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A Study on Improving the Effectiveness of Special Safety and Health Education in the Construction Industry through Empirical Analysis

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Abstract

Purpose: This study aims to diagnose the operational status of special safety and health training for high-risk workers at construction sites, empirically analyze the impact of qualitative training factors on workers' safety behaviors, and propose effective improvement measures. **Research design, data and methodology:** A survey was administered to 365 workers and safety managers at 20 construction sites across the country. Descriptive statistics, reliability analysis (Cronbach's α), multiple regression analysis, and mediation effect analysis (Baron & Kenny's 3-step approach, Sobel Test) were executed using SPSS 28.0. **Results:** The operational review identified two major deficiencies: the practical difficulty of fulfilling legally mandated training hours and the repeated reliance on generic instructional materials disconnected from real site conditions. The empirical examination confirmed that training quality dimensions—namely content relevance, instructor expertise, and smart media adoption—exerted a significant positive effect on both training satisfaction and behavioral commitment toward safety. Smart media adoption via VR and mobile platforms registered the strongest effect on safety behavior change (β=.418, $p<.001$), underscoring the primacy of immersive, visually driven instruction. **Conclusions:** Drawing on these findings, this study advocates for the introduction of an IT-based Smart Safety Education System (S-SES) and the legislative institutionalization of micro-learning sessions tied to daily TBM (Tool Box Meetings). The outcomes are anticipated to offer essential scholarly and applied reference material for developing safety and health training guidelines that support a self-regulatory prevention culture at construction sites.

Keywords: Construction Safety, Special Safety and Health Education, Educational Effectiveness, Safety Behavior, Smart Safety Education, Mediation Effect

JEL Classification Code: J28, J61, L74, K32

1. Introduction

1.1. Research Background and Necessity

Relative to other sectors, the construction industry concentrates a disproportionate share of high-risk activities, rendering workplace accidents particularly prone to catastrophic outcomes. Data published by the Korea Occupational Safety and Health Agency (KOSHA, 2023) show that construction workers comprise more than half of all occupation-related fatality victims nationally, with fall incidents, dropped materials, and structural failures constituting the dominant accident categories. To address this, the government embedded a mandatory 'Special Safety and Health Training' requirement within the Occupational Safety and Health Act, covering 40 categories of hazardous work.

The legislative landscape shifted considerably when the Serious Accidents Punishment Act took effect

in 2022. The statute elevated the supervisory competence of line managers and workers' capacity to perceive site-level risks to the status of primary accident-prevention benchmarks. Critically, it placed direct accountability on chief executives for the substantive operation of safety training programs, thereby enshrining in law the imperative to move beyond perfunctory compliance toward genuinely effective educational structures (Lee, 2019).

Despite these regulatory advances, special safety and health training at construction sites continues to prioritize formal fulfilment of the statutory hour requirement (8–16 hours) over substantive learning. Persistent criticism holds that course materials consist overwhelmingly of generic theory ill-suited to the particularities of individual sites, impeding the 'Transfer of Training' to actual work contexts. Compounding this, the accelerating digital transformation of construction operations has not been mirrored in training delivery, which remains anchored to conventional didactic formats incapable of meeting evolving worker needs (Ministry of Employment and Labor, 2024).

Prior research in this domain has been predominantly restricted to attitudinal surveys or isolated case studies, leaving unresolved how qualitative training variables translate into measurable behavioral change among workers (Shin et al., 2015). Addressing this gap necessitates empirical investigation of the structural relationships linking training content, instructional methodology, educational media, and safety behavior outcomes..

1.2. Purpose of the Study

This study undertakes a precise assessment of the operational state of special safety and health training at key construction sites in the Seoul metropolitan region and across the country. It further seeks to empirically quantify the effect of training quality dimensions—content relevance, instructor expertise, and smart media adoption—on worker satisfaction and tangible shifts in safety behavior. Three operational aims guide the inquiry:

First, to quantitatively characterize the current delivery of special safety and health training, including methods employed, hours allocated, instructor credentials, and the degree of technology integration in use.

Second, to empirically trace the causal chain by which training quality attributes, mediated by training satisfaction, ultimately shape workers' disposition to enact safety behaviors.

Third, to translate analytical findings into concrete policy and operational recommendations—including the deployment of an IT-driven Smart Safety Education System (S-SES) and the codification of TBM-linked micro-learning —that strengthen the practical impact of on-site training.

