International Journal of Internet, Broadcasting and Communication Vol.13 No.4 154-168 (2021)
http://dx.doi.org/10.7236/IJIBC.2021.13.4.154

IJIBC 21-4-19

Development and Validation of an Instrument to Measure High School Students' Disaster Safety Awareness

Soon-Beom, Lee*, Ha-Sung, Kong**

**Teacher, 54073 Gunsan Jeil High School, 142 Gyeonggijang-ro, Gunsan-si, Jeollabuk-do, Korea.*
***Associate professor, 55338 Dept. of Fire Protection and Disaster Prevention, Woosuk Univ, 443 Samnye-ro, Samnye-eup, Wanju-gun, Jeollabuk-do, Korea*
Corresponding Author E-mail: 119wsu@naver.com

Abstract

The purpose of this study is to develop and validate the disaster safety awareness scale for high school students. For this purpose, the previously developed disaster safety awareness scale and related prior research was analyzed. Questionnaire data was collected from March 22 to May 25, 2021 from 1054 students (male: 569, female: 485) in the first, second, and third grades of 5 high schools in 3 cities. Through the process of revising, supplementing, and reviewing the items extracted through preliminary research and preliminary test together with experts and students, a final disaster safety awareness scale consisting of 24 items was developed. This scale consists of four sub-factors: 'disaster prevention', 'disaster response A', 'disaster response B', and 'disaster recovery'. Good reliability and validity were secured through exploratory and confirmatory analyses. The significance of this study is that it laid a basic and objective foundation for high school students' disaster safety awareness research by developing a validated scale in a situation where the development of disaster safety awareness scales for high school students was still insufficient. It can be used as useful data for fire safety education as well as a psychological measurement tool for fostering fire safety awareness.

Key Words: *Disaster Safety Awareness, Scale Development, Validation, High School Students*

1. INTRODUCTION

Natural disasters such as typhoons, floods, earthquakes, and tsunamis as well as social disasters such as gas explosions, building collapses, and large fires threaten the right to live. Modern society has made life richer and more comfortable than in the past through the development of science and technology and rapid industrialization. However, due to reckless industrialization and insensitivity to safety, we are facing new natural disasters such as various environmental pollution, ecosystem destruction, collapse, and infectious diseases [1]. The Pohang earthquake in 2017, which caused an unprecedented situation in which elementary, middle, and high schools were closed and the college entrance exam was postponed, could be an example of such a case.

A series of events related to natural disasters, such as the Umyeonsan landslide in Seoul, which resulted in 16 casualties, Gyeongju and Pohang earthquakes, yellow dust, and the Corona 19 virus, have raised national awareness of disaster safety. Awareness to prevent safety accidents is gradually spreading in schools that are responsible for the education of future generations [2, 3]. Since natural disasters are difficult to predict and

Manuscript Received: October. 11, 2021 / Revised: October. 15, 2021 / Accepted: October. 18, 2021
Corresponding Author: Ha-Sung, Kong 119wsu@naver.com
Tel: +82-63-290-1686, Fax: +82-63-290-1478
Associate Professor, Dept. of Fire and Disaster Prevention, Woosuk Univ., Korea

are easy to neglect, systematic disaster safety education needs to be strengthened in kindergartens, elementary and secondary schools.

To increase the effectiveness of school disaster safety education, it is first necessary to measure whether students' safety awareness belongs to safety or danger. In addition, self-measurement of one's own disaster safety awareness can predict safety accidents, prevent accidents in advance, and correct one's lack of safety habits. To this end, it is necessary to develop a scale that has verified the reliability and validity to measure students' awareness of disaster safety.

As a previous study, the Disaster Safety Awareness Scale of National Fire Agency (2007) [4] targeted adults and the questionnaire was narrow to 15 items, so there may be limitations in applying it to high school students. Kim Hye-won and Lee Myung-sun (2002) [5] developed a scale for measuring safety awareness in the fields of home safety, school safety, traffic safety, fire safety, and first aid for middle school students, and it is difficult to apply it to the disaster safety awareness of high school students. Kim Se-hyeong (2018) [6] suggested the scope of the safety awareness scale development as an elementary school physical education subject, so it is not suitable as a psychological measurement tool in the field of disaster safety awareness. Despite the need for a tool to measure students' awareness of disaster safety as a starting stage in high school disaster safety education, there has been almost no development of a scale for disaster safety awareness targeting high school students.

In sympathy with such awareness and necessity, the purpose of this study is to develop a scale of disaster safety awareness that has been tested for reliability and validity for high school students. Not only is it meaningful as the first study in this field, but it is also expected that this study will be able to broaden the understanding of high school students' general disaster safety awareness as well as their awareness of disaster safety and provide educational measures. In this study, according to the classification of safety awareness of the Fire Department, the study was limited to disaster safety awareness as a natural disaster safety awareness.

The research questions set according to these research objectives are as follows.
First, what are the components of the high school students' disaster safety awareness scale?
Second, what is the reliability and validity of the high school students' disaster safety awareness scale?

