JTS

The Journal of Transdisciplinary Studies, 8(1): 1-20, 2024
https://doi.org/10.22685/JTS.2024.8.1.001

The Moderating Effect of Digital Human-Based Safety Education on the Relationship between Safety Culture, Safety Awareness, and Safety Participation Behavior of Foreign Workers*

Younghee Noh[1], Jong-Hwa Jang[2]

[1]Professor, Department of Library and Information Science, Konkuk University, Korea (irs4u@kku.ac.kr), First Author
[2]Professor, Department of Dental Hygiene, College of Health Science, Dankook University, Korea (jhj@dankook.ac.kr), Corresponding Author

ARTICLE INFO

Article history:
Received 29 March 2024
Revised 11 April 2024
Accepted 25 April 2024

Keywords:
Foreign construction workers,
Improvement plans,
Quality of life,
Safety training status

ABSTRACT

This study aimed to investigate the effect of safety training measures to reduce the fatality rate from accidents among foreign construction workers and to provide a safer work environment, in conjunction with the Serious Accidents Punishment Act. A face to face interviews survey was completed by 171 foreign workers in the construction sector in Korea. Workers' safety culture, safety consciousness, safety participation behaviors, and human-based safety training were measured. In the multiple regression, the most significant revealed, first, that safety culture has a positive impact on safety consciousness, clearly demonstrating the relationship between workers' safety culture and their safety consciousness. Second, in terms of the relationship between safety culture and safety behavior, it was found that safety culture, especially communication and work environment, significantly positively affects safety participation behaviors. Third, regarding the relationship between safety consciousness and safety behavior, safety consciousness was found to have a very high positive impact on safety participation behaviors. This study marks an important milestone in the research on safety culture among foreign workers in the construction industry. It confirmed that strengthening workers' safety culture leads to an improvement in safety consciousness and a direct increase in safety participation behaviors, highlighting the role of safety consciousness and the importance of human-based safety training in this process. Construction industry stakeholders and policymakers should base their strategies for more effective safety management on these findings.

* This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2023S1A5A2A21083786).

1. Introduction

Recent issues that have become a focal point include a low birth rate hovering around 0.7, a rapid decline in the domestic working-age population, the influx of foreign workers into industries such as construction, and the ensuing problems associated with the Serious Accidents Punishment Act (Ju et al., 2024). These issues are not isolated but are interconnected like a chain.

To begin with, the low birth rate is expected to lead to a long-term population decline, specifically a decrease in the working-age population (economically active population), which could limit the country's economic growth potential and negatively impact the labor market. The shrinking working-age population leads to a labor shortage, which can become a serious issue, particularly in labor-intensive industries. Industries like construction are experiencing significant difficulties due to labor shortages. To address the labor shortage, South Korea has been allowing the influx of foreign workers since 2005 through the Employment Permit System, and in various industries, including construction, foreign workers have become a crucial labor resource. However, this has posed new challenges in terms of social integration, labor rights protection, and cultural differences.

In an effort to strengthen workplace safety, the Serious Accidents Punishment Act was introduced. This law imposes legal responsibilities on employers and corporations to ensure the safety of their workers. However, the law has increased the burden on business operations and can pose an even greater challenge, especially for small and medium-sized enterprises and industries where many foreign workers are employed.

According to the immigration statistics from the Ministry of Justice, as of 2022, there are approximately 2.2 million foreign nationals residing in the country. The primary nationalities of foreign workers include Chinese of Korean descent, along with nationals from China, Vietnam, Thailand, Uzbekistan, and the Philippines (Ministry of Justice, 2024).

Furthermore, in 2022, the average quarterly number of foreign workers employed in the construction sector was 5,639 (Korea Employment Information Service, 2024). A look at the industrial accident statistics for 2022 (last updated on January 18, 2024) from the National Statistical Portal (2024) shows that out of the 31,245 industrial accident victims in the construction industry, 3,511 (11.23%) were foreign workers (Ministry of Employment and Labor, 2023). According to the Korea Employment Information Service (2024), the fatality rate per 10,000 workers in the construction industry in 2022 was 2.16‰, which is approximately twice as high as the overall fatality rate of 1.10‰, suggesting that the construction industry has a higher rate of serious accidents compared to other sectors. When reviewing the rate of industrial accidents for foreign workers in construction based on the minimum and maximum number of employed workers, it is evident that between 15.56% and 60.03% are exposed to industrial accidents.

This study aims to contribute to the enhancement of labor market stability by providing practical and effective safety education. As one solution to these issues, we have developed digital human content, applying the latest technology for effective safety training specifically designed for foreign workers in the construction sector. The application of this training and its proven effectiveness is intended to deliver practical and impactful safety education.

To this end, the present study aimed to explore ways to provide effective safety education content

to foreign workers in the construction industry by implementing the latest digital human technology. This was approached through perception surveys and demand surveys targeting foreign workers, to identify their needs and the most effective methods to enhance their safety awareness and behaviors within the construction sector.

2. Theoretical Background

2.1 Prior research

According to the Industrial Safety and Health Encyclopedia, occupational safety and health education is defined as educating and training workers to recognize the importance of safety and to acquire the instructions or skills for safe work methods specific to the given task, as well as fostering a safety attitude towards the work performed. Furthermore, "Basic Safety and Health Education in Construction" refers to the training that construction day laborers must receive at the industry level to replace site-by-site hiring education provided by employers whenever they move to a different site, as mandated by Article 31 of the Occupational Safety and Health Act. This training is conducted at designated professional education institutions based on Article 28 of the enforcement regulations, with the aim to prevent accidents that workers may face in the process of their work (hereinafter referred to as "Basic Construction Safety Education").

This study aimed to analyze the impact of safety culture on safety awareness and behavior from the perspective of Basic Construction Safety Education. However, it was determined that there is a scarcity of related prior research. Studies related to foreign workers in the construction sector or conducted on workers in other sectors, not specifically targeting foreign construction workers, were reviewed.

