

Latent Profile Analysis of High School Students' Fire Safety Awareness

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Abstract

The purpose of this study is to analyze the types of latent profiles of high school students' fire safety awareness and to identify the characteristics of related variables. For this purpose, a survey was conducted from March 22 to May 25, 2021 for 1054 high school students (male; 569, female; 485) in 3 cities, in Jeollabuk-do. The latent profile was analyzed using a scale consisting of 4 sub-factors: 'fire prevention', 'fire preparedness', 'indirect fire response', and 'direct fire response'. It was checked whether there were differences according to the inter-individual differences of the latent group. As a result of the analysis, fire safety awareness of high school students was classified into three latent profiles. The three groups were named 'High Perception Type', 'Moderate Perception Type', and 'Low Perception Type' according to their types. In fire safety awareness, there is a significant difference in the individual differences according to the gender and academic achievement of the latent profile. These results are meaningful as the first study to analyze the latent profile of high school students' fire safety awareness, and it is also meaningful to provide a useful basis for the contents and methods of customized fire safety education by identifying the tendencies of spontaneous groups and their fire safety awareness.

Keywords: Latent Profile Analysis, Fire Safety Awareness, High School Students

1. Introduction

According to the data of the Fire Department [1], 49.6% of the 38,659 fires that occurred in Korea in 2020 were caused by negligence. During the five years from 2015 to 2019, 829 people were killed or injured in large-scale fires, and an average of 9.5 large-scale fires occurred per year [2]. Most of the large-scale fires whose causes were identified were found to be mainly due to a simple lack of safety awareness and mistakes due to insensitivity to safety. Awareness to prevent safety accidents is gradually spreading in schools responsible for the education of future generations due to fires caused by this lack of safety awareness and insensitivity to safety [3].

In the 2015 revised curriculum, which introduced 'safe living' from the lower grades, safety education is not only 'safe living', but also systematic repetition learning through creative experiential activities and

subjects as one of the subjects of cross-curricular learning [3]. In order to cultivate safety awareness and increase the effectiveness of safety education, it is necessary to first understand the level of one's own safety awareness. Diagnosing the suitability of a student's own fire safety awareness can help not only to heal insensitivity to safety, but also to change a desirable fire safety awareness [4, 17]. In addition, the diagnosis of fire safety awareness increases the preparation and satisfaction of fire safety education and plays an important role as a feedback material for fire safety education. For proper fire safety awareness diagnosis, measurement tools and methods with proven reliability and validity are required. However, although steady studies on fire safety awareness have been conducted, studies on the characteristics of high school students' fire safety awareness and methods to measure it are insufficient. It is necessary to systematically study various aspects that can identify the level and characteristics of students' fire safety awareness using scales that have been verified for reliability and validity.

Previous studies on fire safety awareness [4-6] focused on the variables affecting safety. However, these studies use measurement tools whose reliability and validity have not been verified, so it is somewhat difficult to generalize the research results, and there are limitations in that they do not consider how high school students are categorized according to the characteristics of sub-factors constituting fire safety awareness. Latent profile analysis is not a variable-centered analysis like in previous studies, but a person-centered approach that considers individual characteristics [7]. This subject-centered approach is useful for verifying heterogeneity within a group that is not directly revealed, finds a potential group showing the same pattern based on heterogeneity, and provides useful information for identifying the characteristics of the research subjects through the potential group [8].

Fire safety awareness includes various knowledge, functions and attitudes about fire such as fire extinguishing activities, evacuating to a safe place, fire extinguisher, earth leakage circuit breaker, gas leak alarm, checking installation and operation of fire alarms, correct use of gas and electric appliances, etc. Therefore, to measure and characterize high school students' fire safety awareness, a study considering the multi-dimensionality of safety awareness is needed. In order to find out what characteristics high school students are classified as a group in terms of fire safety awareness, this study is to analyze the latent profile using a developed scale [9] through verifying reliability and validity. Exploring how high school students are classified according to the sub-factors of fire prevention, fire preparedness, and fire response that constitute fire safety awareness can provide information on the content and method of safety education according to group characteristics.