2. METHODS

2.1. Sampling

A survey was conducted from March 22 to May 25, 2021, targeting 1,054 students (male: 569, female: 485) in grades 1.2.3 of 5 high schools in 3 cities. To examine the cross-validation of the scale, the study subjects were composed of a search group and a crossover group. Table 1 shows the distribution of preliminary survey, preliminary test, main test, search group and crossover group.

Table 1. Distribution of gender, search group and crossover group

Division		Preliminary Survey	Preliminary Test		Main Test	Total
			First	Second		
Sex	Male	29	120	109	311	569
	Female			120	365	485
	Sum	29	120	229	676	1054
Group	Search Group				400	666
	Crossover group				266	

2.2. Scale Development Process

The first and most important step in developing a scale is to select reliable and valid items that can measure an invisible variable after correctly deciding what to measure. For this purpose, it is necessary to check the structural relationship between latent variables through exploratory and confirmatory factor analysis [7, 8]. The process of developing a scale is a process of researcher's effort to accumulate empirical evidence for the characteristics of a measurement object that satisfies the theoretical background in the process of validating a scale logically.

As the first stage of the disaster safety awareness scale development process, 31 items were extracted from previous studies, related literature, and experts. Using a questionnaire composed of 31 items and the item that can describe other items, a preliminary survey was conducted for 29 high school students and 12 experts to verify content validity and explore items. Through the process of revising, supplementing, and reviewing the extracted items, the first preliminary scale of disaster safety awareness consisting of 29 items was developed and the first preliminary test (2021, March 22) was conducted with 120 high school students. Based on the item analysis and exploratory factor analysis data for the first preliminary scale, it was revised and supplemented again. After supplementing the suitability of the contents of the items for 20 high school students, a secondary preliminary scale for fire safety awareness consisting of 29 items was developed and a secondary preliminary test (April 05, 2021) was conducted for 229 high school students. The 3rd preliminary scale with 27 items was developed through item analysis and exploratory factor analysis of the 2nd preliminary scale. It was applied to the main test taken part in by 676 students (male: 311, female: 365) in 1st, 2nd, and 3rd grades of high school (May 10-25, 2021), from which the final disaster safety awareness scale was developed with 24 items verified reliability and validity.

2.3. Survey Tool

The disaster safety awareness scale was in 4-point Likert-scale format. Each item had four levels of options for students to use to express their attitude. The options are: 1 point for 'not at all', 2 points for 'disagree', 3 points for 'yes', and 4 points for 'strongly agree'. The higher the score, the higher the level of fire safety awareness. The collected data were uploaded to SPSS 26.00, Amos 27 and Mplus 8.4 to analyze the validity and reliability of the scale.

2.4. Data Analysis

Data analysis of disaster safety awareness scale was conducted in the order of item and descriptive statistical analysis, exploratory factor analysis, and confirmatory factor analysis. The mean, standard deviation, skewness, and kurtosis of all items were checked, and any items with severe bias were reviewed and analyzed. Through exploratory factor analysis, it was confirmed whether the items constituting the variable were measured with the same concept. Principal component analysis (PCA) was performed to confirm the one-dimensionality of the scale factor, and Cronbach's α, which is an index of internal fit of items included in the sub-factor, was calculated to calculate the reliability of the scale. Correlation between sub-factors was investigated through Pearson's correlation analysis.

The validity of the disaster safety awareness scale was reviewed in terms of content validity, construct validity, and cross validity. Content validity was reviewed in item development and selection, preliminary test, and main test analysis during the scale development process. Construct validity to check the validity of the relational structure between factors and items of the disaster safety awareness scale was verified. Confirmatory factor analysis was conducted to verify the factor coefficient, determination coefficient, and fit of the measurement model. The fit of the model was checked by referring to the chi-square(χ^2) validation value, as well as goodness-of-fit indices such as TLI (Tucker-Lewis' Index), CFI (Comparative Fit Index), RMSEA (Root Mean Square Error of Approximation), and SRMR (Standardized Root Mean Square Residual). Looking at the fit criteria of the model, if TLI and CFI value are .9 or higher, it is considered good fit [9]. The absolute fit index RMSEA is judged as a very good fit if it is between .05 and .08 [10]. SRMR is a standardized index that can be considered to have a good fit if it is less than .08 [11]. To confirm the possibility of generalization by cross-validation, confirmatory factor analysis was performed by dividing the study subjects into a search group and a crossover group [12].

3. FINDINGS

3.1. Disaster Safety Awareness Scale

The results of the exploratory factor analysis of the items of the scale and the content of the items are examined by dividing them into preliminary and final scales.