As a study on the impact of safety culture on safety awareness and behavior, Kim (2019) researched the effects of safety culture on the safety awareness and behaviors of workers in the manufacturing sector, aiming to present ways to help these workers understand safety culture and improve their safety awareness and behaviors. For this purpose, workers from manufacturing companies in 50 industrial complexes, including the Korea Export Industrial Complex and the Seoul On Industrial Complex, among the 176 industrial complexes registered with the Korea Industrial Complex Corporation in the Seoul and Gyeonggi region, were selected as research subjects. The survey was conducted over approximately one month from August 1 to August 31, 2019, during which 300 questionnaires were distributed through middle managers and environmental health and safety managers at manufacturing companies, with 282 questionnaires ultimately being statistically processed after excluding 18 that were deemed to have been responded to insincerely. The research findings showed that, first, safety culture (safety climate, safety procedures) has a positive (+) impact on the safety awareness (recognition of importance, level of interest, and inducement of participation) of manufacturing sector workers. Second, safety culture (safety climate, safety procedures) has a positive (+) impact on the safety behaviors (safety planning, safety inspections) of manufacturing sector workers. Third, safety awareness (recognition of importance, level of interest, and inducement of participation) has a positive (+) impact on the safety behaviors (safety planning, safety inspections) of manufacturing

sector workers. Fourth, safety awareness (recognition of importance, level of interest, and inducement of participation) was found to have a partial mediating effect on the relationship between safety culture (safety climate, safety procedures) and safety behaviors (safety planning, safety inspections) of manufacturing sector workers.

Based on research conducted with the premise of such meanings, Kim and Ahn (2021) identified the characteristics and issues of foreign workers and considered the employment and working environment, as well as physical, psychological, physical, linguistic, cultural, and educational factors faced by foreign workers on domestic construction sites. They aimed to analyze the factors influencing safety consciousness by targeting 312 foreign workers working at large construction sites in Seoul and Gyeonggi Province, and the results of the research model analysis showed that as the safety of employment and labor increases, the intention of safety behavior also increases. Compared to the impact of subjective injury risks, it was recognized that employment and labor factors are specific to foreign workers.

Since the 1990s, the composition of workers on domestic construction sites has been shifting towards foreign workers, mainly in simple labor-intensive jobs. According to the 2019 Foreign Employment Survey, the total number of foreign workers is approximately 863,000, among which about 15,000 (11%) are estimated to be employed in the construction industry. The trend of aging of domestic workers and the increase in foreign construction workers help alleviate the chronic labor shortage in construction sites, thereby contributing to enhancing the competitiveness of the construction industry. However, there are serious risk factors in terms of safety management due to language and cultural differences of foreign workers, communication issues in construction sites with different occupations and trades, as well as the complex procedures of hiring foreign workers, labor shortages, and psychological pressure to comply with construction deadlines leading to the use of illegal residents for labor management issues. In this situation, this study aims to identify the characteristics and issues of foreign workers and to provide basic data for formulating measures to reduce safety accidents among foreign workers in domestic construction companies by considering the employment and working environment, as well as physical, psychological, physical, linguistic, cultural, and educational factors faced by foreign workers on construction sites in Seoul and Gyeonggi Province.

2.2 Safety consciousness and behavior, and safety culture

2.2.1 Safety consciousness

Safety consciousness refers to the degree to which workers' interest in safety, which they potentially possess, is manifested in concrete behaviors and practices. This was defined by the Ministry of Employment and Labor (2017). Depending on the extent to which individuals go beyond knowledge about safety to practice and implement it, safety consciousness is evaluated as strong or weak. Safety consciousness includes the willingness of individuals to protect themselves from cognitive awareness and risks, as well as an attitude of actively coping with tasks. It can be defined as proactive awareness and coping attitudes to create a safe environment and prevent accidents. Furthermore, it can be understood as a state that includes knowledge to secure and maintain the safety of work and the behavioral capacity in terms of safety based on this knowledge. In other words, safety consciousness signifies an active approach towards one's work, which serves as the driving force behind safety behavior.

2.2.2 Safety participation behavior

Safety participation, along with safety compliance, constitutes safety behavior (Neal et al., 2016). According to Heinrich's Domino Theory of Accident Causation, if the first step is the genetic social environment and the second step is personal fault as indirect causes of accidents, then unsafe behaviors and conditions in the third step become direct causes of accidents. Safety participation behavior is crucial for accident prevention, safety culture, and fostering a safe atmosphere in the workplace by assisting in compliance with regulations and procedures during work. Safety participation behavior is an important factor influencing accident reduction (Christian et al., 2009). This study focuses on safety behavior. Safety behavior can be defined as actions that ensure that a task is carried out safely. Safety behavior is heavily influenced by safety culture, and there is a school of thought that sees safety culture and safety behavior as interlinked. In fact, a study conducted in the United States analyzing the causes of industrial accidents over a 10-year period revealed that 76% of all accidents occurred due to behavior, and when including indirect factors of the work environment or behavior, 96% of accidents were found to be caused by behavior. Similarly, an analysis of the causes of industrial accidents in Korea showed that 70% of all accidents were caused by human behavior, and when including indirect factors of the environment and behavior, 94% of accidents were found to be caused by behavior (Korea Occupational Safety and Health Agency, 2018).

2.2.3 Safety culture

Safety culture refers to the attitude and behavior patterns in which organizations and individuals recognize the importance of safety and actively incorporate it into their daily lives and work. This term was first used in a report by the International Nuclear Safety Advisory Group (INSAG) following the 1986 Chernobyl nuclear power plant accident in the Soviet Union. At that time, the report defined safety culture as requiring dedication and responsibility from all individuals, and described it as the culmination of the attitudes and character of both organizations and individuals. In South Korea, following the collapse of the Sampoong Department Store in 1995, public interest in safety increased, leading the government to make efforts to promote safety culture. In October of the same year, the Safety Management Advisory Committee defined safety culture for the first time in Korea as a state where the values of safety come first for individuals or organizational members, and where consciousness and practices are structured around safety in personal lives or organizational activities. This encompasses a holistic meaning that encompasses all behaviors, ways of thinking, attitudes, etc., that concretely realize the dignity and value of human beings.