2. Theoretical Background

2.1. Review of the Special Safety and Health Training System in the Construction Industry

Under Article 29 of the Occupational Safety and Health Act, employers are obligated to complete special safety and health training before deploying any worker to a task classified as hazardous or dangerous. Supplementary Table 5 of the Act's Enforcement Regulations enumerates 40 qualifying work categories and prescribes minimum training durations—eight hours for initial placement, sixteen hours for short-duration roles, and one hour for daily-contract workers. The content must address the distinctive risk profile of each task type, relevant protective measures, and proper personal protective equipment (PPE) use.

The construction sector presents structural challenges that make training delivery uniquely complex: a workforce dominated by short-term contractors and task configurations that shift constantly. These characteristics elevate 'timeliness' and 'contextual fit' to decisive determinants of program success. An operational audit conducted by the Ministry of Employment and Labor (2024) found that 68.3% of surveyed participants acknowledged maintaining completion records while conceding that the material rarely translates into usable field knowledge—a pronounced gap between documented compliance and practical impact.

2.2. Training Effectiveness Theory and Safety Behavior Transfer Model

The four-level evaluation framework developed by Kirkpatrick & Kirkpatrick (2016) offers the primary theoretical lens for this study. Within that model, learner reaction to training (Level 1) stimulates knowledge acquisition (Level 2) and progressively gives rise to on-site adherence to safety protocols (Level 3). This study leverages that progression to empirically trace the pathway through which training quality shapes satisfaction, which in turn drives behavioral transfer.

Reason's (1997) Swiss Cheese Model supplies the systemic perspective underpinning this analysis. The model posits that accidents materialize when latent

organizational vulnerabilities align with active operational failures. In this framework, superficial training widens the gaps in institutional defenses, making the case for substantive educational interventions a matter of system integrity.

Safety Behavior denotes the suite of on-site protective actions—PPE wear, hazard correction, pre-task verification—grounded in knowledge imparted through training (Seo & Do, 2024). Risk Perception captures an individual's cognitive capacity to detect latent site hazards before they materialize into incidents. Emerging scholarship documents that visually immersive smart-media instruction substantially elevates workers' risk perception acuity (Park & Koo, 2022).

2.3. Utilization of Smart Safety Education Media and Edutech

The construction safety field has witnessed rapid uptake of Edutech solutions—VR, AR, and mobile platforms—as complements or alternatives to conventional classroom delivery. Scenario-based simulation, which immerses workers in rendered high-risk environments, generates more potent cognitive encoding than text-driven lectures and meaningfully strengthens emergency responsiveness (Park & Koo, 2022).

Lee et al. (2021) provided empirical confirmation that safety-awareness levels, safety-practice proficiency, and instructional format each independently predict the perceived adequacy of the training system among foreign construction workers, thereby calling for customized, site-sensitive media. Son (2025) further demonstrated that language-mediated safety instruction—specifically 'Safety Korean' curricula—reduces communication barriers and concretely improves hazard recognition and safety responsiveness among non-native workers. Collectively, these findings signal that the modernization of training media transcends technical convenience, yielding measurable safety dividends.

3. Research Method

3.1. Research Design and Research Model

This study is structured as a causal inference investigation grounded in an input–process–output logic model designed to empirically establish the effectiveness of special safety and health training in construction. Three independent variables were specified: field applicability of training content, instructor expertise, and smart media adoption. Training satisfaction and comprehension serve as mediators; the willingness to enact safety behaviors (PPE compliance, risk assessment participation) constitutes the dependent variable. Variable interrelationships are depicted in [Figure 1].

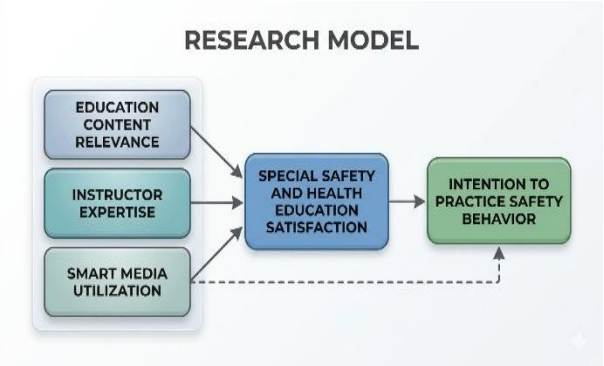

Figure 1: Research Model

3.2. Operational Definition of Variables and Measurement Tools

Survey instruments were assembled by drawing on previously validated scales from the safety-education literature and adapting them to reflect the operational realities of Korean construction sites. Each item employs a five-category response continuum anchored at 1 (strongly disagree) and 5 (strongly agree), consistent with Likert-type measurement conventions.