1.1 Preliminary Scale Components

Factor analysis was performed on 27 items of the 3rd preliminary scale developed by modifying and supplementing the 1st and 2nd preliminary scales. Scree chart tests were performed to identify the number of potential factors. The results of the scree diagram inspection are shown in Figure 1. Scree implies that the vertical portion of the plot is where the substantial factors are located while the horizontal portion is the scree, or rubble, that should be discarded [13]. There was no significant difference between factors 3 and 4, so in this study, 4 pieces of factors were set. The Promax factor analysis was performed for 4 factors of 27 items. If the KMO value is 0.5 or more and the Bartlett value is suitable for the significance level, it is suitable for factor analysis [14]. Kaiser-Meyer-Oklin (KMO) and Bartlett's tests were applied to the data obtained during the study to determine whether the data were appropriate for testing the construct validity of the scale. KMO = .960 and $\chi 2$ = 9940.917 (p<0.001) values indicated that the data were appropriate for factor analyses. Items 1, 12, and 13 were removed to increase the fit of factor classification and load. As a result of checking the load amount for each factor, the size of the factor coefficient was distributed from .382 to .922, and the correlation coefficient between the factors was found to be more than .30, indicating a high correlation. If the correlation coefficient is .30 or higher, the correlation is considered good [15]. Thus, it can be stated that each item is related to the factor to which it belongs, which means it works towards the common purpose. Table 2 shows the results of the 4 factors analysis of 24 items on the final scale of disaster safety awareness. After identifying the characteristics of the items included in the 4 factors and consulting with experts, for each factor, disaster prevention (1st factor), disaster response A (2nd factor), disaster response B (3rd factor), and disaster recovery (4th factor) were named.

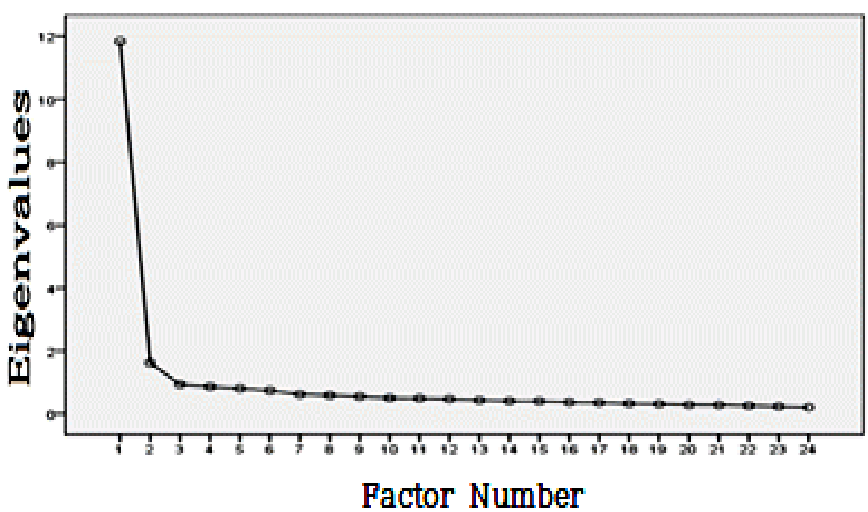

Table 2. Factor variance and item load values of final 24 items

Item No.	F 1	F 2	F 3	F 4
	Factor and Item Load			
7	.901	.079	-.119	-.084
6	.833	-.101	.203	-.140
5	.764	-.198	-.064	.217
9	.716	-.020	-.127	.234
8	.592	.054	-.059	.223
10	.522	.258	.108	-.063
3	.487	.072	.159	.075
4	.476	.171	-.057	.167
2	.461	.148	.149	-.052
15	.110	.922	-.114	.046

16	.007	.873	-.165	-.004
17	.063	.626	.155	-.137
14	-.113	.593	.10	.16
11	.249	.482	.108	-.004
18	.176	.478	.087	.007
20	.084	-.029	.650	.082
23	.177	.044	.638	-.047
19	.274	-.083	.469	.076
22	-.004	.361	.455	.032
21	.103	.190	.382	.160
25	-.075	-.115	.071	.884
24	.083	.111	-.034	.550
26	-.045	.187	.226	.506
27	.013	.378	-.024	.464

1.2 Item Content, Item Characteristics, Reliability and One-Dimensionality of the Final Scale

The contents of 24 items for each of the 4 factors of the finally selected disaster safety awareness scale are shown in Table 3.

Table 3. Item content by factor of 24 items on the final scale

Factor	Item No.	Item Content
Disaster Prevention	1	Prepare medicines and daily necessities for emergency use.
	2	Know in advance where you can evacuate in case of a disaster.
	3	To prevent disasters, install and use the disaster guidance system application on your mobile phone.
	4	Be sure to know how to use the National Disaster Safety Portal to utilize disaster information by type.
	5	Prepare rain gear (umbrella, raincoat, boots, etc.) in advance.
	6	Find a safe indoor location in case of an earthquake.
	7	Check for objects that may fall or break in strong winds.
	8	To prevent disasters, check the weather information through the mass media or the Internet and go out.
	9	To prevent electric shock in the event of a flood or lightning, unplug the power plug after using electrical appliances.
Disaster Response A	10	In the event of an earthquake, cover your head to protect it and evacuate quickly under a desk, table, or bed.
	11	After an earthquake and shaking, turn off the power and close the gas valve.
	12	Do not ride in elevators or cars during earthquakes.
	13	Avoid underground facilities or low-lying areas that are expected to be flooded by flooding and ascend to a higher place.
	14	In case of flooding or isolation, evacuate to a safe place such as a rooftop and wait for rescue.
	15	In the event of an earthquake, the door may be twisted and cannot be opened, so leave the door open in advance.
Disaster Response B	16	In case of yellow dust, wear a mask, protective glasses, and long-sleeved clothing.
	17	Disaster messages received through the smartphone app are shared with people around them.
	18	After it snows, clear the snow in front of the house.
	19	When a disaster occurs, listen to the broadcast, and follow the instructions of the

		disaster broadcast.
	20	In case of an emergency, report it to 119 or a safety steppingstone.
Disaster Recovery	21	In the event of a flood or heavy rain, tap water or stored drinking water should be checked for contamination before drinking.
	22	Discard flooded food or ingredients as there is a risk of food poisoning.
	23	When returning home after evacuation, check whether it is safe before entering.
	24	The damaged house may have a gas leak, so be sure to ventilate it sufficiently.