In the development of safety awareness measurement scales [5] and the analysis of public safety awareness [4], it was found that there is a difference in the level of safety awareness according to individual differences. It is necessary to find out what the fire safety awareness looks like through latent profile analysis according to the individual differences of students. This can provide the basis for whether there is a need for customized fire safety education considering individual differences of students.

In consideration of such awareness and necessity, this study aims to identify which characteristics high school students have in fire safety awareness through latent profile analysis and whether there are differences between latent classes according to individual differences.

The research questions for carrying out this research purpose are as follows.

First, how many types of latent profiles of high school students' fire safety awareness are classified, and what are the characteristics of the classified latent groups?

Second, is there a difference between latent classes by gender, grade, and academic achievement in the fire safety awareness of high school students?

2. Methods

2.1. Research Model

This study aims to analyze the latent profile of high school students' fire safety awareness using the reliable and valid fire safety awareness scale [9] and to analyze differences between latent classes according to individual differences. For this, two issues need to be considered: the type of latent profile and how to reveal the characteristics of inter-individual differences by gender, grade level, and academic achievement. Accordingly, this study was divided into latent profile analysis and individual difference analysis model. In the latent profile analysis, the classification and characterization of the latent group were used, and individual differences were analyzed separately by gender, grade and academic achievement. For analysis of latent profiles and individual differences, previous studies [10-11] were referred to. The structure of the latent profile and individual differences analysis model is shown in Figure 1.



Figure 1. Research model

2.2. 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 high schools in 3 cities. Table 1 shows the distribution of preliminary survey, preliminary test, main test, search group and cross-group.

Table 1. Distribution of gender, search group and cross-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		

2.3. Survey Tool

In this study, the reliable and valid fire safety awareness scale [9] was applied to analyze the latent profile of fire safety awareness. As presented in Table 2, the fire safety awareness scale was composed of 4

sub-factors and 22 items. The four sub-factors consisted of 4 items of 'fire prevention', 7 items of 'fire preparedness', 7 items of 'fire response A' and 4 items of 'fire response B'. The fire 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 26.0, Amos 27 and Mplus 8.4 in order to analyze the latent profile.

Table 2. Contents of each factor of 22 items on the fire safety awareness scale

Factor	Item No.	Item Content
Fire Prevention	1	Make sure the power cutoff switch of the electrical outlet is turned off.
	2	Check the operation by pressing the button of the earth leakage breaker at least once a month.
	3	Check for frayed wires or damaged cords.
	4	Check the cleanliness of the back of the refrigerator from time to time.
Fire Preparedness	5	Learn how to use an Automatic External Defibrillator (AED) and CPR in case of an emergency.
	6	Be sure to know the exits of the various routes of escape in the event of a fire,
	7	A fire extinguisher should be provided where there is a risk of fire.
	8	You need to know the location of fire extinguishers in school.
	9	Familiarize yourself with the signs of evacuation exit guide lights for quick evacuation in case of fire.
	10	You must know how to use a fire extinguisher.
	11	In case of fire, a single alarm type detector for the house should be installed.
Indirect Fire Response	12	The first person to discover a fire should call out loudly for people to evacuate quickly.
	13	For quick evacuation, in case of a fire, an emergency bell should be sounded to notify the surrounding area.
	14	If there is a fire, call 911 and evacuate promptly according to the instructions.
	15	If there is a lot of smoke, cover your nose and mouth with a wet handkerchief or tissue, etc. and evacuate quickly in a low position.
	16	In case of fire, do not use the elevator and evacuate by stairs.
	17	If you do not see your friend after evacuating to a safe place, notify the teacher or fire fighter immediately.
	18	In case of fire, evacuate quickly according to the fire evacuation plan.
Direct Fire Response	19	If your clothing catches fire, stop there, cover your eyes and mouth, and continue rolling until the fire is out.
	20	When using a fire extinguisher, it must be extinguished with your back facing the wind.
	21	Fire doors must be kept closed at all times.
	22	When using a fire hydrant, become a pair of two, move the lake to the point of fire, and then turn the valve to use it.

Table 3 shows the item characteristics examined by reliability, mean, and standard deviation of the 22 items of firesafety awareness scale. The overall mean reliability of the factors was .81, which was as high.