Field applicability of training content captures how faithfully instructional resources mirror the actual task types and hazard profiles encountered on site (four items). Instructor expertise taps the trainer's capacity to convey knowledge drawing on direct field experience and recognized professional credentials (four items). Smart media adoption gauges the extent to which VR/AR technology and mobile content supplant conventional rote formats (four items). Training satisfaction, the mediating construct, reflects workers' subjective assessment that course content aids actual job performance (four items). Finally, behavioral commitment to safety operationalizes the degree to which completers correctly apply PPE and actively engage in pre-work hazard assessments (five items).

3.3. Sample Design and Data Collection Methods

The target population encompassed workers who had undergone special safety and health training at construction projects operating in the Seoul–Gyeonggi–Incheon corridor and at sites distributed nationally.

Stratified sampling, facilitated through a network of construction safety officers and accredited training providers, was used to ensure representativeness across site types and work categories. The final analytical dataset comprised 365 usable responses from workers and safety managers at 20 sites nationwide (400 questionnaires issued; 378 returned; 365 cleared post-screening; retention rate: 96.6%).

The quantitative data were gathered through pencil-and-paper questionnaires completed by respondents on-site at the close of their training session. To deepen interpretation of the statistical findings, a purposive subsample of seven key informants—drawn from KOSHA specialists, accredited training instructors, and site safety supervisors—participated in semi-structured interviews of approximately 60 minutes each.

3.4. Data Analysis Methods

Statistical procedures were executed in SPSS 28.0 and organized into four sequential stages. (1) Descriptive analysis summarized respondent profiles and the prevailing delivery modalities of training. (2) Internal consistency was evaluated by computing Cronbach's alpha for each scale. (3) A multiple regression model was estimated to quantify how strongly training quality predictors explain variance in workers' safety-behavior commitment. (4) Baron and Kenny's (1986) sequential mediation procedure, supplemented by the Sobel Test, examined whether training satisfaction functions as an intermediary linking training quality to behavioral outcomes.

4. Results and Analysis

4.1. Analysis of Respondent Characteristics and Training Operational Status

Descriptive profiling of the 365 respondents is presented in [Table 1]. Male workers account for an overwhelming 81.6% of the sample, mirroring the established gender distribution of the construction labor force. Age cohorts in the 30s–40s bracket represent 43.3% of respondents, while those aged 50 and above constitute 39.7%. In terms of tenure, the single largest group (40.8%) reported ten or more years of industry experience.

Lecture-based delivery dominated training modalities at 65.2% of reported sessions. Nonetheless, satisfaction scores among workers who received experiential or VR/AR instruction (mean = 4.12) significantly outpaced those recorded for the conventional lecture cohort (mean = 2.87), pointing to an urgent need for a shift in delivery quality.

Table 1: Demographic Characteristics of Respondents and Current Status of Training Methods (N=365)]

Classification	Item	Frequency (n)	Percentage (%)	Cumulative (%)
Gender	Male	298	81.6	81.6
	Female	67	18.4	100.0
Age	**Under 30s**	62	17.0	17.0
	Aged 30–49	158	43.3	60.3
	50s or Older	145	39.7	100.0
Work Experience	Under 5 Years	89	24.4	24.4
	5–10 Years	127	34.8	59.2
	10+ Years	149	40.8	100.0
Training Method	Lecture-based	238	65.2	65.2
	Experiential	79	21.6	86.8
	VR/AR Utilization	48	13.2	100.0

4.2. Reliability Analysis and Descriptive Statistics

Scale reliability is reported in [Table 2]. Alpha coefficients for every construct exceeded the conventional .80 threshold, establishing satisfactory internal consistency across all instruments. The Smart Media Adoption subscale returned the lowest mean score (M = 2.87) among the constructs examined, a pattern attributable to the limited diffusion of VR/AR-

enabled instruction at Korean construction sites at this time.

Table 2: Results of Descriptive Statistics and Reliability Analysis for Major Variables

Variable	Mean (M)	Standard Deviation (SD)	Minimum	Maximum	Cronbach's α
Field Relevance of Training Content	3.42	0.71	1.00	5.00	.84
Instructor Expertise	3.61	0.68	1.00	5.00	.81
Use of Smart Media	2.87	0.83	1.00	5.00	.89
Training Satisfaction	3.35	0.74	1.00	5.00	.86
Commitment to Safety Behavior	3.58	0.72	1.00	5.00	.88

4.3. Hypothesis Testing through Multiple Regression Analysis

A multiple regression equation was estimated to assess how training quality predictors account for variance in workers' safety-behavior commitment. Model diagnostics confirmed residual independence (Durbin-Watson = 2.031) and the absence of multicollinearity (VIF range: 1.4–1.6).