Table 4 shows the item characteristics such as reliability, mean, standard deviation, skewness, and kurtosis for the finally selected fire safety awareness scale.

Table 4. Item characteristics and reliability of the final scale

Factor	M	SD	Item No.	M	SD	Skewness	Kurtosis	Cronbach's α
Disaster Prevention	3.47	.69	1	3.48	.688	-1.171	.817	.912
			2	3.44	.701	-1.125	.904	
			3	3.17	.908	-0.804	-.315	
			4	3.37	.747	-1.015	.543	
			5	3.51	.652	-1.222	1.279	
			6	3.54	.612	-1.14	1.014	
			7	3.57	.587	-1.148	1.014	
			8	3.55	.65	-1.359	1.591	
			9	3.56	.632	-1.288	1.158	
Disaster Response A	3.61	.52	10	3.71	.488	-1.367	1.292	.868
			11	3.37	.487	-1.526	1.359	
			12	3.68	.52	-1.556	2.659	
			13	3.67	.523	-1.369	1.668	
			14	3.64	.534	-1.221	1.194	
			15	3.61	.586	-1.488	1.590	
Disaster Response B	3.54	.65	16	3.53	.651	-1.28	1.405	.848
			17	3.5	.674	-1.303	1.557	
			18	3.46	.729	-1.265	1.12	
			19	3.62	.555	-1.181	.709	
			20	3.57	.638	-1.496	1.485	
Disaster Recovery	3.63	.56	21	3.61	.596	-1.518	2.47	.835
			22	3.61	.597	-1.367	1.449	
			23	3.64	.525	-1.178	1.108	
			24	3.67	.525	-1.4	1.75	
Overall Average				3.55	.62			.87

In the final disaster safety awareness scale, the mean was 3.17-3.71, standard deviation .487-.908, skewness <±2 and kurtosis <±2. It is judged to be suitable for the normal distribution criteria of |skewness|<2 and |kurtosis|<4 [16]. Looking at the mean and standard deviation for each factor, the mean 3.17-3.57 and standard deviation .587-0.908 of disaster prevention, the mean 3.37-3.72 and standard deviation .487-.586 of disaster response A, the mean 3.46-3.62 and standard deviation .555-.729 of disaster response B and the mean 3.61-3.67 and standard deviation .525-0.597 of disaster recovery are shown. Among them, the overall average of disaster recovery was the highest with 3.63, and the average of disaster prevention was the lowest with 3.47.

Disaster prevention had the highest standard deviation of .69, and disaster response A had the lowest with 0.43. Since the mean and standard deviation of the items were not biased toward extreme values, it was indicated that the distribution of items on the scale was appropriate. If the alpha coefficient is .6 or more and less than .7, it is considered an acceptable level, and if it is .7 or more and less than .8, it is judged as a good level [17]. The Cronbach's α reliability of each factor was .835 -.912, which satisfies the criteria. The overall reliability of the items was also very high at .953.

Table 5 shows the results of the one-dimensionality analysis for each factor of the final disaster safety awareness scale. The one-dimensional assumption means that one test tool should measure one characteristic of a subject and is a basic assumption that must be satisfied when developing item responses [18]. The one-dimensionality of the items was supported in all factors, as it was considered appropriate when the eigenvalues of the remaining components except the first component of each factor were all less than 1.

Table 5. One-dimensionality by factor

Factor	Eigenvalues								
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th
Disaster Prevention	5.401	.81	.587	.513	.445	.384	.357	.261	.241
Disaster Response A	3.556	.65	.521	.481	.416	.375			
Disaster Response B	3.195	.619	.48	.388	.319				
Disaster Recovery	2.688	.55	.473	.289					

3.2. Validity of Disaster Safety Awareness Scale

The validity of the disaster safety awareness scale was reviewed in various ways in terms of content validity, construct validity and cross validity. As a previous study, there was no standardized similar disaster safety awareness scale for high school students, so criterion-related validity was excluded. Content validity was thoroughly reviewed in the first stage of scale development, item development and selection, and in the second stage, preliminary testing. For construct validity verification and cross-validation, 400 out of 666 respondents in the main test were divided into a search group and 266 people were divided into a cross group to analyze how much difference there was in the disaster safety awareness measurement model between the groups. To verify construct validity, confirmatory factor analysis was performed in the order of convergence and discriminant validity, correlation matrix, and measurement model fit of the search and crossover groups. Convergent validity indicates the correlation with other methods of measuring one characteristic. The higher the correlation coefficient, the better. Although it is not a value that must be satisfied, Kline (2011) [19] considers an appropriate criterion for a standardized estimate confirming convergent validity to be .7 or higher [7]. Discriminant validity indicates the correlation between methods for measuring different characteristics, and the lower the correlation coefficient, the better. Regarding discriminant validity, although it is not a value that must be satisfied, Kline (2011) [19] considers the standard value to be .9 or less [7].

