared to other kinds of knowledge (all of the things learnt in school and everyday life), programming knowledge is useful.
	13	It is possible to apply contents of programming to various areas.

4. RESULT AND ANALYSIS

4.1 Group Comparison
4.1.1   Pre-test

Pre-test was conducted in order to find homogenity between the control group and the experimental group. Data were collected in a questionnaire survey. Based on the data, independent sample t-test was conducted with the two groups. The result of the pre-test is presented in table 6.

According to the pre-test, the average task value of the control group was 58.04, and its standard deviation was 12.90. The average task value of the experimental group was 58.95, and its was 10.01. According to the independent sample t-test, the two groups has no statistically significant difference in the average value. Therefore, the two groups were found to be homegenous at the significant level of $.05(t=.378, p=.706, p>.05)$.

4.1.2   Post-test

After 10 sessions of programming class were provided to the experimental and control groups, a post-test was conducted by using the same questionnaire as the one used for the pre-test in this study. To verify homoscedasticity between the two groups, Levene's test was performed and the result showed that, with p= .027 in interest, p = .009 in utility, and p= .023 in overall task value, the null hypothesis that the two populations have the same variance was rejected (p < .05). Therefore, to compare the averages between the two groups, a Welch-Aspin test was conducted, and the result is shown in table 7.

According to the Welch-Aspin test result, the average interest was higher in the experimental group than in the control group; however, the difference, i.e., t= 1.765 and p= .081, was not statistically significant (p > .05). Considering previous research that suggests programming class based on Scratch has a positive effect on the interest in programming among learners[20], this finding may be due to the significant effect of the programming experiences applied to the control group on the interest of subjects. By contrast, utility, which is another sub-factor of task value, was significantly higher in the experimental group with t= 2.152 and p= .034 (p < .05). Also, the overall task value, which includes both interest and utility, was significantly higher in the experimental group, with t= 2.009 and p= .048 (p < .05).

In conclusion, the result of this study suggests, compared to programming experiences that is solely based on Scratch, MR implementation programming have more positive effects on task value.

4.2 Comparison of Pre-test and Post-test Results

After 10 sessions of programming class were provided to the subjects, a post-test was conducted by using the same questionnaire as the one used for the pre-test in this study.

To compare perception of programming task value before programming education and after it, a dependent sample t-test was conducted.

4.2.1   Control group

The pre-test and post-test results of the control group which had general programming learning experience were compared. The comparison is presented in table 8

According to the analysis on the pre-test and post-test of the assignment value in the control group, the average assignment value before test was 58.55, and that after test was 55.32. Therefore, the post-test value was a little lower than the pre-test value, but there was no statistically significant difference at $t = 1.446$ and $p = .155$ ($p > .05$). According to the analysis on sub categories, in the sub category of interest, its pre-test average value was 29.78, and its post-test average value was 29.04, and therefore, there was no statistically significant difference between pre-test and post-test values ($p > .05$). In the sub category of usability, its pre-test average value was 28.26, and its post-test average value was 26.28. The post-test value was lower than the pre-test value, and there was a statistically significant difference ($p < .05$).

Given the results, the study subjects had interest and overall task value in the same levels statistically before and after experiment. Therefore, their recognition at the beginning remained unchanged in a certain level. However, in case of utility, its value fell significantly. That was because the programming class in a beginning level fell short of their large expectation for programming usability which they had at the beginning.

4.2.2   Experimental group

Table 9 presents the comparison between pre-test and post-test results of the experimental group which experienced MR implementation programming.

The average interest, which is one of the sub-factors, was higher after the experiment, with a significant difference found in a paired sample t-test, with $t = -3.516$ and $p = .001$ ($p < .05$). In another sub-factor, utility, the average was slightly higher after the experiment compared to before the experiment. However, the difference was not statistically significant with $t = -.209$ and $p = .840$ ($p > .05$). This implies learners perceived the same level of utility value related to programming before and after the experiment.

Regarding the overall task value, the average was higher in the post-test than in the pre-test, with $t = -2.327$, $p = .024$, indicating a statistically significant difference ($p < .05$). In conclusion, MR implementation experiences had positive effects on improving task value in learners, especially on interest.

5.   CONCLUSION

This study found MR implementation experiences had positive effects on perception of programming task value among learners. With recently growing awareness of the need for software education, further research and effort are required in order to continue such awareness. In that regard, it is important to find a way to help teachers, students, and parents have positive perception of the task value of overall software education. Such continued awareness of the need for software education among participants of the education field will create the foundation for fostering members of society equipped with knowledge of information culture, which is essential in the age of the fourth industrial revolution.