Yoo (2014) defined safety culture as a culture where all members of an organization prioritize personal and public safety, take responsibility for their own actions, engage in ongoing conversations, learning, correcting and modifying behaviors to enhance safety, and provide organizational rewards to ensure these values are consistently maintained. Safety culture is the result of the shared perceptions or beliefs related to workplace safety held by organizational members, representing the values, attitudes, and capabilities pursued by individuals and groups (Lee & Lee, 2023). According to Lee (2023), safety culture explains about 72% of safety participation behaviors and has been shown to promote safety participation behaviors.

3. Research Design

3.1 Research model and hypotheses

The aim of this study was to examine the influence of safety culture among foreign construction workers on safety participation behaviors, considering the mediating effect of safety consciousness and the moderating effect of human-based safety education. The research hypotheses to be tested through this study are as follows:

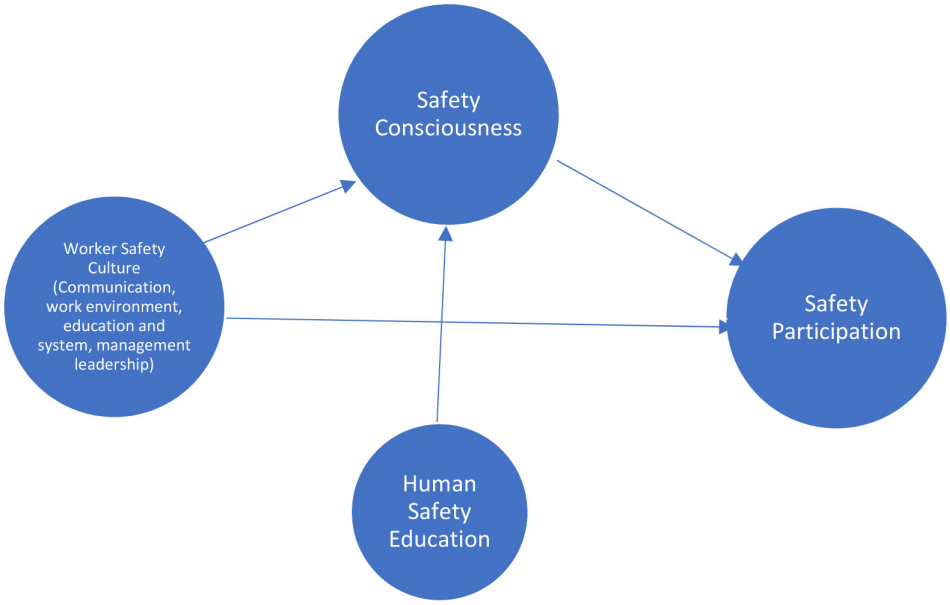

Fig. 1. Research Model

Hypothesis 1: Worker safety culture will influence safety participation behavior.
- Hypothesis 1-1: Communication within worker safety culture will influence safety participation behavior.
- Hypothesis 1-2: Work environment within worker safety culture will influence safety participation behavior.
- Hypothesis 1-3: Education and policies within worker safety culture will influence safety participation behavior.
- Hypothesis 1-4: Management leadership within worker safety culture will influence safety participation behavior.

Hypothesis 2: Worker safety culture will influence safety consciousness.
- Hypothesis 2-1: Communication within worker safety culture will influence safety consciousness.
- Hypothesis 2-2: Work environment within worker safety culture will influence safety consciousness.
- Hypothesis 2-3: Education and policies within worker safety culture will influence safety consciousness.

Hypothesis 2-4: Management leadership within worker safety culture will influence safety consciousness.
Hypothesis 3: Safety consciousness will influence safety participation behavior.
Hypothesis 4: There will be a mediating effect of safety consciousness in the relationship between worker safety culture and safety participation behavior.
Hypothesis 4-1: There will be a mediating effect of safety consciousness in the relationship between communication within worker safety culture and safety participation behavior.
Hypothesis 4-2: There will be a mediating effect of safety consciousness in the relationship between work environment within worker safety culture and safety participation behavior.
Hypothesis 4-3: There will be a mediating effect of safety consciousness in the relationship between education and policies within worker safety culture and safety participation behavior.
Hypothesis 4-4: There will be a mediating effect of safety consciousness in the relationship between management leadership within worker safety culture and safety participation behavior.
Hypothesis 5: There will be a moderating effect of human-based safety education in the relationship between worker safety culture and safety participation behavior.
Hypothesis 5-1: There will be a moderating effect of human-based safety education in the relationship between communication within worker safety culture and safety participation behavior.
Hypothesis 5-2: There will be a moderating effect of human-based safety education in the relationship between work environment within worker safety culture and safety participation behavior.
Hypothesis 5-3: There will be a moderating effect of human-based safety education in the relationship between education and policies within worker safety culture and safety participation behavior.
Hypothesis 5-4: There will be a moderating effect of human-based safety education in the relationship between management leadership within worker safety culture and safety participation behavior.

3.2 Data collection and variables

This study was designed to investigate the relationships among worker safety culture, safety consciousness, safety participation behavior of foreign workers in the construction industry in Korea, as well as the mediating effect of safety consciousness and the moderating effect of human-based safety education. The research was conducted based on data collected using a survey method.

The research data was collected through a survey conducted from February 1 to March 10, 2024, over a total of 40 days. The survey questionnaires were distributed through face-to-face interviews, with a total of 150 questionnaires distributed and 121 (80.7%) collected. The measurement tools include worker safety culture, safety consciousness, safety participation behavior, and human-based safety education as presented in Table 1.

This study is based on the voluntary participation of research participants, and all participants were provided with information regarding the purpose, methods, and anonymity assurance of the research. Participants expressed their consent to participate in the study by signing the research consent form (IRB Approval No: DKU 2023-07-025-004).