Table 3. Item characteristics and reliability of the final fire safety awareness scale

Factor	M	SD	Item No.	M	SD	Cronbach's α
Fire Prevention	2.96	.88	1	3.41	.708	.809
			2	2.51	1.052	
			3	3.35	.73	
			4	2.56	1.035	
Fire Preparedness	3.54	.59	5	3.55	.571	.863
			6	3.52	.598	
			7	3.67	.514	
			8	3.46	.627	
			9	3.72	.474	
			10	3.33	.75	
			11	3.5	.611	
Indirect Fire Response	3.77	.43	12	3.82	.392	.899
			13	3.79	.421	
			14	3.84	.373	
			15	3.75	.444	
			16	3.74	.452	
			17	3.73	.466	
Direct Fire Response	3.42	.69	18	3.7	.489	.657
			19	3.41	.675	
			20	3.42	.72	
			21	3.71	.48	
Overall Average			22	3.14	.865	
				3.48	.61	.81

2.4. Data Analysis

In this study, four fitness indices were applied to determine the optimal number of potential groups: information index, model comparison test, classification quality, and intragroup classification ratio. This classification procedure followed the latent profile analysis procedure [12-13]. First, the number of latent groups is determined by verifying the model fit through the information criterion. For the optimal number of latent types, the smaller the fit indices AIC, BIC, and SABIC, the better [10]. Second, we check how accurately each case was classified in the group through the entropy value. Entropy values range from 0 to 1, and the closer to 1, the more accurate the classification. If it is 0.8 or more, 90% or more is considered to be properly classified [14]. Third, for model comparison verification, LMRT (Lo-Mendell-Rubin Adjusted Likelihood Ratio Test) likelihood ratio verification and bootstrap likelihood ratio verification BLRT (Bootstrap Likelihood Ratio Test) are used. This method is a model comparison verification that judges the suitability by comparing the case where the latent profile model is k and $k-1$. When comparing k latent group models and $k-1$ latent group models, if there is a statistically significant difference, k models are suitable, and if not significant, $k-1$ latent groups are judged to be suitable [11]. Fourth, care should be taken not to include less than 5% of the sample by checking the classification ratio within the potential group [13] [15-16].

3. Findings

3.1. Latent Profile Analysis of Fire Safety Awareness

Information index, model comparison test, classification quality, and intragroup classification ratio were verified to understand the characteristics of the group according to the classification of the fire safety awareness latent group. The results are shown in Table 4.

In order to extract a suitable potential group for fire safety awareness, the fit and significance of the model were examined while increasing the number of groups from 2 to 5. First, in Table 4, as the number of groups increased, the size of the information indices of AIC, BIC, and SABIC gradually decreased, indicating that the fit of the model was good. Second, as a result of confirming the entropy value, which identifies the quality of latent class classification, all models maintain .8 or higher and are the highest in the three groups. Third, model validation by LMRT and BLRT showed significant significance in both criteria of $p < .05$. Fourth, when looking at the classification ratios of the latent classes of the five groups, the ratio of the number of samples was more than 5% in all of them, which satisfies the criteria of the model.

Table 4. Comparison of fit of fire safety awareness latent profile analysis model

Classification Criteria		Number of Latent Profile			
		2	3	4	5
Fitness Indices	AIC	2660.406	2268.422	2042.093	1780.217
	BIC	2718.923	2349.445	2145.622	1906.254
	SABIC	2677.647	2292.294	2072.596	1817.352
Classification Quality	Entropy	.945	.968	.871	.906
Model Comparison Test (p)	LMRT	.0001	.0001	.0001	.0001
	BLRT	.0001	.0001	.0001	.0001
Classification Ratio (%)	1	23.9	16.4(109)	28.1	12.8
	2	76.1	16.7(111)	16.7	12.9
	3		67.0(446)	39.8	27.8
	4			15.5	7.5
	5				39

Therefore, when statistical indicators such as information index, classification quality, model comparison verification, and latent class classification ratio and interpretability were comprehensively judged, three latent groups were identified as the most suitable model.