2.1. Construct Validity of Search Group

1.1 Convergent Validity and Discriminant Validity

Figure 2 shows the convergence and discriminant validity of the path road of the confirmatory cross-group factor analysis model. The standardized factor load of the search group is .606-.805, confirming that it has convergent validity. Since Figure 2 is a standardized estimate, the covariance between factors can be said to be the correlation coefficient between factors [7]. The correlation coefficient between factors is .775-.897, which is smaller than the reference value of .9, indicating good discriminant validity.

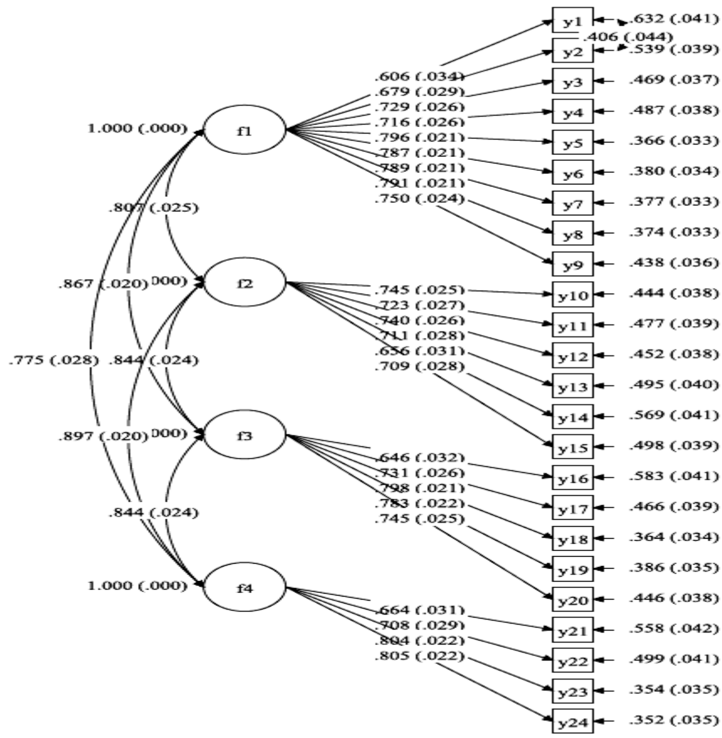

Figure 2. Confirmation Factor Analysis Model Path Diagram of Search Group

1.2 Correlation Matrix between Factors

In addition to testing the fit and factor load, correlations between factors were analyzed to secure additional evidence for construct validity of the disaster safety awareness scale for the search group. The correlations among disaster prevention, disaster response A, disaster response B, and disaster recovery were all positively significant. disaster response B and disaster prevention appear to be very strong at .781. The correlation matrix between disaster prevention, disaster response A, disaster response B, and disaster recovery is presented in Table 6.

Table 6. Correlation matrix between factors of search group disaster safety awareness scale

Factor	Disaster Prevention	Disaster Response A	Disaster Response B	Disaster Recovery
Disaster Prevention	1			
Disaster Response A	.724***	1		
Disaster Response B	.781***	.718***	1	
Disaster Recover	.679***	.746***	.695***	1

***p<.001

1.3 Measurement Model Fit

A confirmatory factor analysis was conducted to confirm the validity of the relational structure between the factors of the disaster safety awareness scale and the items. Table 7 shows the fit analysis results of the disaster safety awareness measurement model of the search group. The fit of the model of the search group was significantly χ^2 (245) =778.772, but since the χ^2 test is sensitive to the sample size [20], other fitness levels such as CFI, RMSEA, and SRMR were suggested. TLI=.900, CFI=.911, RMSEA=.074, and SRMR=.047 were found to be well satisfied.

Table 7. Disaster safety awareness measurement model fit of search group

χ^2	*df*	*p*	TLI	CFI	RMSEA	SRMR
778.772	245	<.001	.900	.911	.074	.047

Table 8 shows the factor loading of the items for each constituent factor of the disaster safety awareness scale of the search group.

Table 8. Factor load of items by constituent factors of the search group

Factor	Item No.	Factor Load			*t*	*p*
		Non-standardization Coefficient	Standardization Coefficient	S. E		
Disaster Prevention	1	1.000	.606	.034	18.023	<.001
	2	1.026	.679	.029	23.365	<.001
	3	1.223	.729	.026	28.567	<.001
	4	1.634	.716	.026	27.044	<.001
	5	1.415	.796	.021	38.781	<.001
	6	1.373	.787	.021	36.884	<.001
	7	1.288	.789	.021	37.468	<.001
	8	1.560	.791	.021	37.710	<.001
	9	1.231	.750	.024	31.135	<.001
Disaster Response A	10	1.000	.745	.025	29.407	<.001
	11	.928	.723	.027	26.969	<.001
	12	.873	.740	.026	28.531	<.001
	13	.841	.711	.028	25.533	<.001
	14	.861	.656	.031	20.936	<.001
	15	.994	.709	.028	25.486	<.001
Disaster Response B	16	1.000	.646	.032	20.238	<.001
	17	1.017	.731	.026	27.633	<.001
	18	1.049	.798	.021	37.149	<.001
	19	.918	.783	.022	34.881	<.001
	20	1.070	.745	.025	29.345	<.001
Disaster Recovery	21	1.000	.664	.031	21.108	<.001
	22	1.019	.708	.029	24.712	<.001
	23	1.028	.804	.022	37.073	<.001
	24	1.029	.805	.022	37.237	<.001