Table 1. Foreign worder survey structure diagram

Domain (Number of Items)		Item	Questionn-aire Method	Source
General Details (9)		Gender / Age / Number of Workers / Type of Work / Employment Status / Experience / Residence Status / Country of Origin / Industrial Accident Experience	Single-sentence Response	Industrial Safety and Health Act
Worker Safety Consciousness (4)		I am well informed about safety education.	5-point Likert scale	Foreign Workers Employment Act Employment Permit System - 16 Sending Countries
		Safety education contributes to increasing my safety consciousness level.		
		I practice safety education well at my site.		
		Safety education contributes to increasing my safety compliance rate.		
Safety Participation (3)		Workers at our site always work according to safety procedures and work standards.	5-point Likert scale	Lee (2011) Lee et al. (2021)
		Workers at our site voluntarily make efforts to improve safety at the workplace without being asked by the company.		
		Construction workers at our site can refuse to work if they consider it unsafe.		
Safety Culture	Communication (5)	Our site regularly asks employees for their opinions on construction safety.	5-point Likert scale	Ncal et al. (2000) Christian et al. (2009) Clake (2006)
		Our site has ample opportunities to discuss safety issues at meetings.		
		At our site, we openly discuss safety issues with each other.		
		At our site, we respond positively to members' suggestions regarding safety.		
		Our site has a system where suggestions for workplace safety can be made.		
	Work Environment (3)	Our site is well organized and tidy.	5-point Likert scale	HSE (2001) Technoplis et al. (2005) Kines et al. (2011) Park et al. (2018)
		Our site has separate areas for vehicle operation, work zones, and pedestrian pathways.		
		Our site is equipped with facilities, equipment, and protective gear to work safely.		
	Education and System (4)	Our site provides ample opportunities for safety and health education and training for employees.	5-point Likert scale	HSE (2001)
		Safety and health education and training at our site are practically helpful in preventing accidents.		
		Our site has systematic safety regulations and procedures.		
		Safety regulations and procedures at our site significantly help in accident prevention.		
	Management Leadership (4)	The management of our company prioritizes safety.	5-point Likert scale	Lee et al. (2020)
		The management of our company considers safety important.		
		The management of our company strongly emphasizes the health and safety of workers.		
		The management of our company considers the balance between workers' lives and work important.		

Table 1. Cont.

Domain (Number of Items)	Item	Questionn-aire Method	Source
Demands for the Development Direction of Basic Construction Safety and Health Education (4)	Effective Frequency of Safety Education	Single-sentence Response	HSE (2001) Technoplis, et al. (2005) Lee et al. (2020)
	Factors Enhancing the Effectiveness of Education	Single-sentence Response	Lee (2011) Lee et al. (2021) Shin (2017) Baek (2017) Shepherd et al. (2021) Korea Information and Communication Association Safety Technology Institute Industrial Technical Data Korea Occupational Safety and Health Agency - Industrial Accident Statistics
	Elements Required for a Safe Construction Site	Multiple-sentence Responses	
	Educational Methods Suitable for the Top 3 Accident Types	Single-sentence Response	
	Additional Comments	Open-ended Response	

3.3 Statistical analysis

In this study, empirical analysis was conducted as follows to verify the established hypotheses through statistical processing of the collected questionnaires after the data coding process, using the SPSS (Statistical Package for Social Science) 22.0 Korean version program.

First, frequency analysis was conducted to analyze the demographic characteristics and general features of the survey respondents.

Second, descriptive analysis was performed to assess the normality of the measurement tools.

Third, an exploratory factor analysis was conducted to review the conceptual validity of the survey items. Specifically, the principal component extraction method was used, and Varimax rotation was applied. Items that loaded on other factors or had factor loadings below 0.4 were excluded, with Eigen values set at 1 as the threshold. Additionally, reliability analysis was conducted to verify the internal consistency of the measurement variables.

Fourth, bivariate correlation analysis was conducted to understand the relationships between the measurement variables.

Fifth, multiple regression analysis and simple regression analysis were conducted to verify the direct effects of each variable.

Sixth, Hayes Model 4 and 5 were used to examine the mediating and moderating effects.

The significance level used in this study was interpreted based on $p<0.05$.

4. Results

4.1 Characteristics of participants

In this study, out of the 121 surveys collected, excluding dishonest participants and missing values, a total of 103 surveys were finally analyzed, and the results are as shown in Table 3. In terms of gender, 77 males (74.8%) and 26 females (25.2%) participated in the survey. In terms

of family structure, the highest proportion was seen in couples with children, with 43 individuals (41.7%), followed by singles (27 individuals, 26.2%), couples (23 individuals, 22.3%), and couples with children and parents (10 individuals, 9.7%).

Regarding age, there were 11 individuals in their 20s (10.7%), 16 in their 30s (15.5%), 27 in their 40s (26.2%), and 49 in their 50s (47.6%), showing the highest participation rate among those in their 50s. In the survey asking about the number of employees at the workplace, the highest number of participants (32 individuals, 31.1%) worked in companies with 20-299 employees, followed by 500-999 employees (31 individuals, 30.1%), and then companies with fewer than 20 employees and 300-499 employees, each accounting for 19.4%.

In terms of employment type, there were 11 full-time employees (10.7%) and 92 part-time employees (89.3%), with subcontractors (101 individuals, 98.1%) being the majority. In terms of construction work experience, 58 individuals (56.3%) had over 3 years of experience, with 14 individuals (13.6%) having 2-3 years of experience, and 8 individuals each having less than 6 months to 1 year or 1-2 years of experience.

Regarding residential status, the survey revealed that H-2 visa holders accounted for the highest proportion with 41 individuals (39.8%), followed by F-4 visa holders (27 individuals, 26.2%) and F-5 visa holders (18 individuals, 17.5%). In addition, in the survey on countries of origin, China had the highest number of participants with 84 individuals (81.6%), followed by Vietnam with 10 individuals (9.7%). In the survey on industrial accident experience in the construction industry, the majority of respondents (92 individuals, 89.3%) reported no such experience.