Considering the characteristics of each latent group of fire safety awareness and the average chart of fire safety awareness factors in Figure 2, the three group models finally selected were named 'Low Perception', 'Moderate Perception', and 'High Perception'.

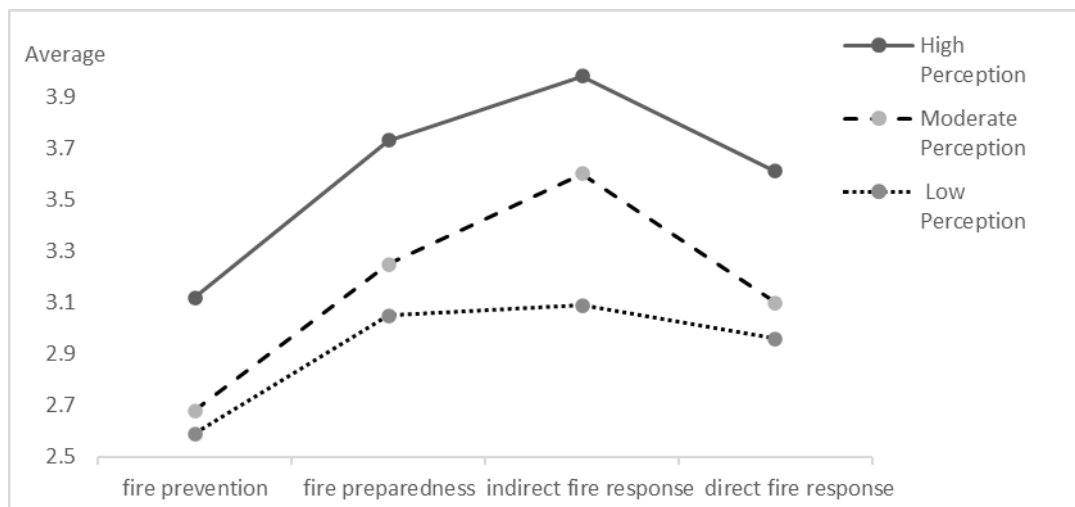


Figure 2. Profile chart between latent profiles of fire safety awareness

The mean and standard deviation for the three groups extracted through latent profile analysis are presented in Table 5. One-way ANOVA was performed to determine the difference between the three latent groups. As a result of confirming the *F*-value and *P*-value of the latent group, both were significant, confirming the difference in the fire safety awareness for the latent group.

Table 5. Latent profile mean and standard deviation of fire safety awareness

Factor	Low Perception (N=111)		Moderate Perception (N=109)		High Perception (N=446)		<i>F</i>	<i>p</i>
	M	SD	M	SD	M	SD		
Fire Prevention	2.59	.56	2.68	.61	3.12	.72	37.674	<.001
Fire Preparedness	3.05	.31	3.25	.44	3.73	.33	218.345	<.001
Indirect Fire Response	3.09	.13	3.60	.12	3.98	.06	5257.358	<.001
Direct Fire Response	2.96	.36	3.10	.42	3.61	.41	157.634	<.001
Total	2.92	.34	3.16	.40	3.61	.38		

3.2. The Relationship between Latent Profile of Fire Safety Awareness According to Individual Differences

A cross-analysis was conducted to investigate the difference in fire safety awareness among latent profile according to individual differences. As a result, in Tables 6, 7 and 8, there is no difference by grade level, but there is a difference between the latent profiles by gender and academic achievement.

Table 6 presents the results of cross-analysis between latent profiles according to gender of fire safety awareness. As a result of analyzing the difference between the gender latent profiles of fire safety awareness in Table 6, as for male, the low perception was 63 (20.3%), the moderate perception was 56 (18%), and the high perception was 192 (61.7%). Moderate perception rate was the lowest. As for female, the low perception was 48 (13.5%), the moderate perception was 53 (16.4%), and the high perception was 254 (71.5%). Low perception rate was the lowest. As a result of cross-analysis, $\chi^2(2) = 7.856$ and $p = .020$ indicated that there is a significant difference.