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Table 2: Video-related Blocks of Scratch[6]

| Blocks	Field	Use
when video motion > 10	Events	Runs a script when the video motion if greater than a specified value.
video motion on this sprite	Sensing	Check the amount of motion over the entire video image.
video motion on Stage		Check the amount of motion in the video under the current sprite.
video direction on this sprite		Check the direction of motion in the video under the current sprite
video direction on Stage		Check the direction of motion in the video image.
turn video on		Turn the video camera on.
turn video off		Turn the video camera off.
set video transparency to 50 %		Set the video transparency from 0-100. Higher numbers make the video more transparent(lighter), while lower numbers make it less transparent(darker).
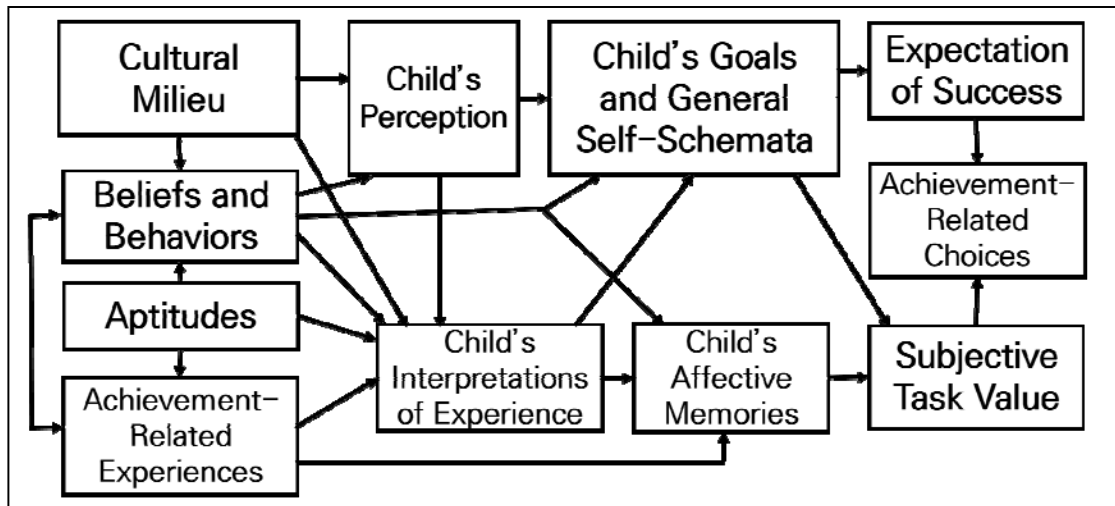
Figure 4: Diagram of the Expectancy-Value Model[9]

Table 6: Result of the Pre-test.

Factor	Group	N	Mean	SD	Levene's test		t	p (2-tailed)
					F	p		
Task value	Control	50	12.90	12.90	1.947	.166	.378	.706
	Experimental	50	10.81	10.81				
Interest	Control	50	29.78	8.39	2.368	.127	-.066	.948
	Experimental	50	29.68	6.70				
Utility	Control	50	28.26	2.13	.086	.770	.972	.333
	Experimental	50	29.26	5.15				

Table 7: Result of the Post-test.

Factor	Group	N	Mean	SD	Levene's test		t	p (2-tailed)
					F	p		
Task value	Control	50	55.32	18.66	5.304	.023	2.009	.048
	Experimental	50	61.66	12.23				
Interest	Control	50	29.04	10.52	5.043	.027	1.765	.081
	Experimental	50	32.28	7.60				
Utility	Control	50	28.26	5.13	7.044	.009	2.152	.034
	Experimental	50	29.26	5.15				

Table 8: Comparison between Pre-test and Post-test Results of Control Group

Factor	Test	N	Mean	SD	t	p (2-tailed)
Task value	Pre	50	58.04	12.90	1.446	.525
	Post	50	55.32	18.66		
Interest	Pre	50	29.78	8.39	.640	.027
	Post	50	29.04	10.52		
Utility	Pre	50	28.26	5.13	2.280	.155
	Post	50	26.28	8.64		

Table 9: Comparison between Pre-test and Post-test Results of Experimental Group

Factor	Test	N	Mean	SD	t	p (2-tailed)
Task value	Pre	50	58.94	10.81	-2.327	.024
	Post	50	61.66	12.23		
Interest	Pre	50	6.70	6.70	.001	.001
	Post	50	7.60	7.60		
Utility	Pre	50	5.15	5.15	-.209	.840
	Post	50	5.39	5.39		