The path coefficient values of all items were found to be significant at $p<.001$. Also, the standardized coefficients for each item were .606-.796 for disaster prevention, .656-.745 for disaster response A, .646-.798 for disaster response B, and .664-.805 for disaster recovery. When judged collectively, each item can be seen as reflecting the relevant component well.

2.2. Construct Validity of the Crossover Group

2.1 Convergent Validity and Discriminant Validity

Figure 3 shows the convergence and discriminant validity of the path road of the confirmatory crossover group factor analysis model. The standardized factor load of the search group is .599-.854, confirming that it has convergent validity. Since Figure 3 is a standardized estimate, the covariance between factors can be said to be the correlation coefficient between factors [7]. The correlation coefficient between factors was .774-.920. Although the correlation coefficient between the disaster prevention factor and the disaster response factor B was slightly higher than the reference value of .9, it showed good discriminant validity among other factors.

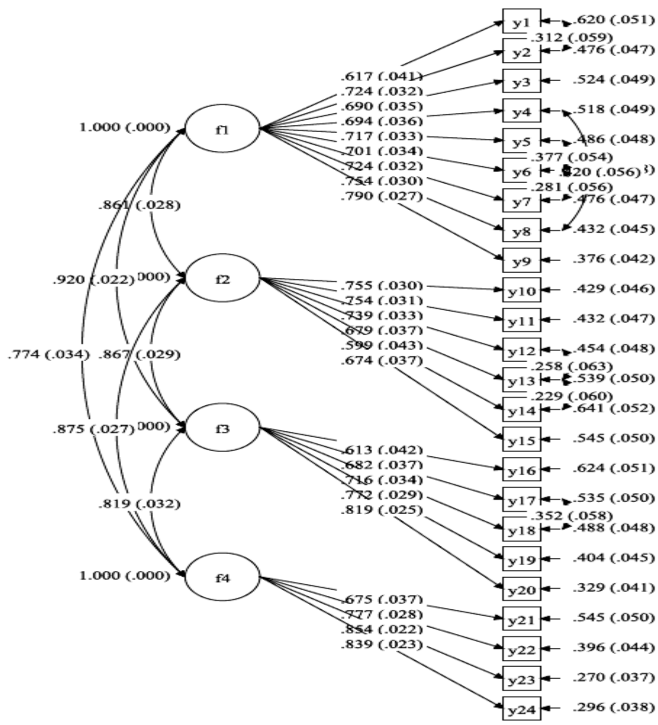

Figure 3. Confirmation Factor Analysis Model Path Diagram of Crossover Group

2.2 correlation matrix between factors

To secure additional evidence for construct validity of the disaster safety awareness scale for the cross-group, correlations between factors were analyzed. Like the results of the crossover group analysis, the correlations among disaster prevention, disaster response A, disaster response B, and disaster recovery were all positively significant. disaster response B and disaster prevention appear to be very strong at .783. The correlation matrix between disaster prevention, disaster response A, disaster response B, and disaster recovery is presented in Table 9.

Table 9. Correlation matrix between factors of cross-group disaster safety awareness scale

Factor	Disaster Prevention	Disaster Response A	Disaster Response B	Disaster Recovery
Disaster Prevention	1			
Disaster Response A	.705***	1		
Disaster Response B	.783***	.716***	1	
Disaster Recover	.645***	.742***	.697***	1

***p<.001

2.3 Measurement Model Fit

Table 10 shows the fit analysis results of the disaster safety awareness measurement model of the crossover group. TLI=.900, CFI=.913, RMSEA=.075, and SRMR=.048 were found to be well satisfied.

Table 10. Disaster safety awareness measurement model fit of crossover group

χ^2	*df*	*p*	TLI	CFI	RMSEA	SRMR
594.780	239	<.001	.900	.913	.075	.048

Table 11 shows the factor loading of the items for each constituent factor of the disaster safety awareness scale of the cross-group.