Table 6. Cross-analysis between latent profiles by gender

Sex	Group			Total
	Low Perception	Moderate Perception	High Perception	
male	63(20.3)	56(18.0)	192(61.7)	311
female	48(13.5)	53(16.4)	254(71.5)	355
total	111(16.7)	109(16.4)	446(67.0)	666

Table 7 presents the results of cross-analysis among latent profiles by grade of fire safety awareness. According to the results of analysis of the difference between potential classes by grade in Table 7, Low Perception was 47 (20%), Moderate Perception 35 (14.9%), and High Perception 153 (65.1%) in the 1st grade. Moderate Perception had the lowest rate. In the 2nd grade, Low Perception was the lowest in 25 (11.2%), Moderate Perception in 38 (17.0%), and High Perception in 160 (71.7%). In the 3rd grade, 39 (18.8%) of Low Perception, 36 (17.3%) of Moderate Perception, and 133 (63.9%) of High Perception, showed the highest in High Perception. As a result of cross-analysis, $\chi^2(4) = 7.744$ and $p = .101$ indicated that there was no significant difference.

Table 7. Cross-analysis between latent profiles by grade

N (%)

Grade	Group			Total
	Low Perception	Moderate Perception	High Perception	
1 st grade	47(20.0)	35(14.9)	153(65.1)	235
2 nd grade	25(11.2)	38(17.0)	160(71.7)	223
3 rd grade	39(18.8)	36(17.3)	133(63.9)	208
total	111(16.7)	109(16.4)	446(67.0)	666

Table 8 presents the results of cross-analysis between latent profiles by academic achievement in fire safety awareness. In the results of the analysis of the difference between latent profiles by academic achievement of fire safety awareness presented in Table 8, 35 (13.2%) of Low Perception, 40 (15%) Moderate Perception, and 191 (71.8%) High Perception of achievement are shown. The Low Perception rate was the lowest. In the middle achievement level, the Low Perception rate was the lowest with 58 (17.3%), compared with Moderate Perception 63 (18.8%) and High Perception 214 (63.9%) students. In the low achievement level, 18 (27.7%) of Low Perception, 6 (9.2%) of Moderate Perception, and 41 (63.1%) of High Perception, showed the lowest rate of Moderate Perception. As a result of cross-analysis, $\chi^2(4) = 11.870$ and $p = .018$ indicated that there is a significant difference.

Table 8. Cross-analysis between latent profiles by academic achievement

N (%)

Achievement	Group			Total
	Low Perception	Moderate Perception	High Perception	
High	35(13.2)	40(15.0)	191(71.8)	266
Middle	58(17.3)	63(18.8)	214(63.9)	335
Low	18(27.7)	6(9.2)	41(63.1)	65
total	111(16.7)	109(16.4)	446(67.0)	666

4. Conclusion

The conclusion according to the research question is as follows. First, the latent profile of high school fire safety awareness presented as a research problem was classified into three groups. The three latent profiles showed an ordered pattern of high, medium, and low levels of safety awareness of fire prevention, preparedness and response, respectively. First, the 'Low Perception Type' group shows the lowest average value in the sub-factors of fire safety awareness among the three groups. It is a group that shows little interest in fire safety and is less willing to change behavior. There is a lack of interest in changing desirable habits for fire safety. However, considering the number of 'Low Perception' groups, it may be easy to provide customized fire safety awareness education for each level of students. Next, the 'Moderate Perception Type' group, in which all four sub-factors, such as fire prevention, fire preparedness, indirect fire response, and direct fire response, are close to the average, is the lowest group, and the average score of fire prevention is somewhat lower than that of fire preparedness and response. Lastly, 'High Perception Type' has the highest distribution among the entire group and has the highest average score in all sub-factors such as fire prevention, fire preparedness, and fire response. The fact that the distribution of 'High Perception Type' is significantly higher than that of other latent profiles is very positive in the sense that high school students have high fire safety awareness overall. Second, it was confirmed that there were differences by gender and academic achievement in the analysis of differences in fire safety awareness among potential classes by gender, grade level, and academic achievement presented as a research question. The results of this study are meaningful in providing the evidence that fire safety education is necessary for each level, considering individual differences by gender and academic achievement, although it is possible to educate students regardless of grade level in fire safety education.

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