Table 2. Structure of survey for foreign workers

Questionnaire items		Frequency	Percentage
Sex	Male	77	74.8
	Female	26	25.2
Type of Family	(Married) couple	23	22.3
	(Married) couple + children	43	41.7
	(Married) couple + children + Parents	10	9.7
	Unmarried	27	26.2
Age	Twenty	11	10.7
	Thirty	16	15.5
	Forty	27	26.2
	Fifty	49	47.6
Number of worker	20 or fewer members	20	19.4
	20-299 members	32	31.1
	300-499 members	20	19.4
	500-999 members	31	30.1
Job Types	Full-time worker	11	10.7
	Daily worker	92	89.3
Forms of Employment	Original contract	2	1.9
	Cooperative firm	101	98.1

Table 2. Cont.

Questionnaire items		Frequency	Percentage
Work Experience in Construction Industry	Under 6 months	7	6.8
	6 months-1year	9	8.7
	1-2year	15	14.6
	2-3year	14	13.6
	3 years or more	58	56.3
Qualifications for Stay	H-2	41	39.8
	F-2	8	7.8
	F-4	28	26.2
	F-5	18	17.5
	Etc.	9	8.7
Country of Origin	China	84	81.6
	Vietnam	10	9.7
	Etc.	9	8.7
Experience of business accident	None	92	89.3
	1-2 times	11	10.7

4.2 Descriptive statistics

In the descriptive statistics analysis conducted on the variables selected in this study, the results are as follows in Table 3. The analysis results for safety culture among workers indicate that communication was 3.21 ± 1.23, working environment was 3.94 ± 0.72, education and system were 3.71 ± 0.85, and management leadership was 3.69 ± 0.89, with the working environment yielding the highest average and communication being the lowest.

For safety consciousness, it was identified as 3.89 ± 0.82, safety participation behavior as 3.58 ± 0.98, and the need for safety education content as 4.01 ± 0.64. The skewness and kurtosis of the data used in this study were analyzed, and the results indicated that the data used in this study conform to the criteria of skewness (absolute value) less than 1 and kurtosis (absolute value) less than 7, confirming that the data used in this study assume a normal distribution (Sung et al., 2011).

Table 3. Descriptive statistics of participants

Items		Mean	Standard Deviation	Skewness	Kurtosis
Worker Safety Culture	Communication	3.21	1.23	-0.26	-1.08
	Work Environment	3.94	0.72	0.08	-0.88
	Education and System	3.71	0.85	-0.04	-0.54
	Management Leadership	3.69	0.89	0.13	-1.11
Safety Consciousness		3.89	0.82	-0.39	-0.21
Safety Participation		3.58	0.98	-0.19	-0.88
Necessity of Safety Education Contents		4.01	0.64	-0.57	-0.69

4.3 Exploratory factor analysis

4.3.1 Exploratory factor analysis and reliability of worker safety culture

The exploratory factor analysis results for communication, working environment, education and system, and management leadership, which are sub-factors of worker safety culture, selected as independent variables in this study, were extracted into four factors as shown in Table 4. According to this table, the eigenvalues range from 3.076 to 4.797, all exceeding 1.0, indicating clear classification of all factors. The total cumulative variance was 86.564%, and factor loading was greater than 0.4, demonstrating both convergent and discriminant validity among the measurement variables of the same factor. Additionally, the KMO value was .914, and in Bartlett's sphericity test, the value was 1832.375 (df=105, p=.000). Specifically, communication consisted of five related items with an eigenvalue of 4.398, explaining 39.317% of the variance. Education and system consisted of four related items with an eigenvalue of 3.318, explaining 22.122% of the variance. Management leadership consisted of four items with an eigenvalue of 3.189, explaining 21.262% of the variance, and was selected as factors for further research. While the working environment initially consisted of three items, during the factor analysis process, it was found that item 3 was incorporated into another factor, leading to its removal. After deletion, the remaining two items had an eigenvalue of 2.079, explaining 13.826% of the variance. The reliability analysis results indicated that the Cronbach's Alpha values for all four factors were above 0.6, confirming the soundness of the measurement tool.

Table 4. Results of exploratory factor analysis and reliability analysis of worker safety culture

Questionnaire Items	Component			
Education and System2	1	2	3	4
Education and System1		0.754		
Education and System4		0.729		
Management Leadership3		0.723		
Management Leadership1			0.838	
Management Leadership2			0.757	
Management Leadership4			0.713	
Work Environment1			0.674	
Work Environment2				0.831
Eigen-value				0.780
Variances Explained(%)	4.398	3.318	3.189	2.079
Cumulative dispersion value(%)	29.317	22.122	21.262	13.862
Cronbach Alpha	0.961	0.930	0.954	0.812

4.3.2 Exploratory factor analysis and reliability analysis of safety consciousness and safety participation behavior

The exploratory factor analysis results of safety consciousness and safety participation behavior,

which are the mediating and dependent variables of this study, were extracted into two factors as shown in Table 5. The KMO value was .887, and in Bartlett's sphericity test, the value was 535.923 (df=15, p=.000). In the case of safety consciousness, item 1 of safety consciousness was found to be included in the factor of safety participation behavior, leading to its removal. After deletion, the eigenvalue was 2.581, explaining 43.023% of the variance, and was selected as the safety consciousness factor. For the exploratory factor analysis of safety participation behavior, item 4 of safety participation behavior was found to be included in safety consciousness, resulting in its removal. After deletion, the eigenvalue was 2.510, explaining 41.839% of the variance. In the reliability analysis, the Cronbach's Alpha values were above 0.6, indicating no issues with the measurement tool.