As [Table 3] indicates, the full model explained 46.1% of outcome variance ($F = 96.82$, $p < .001$). Each of the three predictors contributed a statistically significant positive coefficient. Smart Media Adoption ($\beta = .418$, $p < .001$) registered the largest standardized effect, establishing digital transformation of instructional delivery as the foremost lever of safety behavior improvement. Field Content Relevance ($\beta = .248$, $p < .001$) and Instructor Expertise ($\beta = .215$, $p < .01$) also reached significance.

Table 3: Results of Multiple Regression Analysis on Willingness to Practice Safety Behavior]

Independent Variable	B	S.E.	β	t	p	VIF
(Constant)	1.243	0.211	-	5.891	.000	-
Field Relevance of Training Content	0.218	0.064	.248	3.406	.001	1.521
Instructor Expertise	0.197	0.071	.215	2.775	.006	1.483
Smart Media Utilization	0.362	0.052	.418	6.962	.000	1.397
Model Summary	R^2=.461, Adj. R^2=.456, F=96.82, p<.001, Durbin-Watson=2.031					

4.4. Mediation Effect Analysis of Training Satisfaction

The three-step procedure prescribed by Baron and Kenny (1986) and the Sobel Test were applied to evaluate whether training satisfaction mediates the training quality–safety behavior relationship ([Table 4]).

Step 1 established that training quality significantly predicts training satisfaction ($\beta = .562$, $p < .001$). Step 2 confirmed that training quality exerts a direct influence on safety-behavior commitment ($\beta = .418$, $p < .001$). When training satisfaction was entered as a covariate in Step 3, the path coefficient from training quality to the outcome attenuated from .418 to .278 yet retained statistical significance, consistent with partial mediation. The Sobel Test corroborated the indirect effect ($Z = 4.52$, $p < .01$), confirming that training satisfaction amplifies the influence of training quality on safety behavior through a distinct indirect mechanism.

Table 4: Analysis Results of the Mediating Effect of Training Satisfaction (Baron & Kenny's 3-Step)]

Step	Analysis Path	B	β	t	p	R^2
Step 1	IV → MV	0.591	.562	10.23	.000	.316

Step 2	IV → DV	0.362	.418	6.96	.000	.461
Step 3	IV+MV → DV	0.241	.278	4.12	.000	.512
	MV → DV	0.204	.198	3.87	.000	
Sobel Test	Z=4.52, p<.01 → The mediation effect is statistically significant.					

4.5. Discussion

First, the ascendancy of Smart Media Adoption (β = .418) as the strongest predictor of behavioral change converges with and extends prior evidence (Park & Koo, 2022; Kim & Lim, 2020). Immersive VR-enabled encounters with construction hazards appear to create durable cognitive impressions that transfer more readily into protective field conduct than does conventional lecturing.

Second, the partial mediation pattern corroborates the Reaction→Behavior trajectory embedded in the Kirkpatrick model within a Korean construction context. High-quality content alone is insufficient; only when it generates genuine satisfaction does behavioral uptake reliably follow. Curriculum designers must therefore treat learner satisfaction as a design objective co-equal with content accuracy.

Third, the divergence between low Smart Media Adoption scores (M = 2.87) and its outsized behavioral impact reveals an untapped performance reservoir. Construction sites are not yet capitalizing on modalities whose efficacy has been empirically validated, suggesting that infrastructure investment in smart training technology offers substantial returns.

5. Conclusion and Suggestions

5.1. Summary of Research Results

This study interrogated the operational realities of special safety and health training across 365 workers at 20 national construction sites and established that training quality influences safety-behavior commitment principally through its effect on training satisfaction. The central findings are threefold.

First, lecture-based delivery dominates current practice (65.2%), yet immersive and VR/AR-equipped groups register markedly higher satisfaction. Repeated use of generic materials disconnected from actual site tasks emerges as a principal inhibitor of worker engagement.

Second, regression estimation returned significant positive coefficients for all three quality dimensions: content relevance (β = .248), instructor expertise (β = .215), and smart media adoption (β = .418). Smart media adoption exhibited the greatest predictive strength, affirming the superiority of visual and experiential instruction leveraging VR and mobile platforms.

Third, the mediation analysis validated the indirect pathway from training quality through satisfaction to safety behavior (Z = 4.52, p < .01).

5.2. Policy Implications and Practical Improvements

The findings yield several targeted recommendations for strengthening special safety and health education in construction, summarized in [Table 5].

