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Development of a safety education program using simulator fire extinguishers in Korea: Focusing on elementary school students

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Abstract

Safety education aims to promote safe habits through experience-oriented education that combines knowledge, skills and attitudes. However, in situations where experience-oriented safety education is challenging, realistic content created through technological advancements can indirectly function as an excellent safety education tool that allows for individual safety experiences. This study conducted a safety education program for 34 elementary school students using the most commonly used realistic safety education content in Korea, the 'simulator fire extinguisher,' four times. Safety knowledge tests and safety problem-solving ability tests were used as measuring tools and statistical significance was verified through paired sample t-tests. This study demonstrated that the safety education program using the 'simulator fire extinguisher' was effective in improving safety knowledge and problem-solving abilities . The average score of elementary school students increased from 8.47 to 9.23 in safety knowledge tests and from 4.26 to 4.64 in safety problem-solving ability tests. These results were statistically significant ($p < 0.001$).

Keywords: Evacuation simulation, Evacuation time, Kids cafe, New publicly used establishments, Room-escape café.

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Contents

Contribution of this paper to the literature
Simulator-based fire extinguishers have emerged as a viable alternative to experiential safety education using real-life scenarios and have been widely adopted. However, the effectiveness of this approach has yet to be assessed. This study is significant to provide empirical evidence of the effectiveness of simulator-based fire extinguisher education.

1. Introduction

According to the standard framework for safety education in Korea, the safety education method presents experience-oriented education as its main method based on habit formation through repeated education of knowledge, skills and attitudes (Korea National Fire Agency, 2019) and emphasizes the importance of safety education (Yu & Lee, 2016). In spite of the importance of safety education, experience-oriented safety education is not properly conducted due to disasters that students cannot train for in the real world.

As a result, theoretical safety education based on multimedia materials such as videos is mostly used as an educational method in safety education in schools. Prior research on educational methods using content for safety education has not escaped from existing multimedia education such as video media safety education (Park, 2012) and audio-visual and website safety education (Park, 2012). Meanwhile, realistic contents such as virtual reality (VR), augmented reality (AR) and mixed reality (MR) that expand human senses based on the recent development of technology have been introduced and applied to Korean educational sites since 2014.

Safety education using realistic content is expected to be more important and useful than other fields. It expands the scope of education and the development of realistic content presents a new direction in safety education (Kim, 2019). In Korea, a simulation fire extinguisher is installed in a safety experience vehicle or safety experience center inside and outside of the school. In order to minimize the difficulty of storing and using CPR dolls, mixed reality CPR education (Johnson, Rodrigues, Gubbala, & Weibel, 2018) is being conducted.

Safety education using realistic content is becoming commonplace by replacing existing safety education. In addition, the existing realistic contents are mainly used as a one-time tool and a theory verification tool (Lee, 2020) and there is a need to apply them to students after producing a systematic program in that content deliberation or specific utilization plans and instructional methods have not been explored.

Therefore, this study designs a four-hour education program with realistic content based on the Korea fire agency's standard safety education frameworks and the procedures of safety education.

After that, we intend to apply the "simulator fire extinguisher" which is used in Korea among realistic contents in the field of safety education to 34 students in two elementary schools and measure its effectiveness.

The purpose of this study is to verify the effectiveness of safety education using simulator-type fire extinguishers for elementary school students in terms of safety knowledge and safety problem solving ability.

2. Research Design and Data Analysis

2.1. Research Design

This study analyzes the effect of a safety education program using a simulator fire extinguisher for elementary school students in Korea.

2.2. Research Subjects and Data Collection

This study conducted a pre-questionnaire survey in September 2021, offline for elementary school students of two elementary school classes in Gyeonggi-do.

After conducting a post-questionnaire survey in October, 2002, 34 copies were collected. The subject of this study is as follows:

14 students in the 5th grade are designated as 'experiment group A' and 20 students in the 6th grade are designated as 'experiment group B' and each group conducted safety education.

Table 1 presents the demographic and sociological characteristics of the study participants.

Table 1. Demographic and sociological characteristics of students.

Group	Grade	Gender	Students (N=34)
Experiment group A	5th grade	Boy	7
		Girl	7
Experiment group B	6th grade	Boy	9
		Girl	11

2.3. Hypothesis Setting

This study analyzes the effect of an education program using a simulator fire extinguisher on their safety knowledge and ability to solve safety problems. Based on this, hypotheses are established as follows:

Hypothesis 1: The education program will have a positive (+) effect on safety knowledge with safety education for elementary school students .