Table 5. Results of exploratory factor analysis and reliability analysis of safety consciousness and safety participation behavior

Questionnaire Items	Component	
	1	2
Safety Consciusness4	0.881	
Safety Consciusness3	0.820	
Safety Consciusness2	0.756	
Safety Participation Behavior2		0.885
Safety Participation Behavior1		0.798
Safety Participation Behavior3		0.731
Eigen-value	2.581	2.510
Variances Explained(%)	43.023	41.839
Cumulative dispersion value(%)	43.023	84.861

4.4 Correlation analysis

The results of the correlation analysis conducted to understand the relationships between the selected factors in this study, including communication, working environment, education and system, management leadership, safety consciousness, and safety participation behavior, are shown in Table 6. Communication yielded the highest significant positive correlation of .735 ($p<0.01$) with education and system, followed by .773 ($p<0.01$) with management leadership, and .762 ($p<0.01$) with safety participation behavior. In the analysis of working environment, management leadership showed positive correlations of .711 ($p<0.01$), education and system of .624 ($p<0.01$), safety participation behavior of .593 ($p<0.01$), and safety consciousness of .549 ($p<0.01$).

In the correlation analysis related to education and system, management leadership showed correlations of .754 ($p<0.01$), safety participation behavior of .662 ($p<0.01$), and safety consciousness of .597 ($p<0.01$). Management leadership demonstrated significant positive correlations of .670 ($p<0.01$) with safety participation behavior and .560 ($p<0.01$) with safety consciousness. For safety consciousness, a significant correlation of .821 ($p<0.01$) was found with safety participation behavior.

Table 6. Correlation analysis results

Factor Order	Communication	Work Environment	Education and System	Management leadership	Safety Consciousness	Safety Participation Behavior
Communication	1					
Work Environment	0.569**	1				
Education and System	0.795**	0.624**	1			
Management leadership	0.773**	0.711**	0.754**	1		
Safety Consciousness	0.640**	0.549**	0.597**	0.560**	1	
Safety Participation Behavior	0.762**	0.593**	0.662**	0.670**	0.821**	1

** $p<0.01$

4.5 Hypothesis testing

4.5.1 Direct effects analysis

The results of the multiple regression analysis conducted to examine hypotheses 1, 2, and 3 selected in this study are as shown in Table 7. First, looking at the analysis results of hypothesis 1, which examines the influence of safety culture on safety participation behavior, it is shown that communication in safety culture had a statistically significant positive impact on safety participation behavior with β=.585 ($p<0.01$), while the work environment showed a positive impact on safety participation behavior with β=.213 ($p<0.05$). These results indicate that as the elements of communication and work environment in safety culture increase, safety participation behavior also increases. It was confirmed that communication has a higher impact on safety participation behavior compared to the work environment. Based on these analysis results, hypotheses 1-1 and 1-2 of this study were accepted, while hypothesis 1 was partially accepted.

Analyzing the impact of safety consciousness, a mediating variable in this study, it was found that communication had a positive impact on safety consciousness with β=.441 ($p<0.01$), and the work environment had a positive impact on safety consciousness with β=.272 ($p<0.05$). This indicates that as safety consciousness and the work environment increase, safety consciousness also increases. Based on the analysis results, hypotheses 2-1 and 2-2 of this study were accepted, while hypothesis 2 was partially accepted. The influence of safety consciousness on safety participation behavior showed a statically significant positive impact with β=.821 ($p<0.01$), confirming that higher safety consciousness leads to higher safety participation behavior. Hypothesis 3 of the study was accepted.

Table 7. Direct effects analysis

Hypothesis	Independence	Subordination	B	S.E	β	t	p	F	R^2
1-1	**Communication**	Safety Participation Behavior	0.473	0.092	0.585	5.159	<0.001**	40.50**	0.625
1-2	**Work Environment**		0.293	0.124	0.213	2.372	0.020*		
1-3	**Education and System**		0.026	0.131	0.011	0.200	0.842		
1-4	**Management Leadership**		0.062	0.129	0.056	0.480	0.633		
2-1	**Communication**	Safety Consciousness	0.299	0.091	0.441	3.285	0.001**	21.88**	0.474
2-2	**Work Environment**		0.313	0.122	0.272	2.559	0.012*		
2-3	**Education and System**		0.115	0.130	0.118	0.883	0.379		
2-4	**Management Leadership**		-0.051	0.128	-0.055	-0.397	0.692		
3	**Safety Consciousness**	Safety Participation Behavior	0.982	0.068	0.821	14.432	<0.001**	208.290**	0.670

** p<0.01

4.5.2 Mediation effects analysis

The results of the analysis using Hayes Model 4 (Bootstrapping, 5000 iterations) to examine the mediating effects of safety consciousness, a mediating variable selected in this study, are as shown in Table 8.

For the influence of communication on safety participation behavior, the mediating effect of safety consciousness ranged from .2018 to .4006, showing a significant mediating effect that did not cross the zero benchmark. In the case of the influence of the work environment on safety participation behavior, the mediating effect of safety consciousness ranged from .3543 to .7413. Similarly, for the influences of education and systems, as well as managerial leadership on safety participation behavior, the mediating effects of safety consciousness ranged from .3222 to .6110 and .2829 to .5201, respectively. Statistically significant mediating effects were observed in all mediation effect analyses. Based on these mediation effect analysis results, hypotheses 4-1, 4-2, 4-3, and 4-4 of this study were accepted, and hypothesis 4 was accepted.

Table 8. Safety consciousness mediation effects analysis

Hypothesis	Independence	Means	Subordination	Effect	Boot SE	Boot LLCI	Boot ULCI
4-1	**Communication**	Safety Consciousness	Safety Participation Behavior	0.2894	0.0506	0.2018	0.4006
4-2	**Work Environment**			0.5320	0.0986	0.3543	0.7413
4-3	**Education and System**			0.4603	0.0737	0.3222	0.6110
4-4	**Management Leadership**			0.3991	0.0604	0.2829	0.5201

4.5.3 Moderating effects of human-centered safety training

In order to examine the moderating effects of human-centered safety training, selected as a moderating variable in this study Table 9, Hayes Model 5 was used for the analysis. The analysis results showed that in the influence of education and systems on safety participation behavior, the interaction term of human-centered safety training (A×C) had a β of .23 ($p<.05$), and with the addition of the interaction term, the change in the R-squared value was .0157 ($p<.05$), indicating the moderating effect of human-centered safety training could be identified. Based on these results, hypothesis 5-3 of this study was accepted.