Table 11. Factor load of items by constituent factors of crossover group

Factor	Item No.	Factor Load			*t*	*p*
		Non-standardization Coefficient	Standardization Coefficient	S. E		
Disaster Prevention	1	1.000	.617	.041	14.987	<.001
	2	1.092	.724	.032	22.291	<.001
	3	1.226	.690	.035	19.533	<.001
	4	1.729	.694	.036	19.473	<.001
	5	1.319	.717	.033	21.616	<.001
	6	1.307	.701	.034	20.320	<.001
	7	1.286	.724	.032	22.339	<.001
	8	1.553	.754	.030	25.027	<.001
	9	1.290	.790	.027	29.716	<.001
Disaster Response A	10	1.000	.755	.030	24.988	<.001
	11	.947	.754	.031	24.242	<.001
	12	.968	.739	.033	22.685	<.001
	13	.801	.679	.037	18.399	<.001
	14	.776	.599	.043	13.927	<.001
	15	.977	.674	.037	18.128	<.001
Disaster Response B	16	1.000	.613	.042	14.743	<.001
	17	.970	.682	.037	18.578	<.001
	18	1.036	.716	.034	21.280	<.001
	19	.941	.772	.029	26.350	<.001
	20	1.273	.819	.025	32.598	<.001
Disaster Recovery	21	1.000	.675	.037	18.160	<.001
	22	1.201	.777	.028	27.334	<.001
	23	1.143	.854	.022	39.717	<.001
	24	1.123	.839	.023	37.029	<.001

The path coefficient values of all items were found to be significant at $p<.001$. Also, the standardized coefficients for each item were .617-.790 for disaster prevention, .599-.755 for disaster response A, .613-.819 for disaster response B, and .675-.854 for disaster recovery. When judged collectively, each item can be seen as reflecting the relevant component well.

3.3. Cross-Validation

Cross validation is the process of confirming the generalizability of the developed disaster safety awareness scale. If the items finally obtained through item analysis for the search group are applied to the crossed group and the fit of the result is similar to that of the search group, cross-validation is supported, and generalizability can be secured.

In this study, to determine the cross-validation of disaster safety awareness among high school students, we divided the groups into a search group and a crossover group and conducted crossover group analysis. When the fitness of the measurement models of the search group and the crossover group presented in Sections 3.2.1 and 3.2.2 was compared, the search group was χ^2=778.772(p<.001), CFI=.911, TLI=.900, RMSEA=.074 and SRMR=.047. The crossover group showed χ^2=594.780(p<.001), CFI=.913, TLI=.900, RMSEA=.075 and SRMR=.048 indicating that the cross-validation between the search group and the crossover group was good.

For the confirmatory factor analysis of the cross-validation between the search and cross-groups, it is possible to verify whether the factor loading, structural covariance, and model residuals of the search and cross- groups are the same as shown in Table 12. If the increased χ^2 relative to the increased degrees of freedom is not large [7, 19], or the increased CFI is .002 or less [21, 7], the identity is seen to be accomplished [7].

In Table 12, Model 1 is an unconstrained basis model, and Model 2 is a measurement invariance model in which factor loads are equally constrained. Model 3 is a structural invariance model, which is a measure that constrains factor loading and structural covariance equally. Model 4 is a model in which factor loading, structural covariance, and residuals of the measurement model are all equally constrained.

Table 12. Results of analysis of invariance between the search group and the crossover group

Model	*df*	χ^2	△*df*	△χ^2	CFI	△*CFI*	RMSEA
Configural Invariance	486	1500.908			.899		.056
Measurement Invariance	506	1515.217	20	14.309	.900	-.001	.055
Structural Invariance	516	1522.510	10	7.293	.900	.000	.054
Residual Invariance	540	1568.551	24	46.041	.898	.002	.054

To confirm the measurement invariance step by step, the difference test between χ^2 and CFI was conducted and the absolute fit index RMSEA (appropriate reference value: .05-0.8) was confirmed. As a result, the assumption of identity was satisfied for all four models. It shows that the measurement tools work in the same way in the search and crossover groups. The result of this comparison implies the possibility of generalization that the disaster safety awareness scale can be applied to various groups.

3.4. Mean and Standard Deviation Interpretation

The disaster safety awareness scale consisting of 4 factors and 24 items is composed of a Likert-type 4-level rating scale. The average (M=3.47) of disaster prevention factors composed of 9 items was the lowest. This means that the safety awareness of high school students about disaster prevention is lower than that of preparing for disaster or recovery. The average (M=3.63) of the disaster recovery factors composed of 4 items was the highest, indicating that the safety awareness for disaster recovery is higher than the safety awareness for disaster prevention or disaster response. When organizing and operating the disaster safety education course, it is necessary to come up with various measures to provide opportunities for more interest and experience in the field of disaster prevention education. In the disaster prevention factor, the average (M=3.17) of the item 'To prevent disasters, install and use the disaster guidance system application on your mobile phone.' was the lowest and the standard deviation (SD=.908) was the highest. The students' awareness of safety in using the disaster guidance system application is low and it is rather ubiquitous to the extreme. In this field, the need for systematic and repeated safety education considering individual differences can be confirmed. On the other hand, the average(M=3.71) of the item ‘In the event of an earthquake, cover your head to protect it and evacuate quickly under a desk, table or bed.’ was the highest and the standard deviation

(SD=.488) was the lowest. This is interpreted as the effect of repeated education on how to respond to earthquakes from the lower grades and publicity in the media.