Hypothesis 2: The education program will have a positive (+) effect on the safety problem-solving ability of elementary school students.

2.4. Measuring Tool

This study aims to evaluate the degree of improvement in safety knowledge and problem-solving ability by conducting pre-and post-inspections on two groups of elementary school students. To investigate the effect of safety education programs using simulator fire extinguishers, safety knowledge tests and safety problem solving tests are selected as inspection tools.

The content of the inspection tool is carried out in the field of 'fire safety' widely used in Korea.

2.4.1. Safety Knowledge Test

The measuring tool for the safety knowledge test uses a total of 12 questions modified and supplementary to suit elementary school students based on the previous studies of Kwak (2000) and the fire survival self- diagnosis program for (Korea National Fire Agency, 2020).

The sub-factors of the fire safety knowledge measurement consisted of 12 items of safety knowledge in a 5-point Likert type (1 = 'not at all' to 5 = 'very much'). The test is conducted through a multiple-choice questionnaire. 1 point is awarded for each student response. 1 point for a correct answer and 0 points for an incorrect answer and it is assumed that the higher the score, the greater the educational effectiveness.

2.4.2. Safety Problem Solving Test

The safety problem-solving test is an accident testing tool that presents safety-related problems and evaluates the ability to solve them. There is a safety problem solving test tool that Kwak (2000) improved to fit the Korean curriculum. This tool was modified and supplemented with five items in consideration of the level and subject (fire safety) of elementary school students in this study. This test tool is conducted in a narrative format without a time limit and the responses are qualitatively analyzed and scored. Only responses related to safety problem solving are given 1 point. All other responses are given 0 points. Based on a total of 5 points, the higher the score, the better the safety problem-solving ability of elementary school students.

2.5. Analysis Method

The analysis of the data collected in this study was conducted in IBM SPSS version 26.0 (Statistical Package for Social Science).

The degree of change in safety knowledge and safety problem-solving ability using a simulator fire extinguisher was analyzed through 't-test'.

3. Development of an Education Program

3.1. Education Program Design

The educational program used in this study was based on the standard course of safety education of the Korea National Fire Agency (2019) and its procedure for safety education.

In the implementation stage of safety education, the instructional programs are as follows: It should be used to cultivate knowledge, skill and attitude.

Cognitive, behavioral and affective approaches must be integrated. A variety of instructional models should be used for each sector's approach.

The procedures for safety education are shown in Table 2.

Table 2. General process and procedures of safety education.

Sessions	Procedure description	Access to learning
1	Sharing experiences and recognizing learning topics	–
2	Safety behavior exploration	Cognitive approach
3	Safety behavior and practice	Behavioral approach
4	Reinforcing the will to practice safety and value or attitude	Affirmative approach

3.2. Teaching and Learning Goal

Table 3 shows the teaching and learning goals to be reached through the safety education program using a simulator fire extinguisher.

Table 3. Teaching and learning goals.

Overall goal	Understand fire safety commandments and solve problems in real life.
Knowledge	Can understand and explain fire safety commands and contents.
Skills	Can experience and solve fire-related problems by using a simulator.
Attitude	Can strengthen their will to practice fire safety and form safe habits in their lives.

4. Analysis of the Study

4.1. Results of the Application

According to the general processes and procedures of safety education, the purpose of this study is to analyze the effectiveness of safety education programs using realistic content. The safety knowledge test and the safety problem solving test are composed. Responses were described before and after application of the education program and the values were quantified. Table 4 presents statistical verification of the differences observed before and after the implementation of safety education.

Table 4. Comparison of scores (Paired t-test).

Category		Dependent variable			t(p)
		N	Mean (M)	Standard deviation	
Safety knowledge	Pre	34	8.47	3.95	3.8(0.000)***
	Post	34	9.23	2.79	
Safety problem solving ability	Pre	34	4.26	0.62	3.41(0.001)**
	Post	34	4.64	0.41	

Note: **p<.01, ***p<.001.

A paired-sample t-test was conducted based on the test responses of all students.

In the field of safety knowledge, the average score of 8.47 points before training increased by about 0.76 points from 9.23 points after training. t=-3.8, p=0.000 showed statistical significance based on the significance level of p<0.001.

Therefore, there is a difference in student safety knowledge scores before and after safety education using a simulator fire extinguisher.