In the influence of managerial leadership on safety participation behavior, the interaction term of human-centered safety training (A×C) had a β of .15 ($p<.05$), and with the addition of the interaction term, the change in the R-squared value was .0093 ($p<.05$), indicating the moderating effect of human-centered safety training could be identified. Based on these results, hypothesis 5-4 of this study was accepted, while hypothesis 5 was partially accepted.

Table 9. Moderating effects of human-centered safety training

Hypothesis	Independence	Subordination	β	S.E	t	p	LLCI	ULCI	F	R^2
5-1	**Communication(A)**	Safety Participation Behavior	0.24	0.07	3.54	<0.001**	0.11	0.38	84.09	0.774
	Safety Consciousness(B)		0.74	0.08	8.79	<0.001**	0.57	0.09		
	Human Safety Education(C)		-0.12	0.08	-1.50	0.14	-0.29	0.04		
	A X C		0.09	0.07	1.22	0.23	-0.06	0.24		
5-2	**Work Environment(A)**		0.23	0.09	3.26	0.011**	0.11	0.45	67.60	0.734
	Safety Consciousness(B)		0.85	0.07	11.43	<0.001**	0.71	1.00		
	Human Safety Education(C)		-0.25	0.07	-3.40	0.001**	-0.40	-0.10		
	A X C		0.10	0.11	0.90	0.37	0.12	-0.32		
5-3	**Education and System(A)**		0.25	0.07	3.29	0.001**	0.10	0.39	75.94	0.758
	Safety Consciousness(B)		0.80	0.07	10.69	<0.001**	0.65	0.95		
	Human Safety Education(C)		-0.23	0.07	-3.23	0.002**	-0.37	-0.09		

** $p<0.01$

5. Discussion

5.1 Relationship between safety culture and safety consciousness

The results of this study clearly demonstrate that employee safety culture has a positive impact on safety consciousness. In particular, the two sub-factors of communication and work environment

were found to play important roles in enhancing safety consciousness. This suggests that effective communication within safety culture helps shape employees' perception and attitude towards safety and that the safety of the work environment strengthens employees' safety consciousness. These research findings are consistent with previous studies such as Lee (2014), which found a high correlation between organizational safety culture and employee safety consciousness, So (2017), which showed that sub-variables of safety culture such as safety climate and safety procedures have a positive impact on safety consciousness, and Choi and Oh (2015), which indicated an inseparable relationship between safety culture and safety consciousness. Therefore, construction companies need to focus on improving the quality of communication and work environment to enhance employees' safety consciousness.

5.2 Relationship between safety culture and safety behavior

In this study, employee safety culture, especially communication and work environment, was found to have a significant positive impact on safety participation behavior. This indicates that safety culture can have a direct impact on enhancing actual safety behavior among employees, rather than just being a theoretical concept. These research findings support previous studies such as Neal and Griffin (2016), who discovered a positive relationship between safety culture and safety behavior, Lee et al. (2011), who found that safety climate is significantly linked to safety behavior, and Mohamed (2002), who confirmed a significant positive relationship between safety culture and safety behavior in the construction industry. Therefore, when employees effectively communicate in a safe working environment, they tend to exhibit higher levels of safety participation behavior, ultimately enhancing the safety standards of the workplace. These findings emphasize the importance of safety culture in the construction industry and can contribute to the development of specific strategies to promote employee safety participation.

5.3 Relationship between safety awareness and safety behavior

This study revealed that safety awareness has a significant positive impact on safety participation behavior. This means that as workers' awareness of safety increases, safety participation behaviors such as compliance with safety regulations and preventive actions against risks also increase. These findings suggest that programs and education aimed at enhancing safety awareness can play a crucial role in promoting safety behaviors. These research results align with previous studies such as Lee's study (2017) on automobile factory workers, a study by the Korea Occupational Safety and Health Agency applying industrial injury prevention programs (2018), and a study by Jeong and Kim (2008) on semiconductor industry workers in Korea, all of which demonstrated that safety awareness positively influences safety behavior. Therefore, organizations should seek various ways to strengthen safety awareness and support workers in translating this awareness into actual behaviors.

6. Conclusion and Recommendations

As the employment permit system is implemented and the demand for foreign workers in the construction industry increases, the industrial accident mortality rate of foreign workers in the construction industry is also significantly rising. In this context, this study aimed to explore effective safety education methods to reduce the accident mortality rate of foreign workers in the construction industry and provide a safe working environment, particularly by implementing up-to-date digital human technologies to deliver effective safety education content to foreign workers in the construction industry.

Based on a survey conducted from February 1, 2024, to March 10, 2024, targeting foreign workers in the construction industry in South Korea, this study analyzed the relationships among workers' safety culture, safety awareness, safety participation behavior, the mediating effects of these factors, and the moderating effects of human-based safety education. Through statistical analysis of the survey results, the study confirmed the impact of workers' safety culture on safety awareness and safety participation behavior and verified the mediating role of safety awareness and the moderating effects of human-based safety education in these relationships.

Firstly, the relationship between workers' safety culture and safety participation behavior was examined. The study confirmed that workers' safety culture significantly influences safety participation behavior, highlighting the importance of communication and work environment factors in safety participation behavior. Effective communication among workers and creating a safe working environment were identified as key factors in increasing workers' safety participation behavior, emphasizing the need for the construction industry to pay more attention to improving communication and work environment to strengthen workers' safety culture.

Secondly, the mediating role of safety awareness was explored. The analysis results showed that safety awareness acts as an important mediating variable between workers' safety culture and safety participation behavior. This means that as workers' awareness of safety increases, their safety participation behavior also increases. The mediating role of safety awareness was confirmed in all aspects, including communication, work environment, education and regulations, and management leadership. This underscores the essential nature of raising safety awareness for improving safety culture and promoting safety participation behavior.