4. DISCUSSION AND CONCLUSION

A safe life is necessary to prevent disaster accidents [23]. It is important to instill a sense of safety through systematic and repetitive education for a safe life to be instilled in the body and to be practiced unconsciously. The starting stage of safety education begins with diagnosing the level of safety awareness. Measurement of safety awareness can also help heal one's insensitivity to safety [1]. However, despite the need for a tool to measure students' disaster safety awareness as the starting stage of high school disaster safety education, a scale whose validity has been verified has not yet been developed. In this study, the purpose of this study was to develop a scale that can measure disaster safety awareness among high school students from this problem awareness. Knowing the suitability of one's disaster safety awareness can help to maintain safety awareness and develop desirable behavioral changes and response capabilities for disaster safety. In this study, the development of the first tool whose validity was verified to measure students' disaster safety awareness is meaningful as a psychological measurement tool for fostering disaster safety awareness.

In this study, to develop a disaster safety awareness scale, the composition of test items that are different from the questionnaires of previous studies and a systematic selection process were performed. Looking at the previous studies related to the scale development, the items in the questionnaire were too narrow to fully reflect the diversity of students' awareness of disaster safety. As a part of the safety awareness study, National Fire Agency (2007) [4] developed a 15-item disaster safety awareness scale targeting adults, but the number of items was small, which did not sufficiently reflect the individual differences of the respondents and the changed level of awareness of safety life culture. Also, the homogeneity between the measured variables and the correlation with other variables were not confirmed through thorough factor analysis, and the generalizability of the scale was not suggested.

To supplement this problem, in this study, in the process of developing the disaster safety awareness scale, a preliminary survey stage was established to extract items directly from students, and various opinions of students were reflected in the development of the items as much as possible [22]. In addition, the reliability of factor analysis was secured by increasing the fit of correlation coefficients between factors by removing items with low homogeneity in factor analysis. The generalizability of the high school fire safety awareness scale was confirmed by dividing the scale validation process into a search group and a cross-group and verifying factor loading, $\chi 2$, TLI, CFI, RMSEA, and SRMR. The development of various items will measure students' safety awareness in various fields and can be used as useful data for customized disaster safety education considering individual differences. The mean and standard deviation of the 24 questions conceptualized with the structure of four factors: 'disaster prevention', 'disaster response A', 'disaster response B', and 'disaster recovery' all showed good distribution. Each factor also showed high reliability, confirming that the disaster safety awareness scale is meaningful in descriptive statistics and reliability analysis. In addition, it is meaningful as a test tool differentiated from the existing questionnaire, which had limitations in educational diagnosis and prescription for disaster safety education by conducting content validity, construct validity, and cross validity verification. The disaster safety awareness scale developed in this study can be used as a checklist as one of the psychological measurement tools for diagnosing disaster safety awareness in the disaster safety education course of high school students.

Correlation analysis between the factors of the search group and the cross group shows a high correlation between disaster prevention and disaster response. Disaster prevention can have a positive effect on disaster response, so it is necessary to consider the importance of safety awareness to prepare and prevent disaster. Rather than responding to disaster after a disaster, it is necessary to seek various ways for desirable safety education to predict and prepare for disaster accidents. It can be one of the measures for disaster response to first determine the level of safety of evacuation of schools [24]. RSET (Required Safe Egress Time) may vary depending on whether the school building is high-rise or the layout of classrooms and offices. The evacuation safety of schools can be analyzed using a simulation program that can measure RSET. Classroom and office relocation and evacuation drills with designated evacuation exits can help reduce RSET [25].

In the disaster prevention factors, the average of the item 'You must know how to use the national disaster safety portal to utilize disaster information by type' is the second lowest among all items and the standard deviation is also the second highest. Students' awareness of the application of the disaster guidance system for a safe life and the use of the national disaster safety portal is low and somewhat ubiquitous at the end. This requires repeated learning and education so that the ability to use the national disaster safety portal can become a part of daily life habits when considering the unconscious high safety awareness of covering one's head and evacuating quickly under a desk or table in case of an earthquake.

In conclusion, this study developed a validated scale in a situation where research on the scale of disaster safety awareness was still insufficient, confirmed the possibility of generalization that can be applied to various groups, and laid a basic and objective basis for research on disaster safety awareness, which is a significance of this study. This study has developed and validated a disaster safety consciousness scale for high school students. Due to this study, disaster safety consciousness will be studied more deeply. Despite the results of the above study and its various significances, this study intends to suggest the following limitations and future research tasks.

First, disasters include not only natural disasters, but also human disasters such as traffic accidents, environmental pollution accident and other disasters such as the spread of infectious diseases, energy, and finance. This study is a study on the safety awareness of high school students regarding natural disasters, and additional research on human disasters and other disasters is needed.

Secondly, in the process of developing the scale of this study, it was not possible to sufficiently secure various samples through regional arrangement when sampling the study subjects. Therefore, it is necessary to study the possibility of generalization by expanding the subject of future research nationwide.

Thirdly, it is necessary to restructure the disaster safety awareness scale in consideration of reality in line with the rapidly changing times and the change of safe living culture.

Finally, it is necessary to analyze the profile and latent profile of students' disaster safety awareness using the disaster safety awareness scale developed in this study. The analysis of gender, achievement, grade, and latent profile groups in consideration of individual differences will increase the effectiveness of disaster safety education by understanding the characteristics of students' disaster safety awareness in more detail and providing information according to individual differences.

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