Table 5: Summary of Improvement Strategies for Special Safety and Health Education

Category	Improvement Strategies	Key Details
Policy Implications	Flexibility in the Training Completion System	Establishing a Basis for Recognizing TBM Micro-learning as Statutory Training Hours
	Advancing Evaluation Indicators for Educational Institutions	Institutionalizing Satisfaction and Behavioral Change Metrics as Management Indicators

Practical Improvements	Smart Safety Education System	Standardizing VR/AR Content and Establishing an Integrated Mobile Training History Management Platform
	Development of Field-Customized Modular Teaching Materials	Selective Learning Modules by Trade, Process, and Proficiency Level, and Integration of Risk Assessment Results

At the policy level, the regulatory framework should be amended to recognize structured TBM micro-learning sessions as creditable toward statutory training hours, thereby overcoming the limitations of infrequent, block-format delivery. Evaluation regimes for designated training providers must also migrate from headcount metrics toward outcome indicators—specifically satisfaction scores and behavioral change measures (Park et al., 2020).

At the operational level, task-specific VR/AR content libraries should be standardized by high-risk work category (e.g., scaffolding, excavation, hot work), and an integrated mobile platform should be deployed to maintain portable training records as workers rotate across projects. These measures collectively constitute the foundation of an IT-based Smart Safety Education System (S-SES). Modular, job-role-differentiated content that embeds site-generated risk-assessment data into instruction would further realize the 'Field Problem-Solving Education' model advocated here (Shin et al., 2015).

5.3. Significance and Limitations of the Research

This study makes a scholarly contribution by constructing an integrated empirical model that links current training status to effectiveness outcomes and behavioral change in a single analytical framework, yielding quantitative guidance for practitioners pursuing quality improvement. Its specific contribution lies in empirically characterizing smart media adoption as a predictor of safety behavior within the domestic construction context.

Its scope is nonetheless bounded: the cross-sectional design and restriction to 20 sites in selected geographic regions limit generalizability. Future inquiry should pursue (1) multi-region comparative designs encompassing small-to-medium enterprises; (2) longitudinal monitoring of accident-rate trajectories before and after S-SES deployment; and (3) structural equation modeling to achieve greater precision in pathway estimation.

References

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*(6), 1173–1182.

Chung, K. H., Lee, H. I., Kwon, H. R., Park, J. E., & Shin, Y. S. (2015). Development of a safety education model for foreign workers in domestic construction sites. *Journal of the Korea Institute of Building Construction, 15*(2), 227–235.

Heinrich, H. W. (1931). *Industrial accident prevention: A scientific approach*. McGraw-Hill.

Kim, S. H., & Lim, C. S. (2020). An analysis of factors influencing learning transfer intentions in VR-based construction safety education: Focusing on task–technology fit theory. *Journal of Global Business Administration, 17*(3), 300–318.

Kirkpatrick, J. D., & Kirkpatrick, W. K. (2016). *Kirkpatrick's four levels of training evaluation*. Association for Talent Development.

Korea Occupational Safety and Health Agency. (2023). *Analysis of industrial accident status*. KOSHA.

Lee, B. H. (2019). A study on construction site safety and the necessity of legal protection measures to improve it. *Journal of Safety Culture, 6*, 73–85.

Lee, S. B., Yoo, S. W., & Shin, D. I. (2021). A study on improving the safety education system for foreign workers at construction sites. *Journal of Standards, Certification and Safety, 11*(2), 103–113.

Ministry of Employment and Labor. (2024). *Survey on the operational status of special safety and health education in the construction industry*. MOEL.

Park, H. S. (2022). A literature review on ergonomic studies related to safety and health in the construction industry. *Journal of the Ergonomics Society of Korea, 41*(2), 109–115.

Park, H. S., & Koo, C. W. (2022). The impact of VR-based construction safety education on the learning effects of construction workers: Utilizing the CAMIL theory. *Korean Journal of Construction Management, 23*(3), 104–115.

Park, Y. H., Lee, H. S., & Kim, J. W. (2020). A study on perceptions and improvement measures for occupational safety and health education. *Journal of the Korea Academia-Industrial Cooperation Society, 21*(4), 89–99.

Reason, J. (1997). *Managing the risks of organizational accidents*. Ashgate Publishing.

Seo, H. J., & Do, B. R. (2024). The impact of construction workers' safety behavior and psychological safety climate: Focusing on the multiple additive moderating effects of job stressors and physical risk factors. *Journal of Safety Culture, 36*, 63–78.

Shin, K. N., Ju, S. W., & Yang, S. H. (2015). A study on the current status and improvement of basic occupational safety and health education in the construction industry: Focusing on education content and methods. *Journal of the Korea Academia-Industrial Cooperation Society, 16*(5), 3484–3490.

Son, H. J. (2025). Principles and methods of 'safety Korean' education for foreign workers. *Journal of Safety Culture, 47*, 1–13.