Thirdly, the moderating effects of human-based safety education were investigated. The study revealed that human-based safety education has a moderating effect on the influence of education and regulations and management leadership on safety participation behavior. Human-based safety education helps workers acquire knowledge and skills related to safety, thereby enhancing safety awareness and promoting safety participation behavior. Therefore, beyond mere compliance with rules, it is crucial for the construction industry to create an environment where workers value safety and actively participate.

This study presents a significant milestone in safety culture research targeting foreign workers in the construction industry. It was confirmed that enhancing workers' safety culture leads to an improvement in safety awareness and a direct increase in safety participation behavior, emphasizing the role of safety awareness and the importance of human-based safety education in this process. The construction industry and policymakers should formulate more effective safety management

strategies based on these results.

One limitation of this study is that it focused on foreign workers in the construction industry in South Korea at a specific time, which may limit the generalizability of the results. Future research should verify the generalizability of the study results through additional research in various countries and industries and further explore the relationships among safety culture, safety awareness, and safety participation behavior in more depth.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

Act on the Punishment of Major Accidents and Others. [Enforcement Jan. 27, 2022.] [Act No. 17907, Jan. 26, 2021, Enacted]. Retrieved from https://www.law.go.kr/%EB%B2%95%EB%A0%B9/%EC%A4%91%EB%8C%80%EC%9E%AC%ED%95%B4%EC%B2%98%EB%B2%8C%EB%93%B1%EC%97%90%EA%B4%80%ED%95%9C%EB%B2%95%EB%A5%A0.

Cho, S. (2022). A study on the perception of industrial safety management of safety vulnerable groups: focusing on foreign workers in Chungcheongnam-do. *Journal of the Korean Private Security Association, 21* (4), 141-160.

Choi, H. (2015). A study on the current status analysis and improvement measures of safety culture movement for enhancing safety consciousness. Seoul: Korea Institute of Public Administration.

Christian, M. S., Bradly, J. C., & Burke, M. J. (2009). Workplace safety: a meta-analysis of the roles of person and situation factors. *Journal of Applied Psychology, 94* (5), 1103-1127.

Jeong, N., & Kim, H. (2008). An empirical study on the workplace safety atmosphere in the Korean semiconductor industry and the safety behaviors of workers. *Journal of the Korean Society of Safety, 23* (2), 57-64.

Ju, S., Noh, Y., Jang, J-H., & Hyun, B. (2024). Analysis and policy implications of industrial accident trends among foreign construction workers. *Korean Journal of Local Government & Administration Studies, 38* (1), 237-260.

Kim, D., & Ahn, H. (2021). Analysis of safety behaviors of foreign workers at domestic construction sites. *Journal of Standard Certification and Safety, 11* (3), 43-56.

Kim, J. (2019). The impact of safety culture on safety consciousness and safety behaviors of manufacturing industry workers - focusing on the mediating effect of safety consciousness. *Journal of the Korean Society for Content Management, 19* (12), 151-163.

Korea Employment Information Service. (2022). Employment status of foreign workers by industry (1st quarter 2022~4th quarter 2022). Retrieved from https://eis.work.go.kr/eisps/rpt/reptDtl.do?menuId=030020020 [Accessed Jan. 24, 2024].

Lee, J. E. (2017). An illustrated guide to medical statistics using SPSS. Seoul: Hannarae, 38-40.

Lee, J., Lee, J., & Seok, D. (2011). Confirmation of sub-factors of organizational safety climate and its relationship with safety behaviors. *Journal of the Korean Psychological Association: Industrial and Organizational, 24* (3), 627-650.

Lee, K. J. (2014). The effect of safety climate and safety awareness on the job satisfaction and organizational commitment: Mediation effect of organization trust (Master's thesis). Soon Chun Hyang University, Asan, Korea.

Lee, S. (2017). A study on factors influencing safety behaviors of organizational members by safety culture (Master's thesis). Hanseo University, Seosan, Korea.

Lee, S. W. (2018). Exploring the relationships between safety leadership organizational safety culture and safety behavior (Master's thesis). Keimyung University, Daegu, Korea.

Lee, W. J., & Lee, S. K. (2023). Effect of safety culture on safety participation action: focus on the moderating effect of the working ratio of elderly workers and foreign workers. Korean *Journal of Safety Culture, 23*, 125-141.

Ministry of Employment and Labor. (2018). Status of industrial accidents in 2017.

Ministry of Employment and Labor. (2023). Statistics on industrial accidents of foreign workers in the construction industry - information disclosure request data. Retrieved from https://www.open.go.kr/com/main/mainView.do?mainBgGubun=search [Accessed Nov. 21, 2023].

Ministry of Justice (National Statistical Portal, Employment by industry (immigrants)). (2024). Foreign residents, immigration statistics data. Retrieved from https://www.moj.go.kr/moj/2412/subview.do [Accessed Jan. 24, 2024].

Mohamed, S. (2002). Safety climate in construction site environments. *Journal of Construction Engineering and Management, 128* (5), 375-384.

National Statistical Portal. (2024). Overall accident status and analysis by industry (classification by industry), https://kosis.kr/statHtml/statHtml.do?orgId=118&tblId=DT_11806_N000&checkFlag=N [Accessed Jan. 24, 2024].

Neal, A., & Griffin, M. A. (2000). Perception of safety at work: a framework for linking safety climate to safety performance, knowledge and motivation. *Journal of Occupational Health Psychology, 5* (3), 347-358.

Neal, A., & Griffin, M. A. (2016). A study of the lagged relationships among safety climate, safety motivation, safety behavior, and accidents at the individual and group levels. *Journal of Applied Psychology, 91*, 946-953.

Sung, D., Lee, H., Lee, S., Jang, C., & Choi, I. (2011). Utilization of SPSS easy statistical techniques. Seoul: Daemyung.

Yoo, S. Y. (2014). *An empirical study on the effect of safety culture on the safety climate and safety behaviors* (Master's thesis). Korea Aerospace University, Goyang, Korea.