In the field of safety problem-solving ability, an average of 0.38 points rose from an average of 4.26 points before education to an average of 4.64 points after education. t=-3.41, p=0.001, it was statistically significant based on the significance level of <0.01. Therefore, it can be seen that there is a difference in student safety problem-solving ability scores before and after safety education using realistic content. Based on the above results, it was found that safety education using a simulator fire extinguisher had a significant effect on the safety knowledge and problem-solving abilities of actual students.

4.2. Experiment Group Result (5th Grade)

Based on safety education knowledge and problem-solving tests, the effectiveness of individual experimental groups was analyzed. Table 5 shows the results of applying the safety education program to 14 students in grade 5.

The results of the 'paired-sample t-test' is to compare the difference in safety knowledge scores pre and post safety education are as follows: t=-2.28, p=0.04, it was statistically significant based on the significance level of <0.05. Therefore, it can be seen that there is a difference between the safety knowledge score before education and the safety knowledge score after education while the average score before education was 7.85, the score after education increased by about 0.86 points to 8.71 points. It is noted that safety education using a simulator had an effect on the safety knowledge of 5th grade students.

Table 5. Experiment groups a comparison of pre and post education.

5th grade (Group A)		**Dependent variable**			***t*(*p*)**
		N	**Mean (M)**	**Standard deviation**	
Safety knowledge	Pre	14	7.85	4.13	2.28(0.04)*
	Post	14	8.71	3.14	
Safety problem solving ability	Pre	14	4.14	0.74	2.28(0.04)*
	Post	14	4.42	0.72	

Note: *p<.05.

4.3. Experiment Group B Result (6th Grade)

Table 6 shows the results of applying the safety education program to 20 students in 6th grade. The results of the 'paired-sample t-test' conducted on 20 students in 6th grade are as follows: In the safety knowledge analysis, the significance level was <0.01(t=-3.19, p=0.004) . Therefore, it can be seen that there is a difference between the safety knowledge score before education and the safety knowledge score after education in 6th grade students. Therefore, it is stated that safety education had an effect on students' safety knowledge.

In the safety problem solving ability analysis, it was statistically significant based on the significance level of <0.05(t=-2.65, p=0.015). Therefore, it can be seen that there is a difference between the safety problem-solving ability score of the 6th grade before education and the safety problem-solving ability score after education. Safety education using a simulator fire extinguisher improves students' safety problem-solving abilities.

Table 6. Experiment group B comparison of pre and post education.

6th grade (Group B)		**Dependent variable**			***t*(*p*)**
		N	**Mean (M)**	**Standard deviation**	
Safety knowledge	Pre	20	8.9	3.56	3.19(0.004)**
	Post	20	9,6	2.35	
Safety problem solving ability	Pre	20	4.35	0.55	2.65(0.015)*
	Post	20	4.8	0.16	

Note: *p<.05, **p<.01.

5. Conclusion

Today, realistic content has emerged that expands the human five senses based on technology development. It is an excellent tool for safety education and helps in dangerous situations indirectly. However, despite this usefulness, empirical studies on the effectiveness of safety education using realistic content were insufficient. There was no research specifically aimed at elementary school students.

Therefore, in this study, 34 students from two classes of elementary school were exposed to 'simulation type fire extinguisher', the most commonly used realistic safety education content in Korea through four safety education sessions and their effectiveness was compared. A safety knowledge test and a safety problem-solving ability test were used as measurement tools and their statistical significance was verified through a corresponding sample t-test.

Safety education using a simulator fire extinguisher affects all students and increases their safety knowledge and problem solving ability. Investigating the effects of each experimental group, the fifth grade of P elementary school students increased by 0.86 points from 7.85 points before education to 8.71 points after education (t=-2.28 points, p=0.04) and 0.28 points after education in the field of safety problem solving. The sixth grade of N Elementary School students increased by 0.7 from 8.9 points before education to 9.6 points after education (t=-

3.19 points, p=0.004) and 0.45 points on average in the safety problem-solving area (t=-2.65 points, p=0.015). It can be seen that safety knowledge and problem-solving ability have a significant effect on both classes.

This study tried to demonstrate the effectiveness of safety education using realistic content(simulator fire extinguisher) for elementary school students but there is a limitation in the sample of this study only 34 students in 5th and 6th grade in elementary school.

Therefore, in the direction of future research, first, verification of the effectiveness of safety education using realistic content tailored to the life cycle. Second, it is necessary to devise a systematic safety education framework using realistic content to solve the problems of education using existing realistic content and improve the content and method suitability of safety education to achieve safe habitation through repeated education of knowledge, skill and attitude.

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