ICCEPM 2022
The 9th International Conference on Construction Engineering and Project Management
Jun. 20-23, 2022, Las Vegas, NV, USA

Customized Safety Information Delivery System for Unskilled Construction Worker Training

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Abstract: Accidents at construction sites in Korea account for more than half of all industrial accidents. To solve this problem, a policy to strengthen safety education was implemented to ensure the safety of workers. However, it was analyzed that there is a high possibility of accidents because workers did not receive proper safety information for each risk factor due to general lecture-style education. In addition, statistics show that the accident status of workers with fewer years of period is high, indicating that a customized information delivery method needs to be proposed for unskilled workers with fewer years of period. Research on the importance of education has been conducted, but no information delivery method has been identified. For unskilled workers to effectively receive safety information, appropriate delivery formats (text, photos, illustrations, 4D-BIM, 360-based panorama, video, animation) were analyzed, and a new method of education was proposed. If customized safety information is provided according to this proposal, effective information delivery to unskilled workers will be possible, and it is expected to be verified in various ways.

Key words: safety education, unskilled worker, delivery format, customized information

1. INTRODUCTION

According to the Occupational Safety and Health Act conducted in South Korea, daily education at construction sites has been required since 2014, and in the case of construction workers who completed basic safety and health education, the accident rate decreased by 14.3% compared to those who did not complete it [1]. According to Heinrich's domino theory, accidents account for 88% of accidents due to unstable behavior, and the importance of education for recognition of safety information and basic safety and health education for new workers was mentioned to reduce unstable behavior [2]. In addition, in terms of the effectiveness of basic safety and health education, it was analyzed that the mortality rate, which is a major disaster, was significantly improved around 2014 when basic safety and health education was fully introduced, and there was a positive effect [3]. A survey on the actual condition of T.B.M(Tool Box Meeting) education firmed that the education helped raise safety awareness for workers who are the subjects of direct education implementation [4].

The basic safety and health education are performed for the first-time workers in the construction site, and after the training is completed for more than four hours through collective training, a certificate of completion will be given. However, it is an education about typical contents that

educate the Occupational Safety and Health Act and the contents of risk factors for each occupation. In addition, T.B.M is conducted for 5 to 10 minutes before work at the site. And the training is conducted quickly and verbally every morning. So there is a limit to conveying information on the work. In addition, in the case of special education, safety matters for particular types of work, which are harmful or dangerous tasks, are educated, but it was confirmed that lecture-style education, a form similar to basic safety and health education, is mainly conducted.

According to the current status of accidents by working period, reported in table 1, it can be seen that workers under six months have the highest accident rate what is 83%. This indicator differs by about 27 times compared to workers with period of 5 years or more, it is accounted for almost the majority of accidents [5]. It can be inferred from accident cases and statistical data that the limitations of education currently being implemented are formal education in which new workers whose training completion period is the fastest fail to recognize risks and reduce human errors. And this shows that in the case of unskilled workers who lack experience in work and knowledge, the ability to respond to hazardous tasks is low.

According to the classification system of functional personnel implemented in Korea, the participating occupations for each type of construction site are divided into four stages: trade apprentices, intermediate workers, skilled workers, and experts. The criteria for calculating each grade were classified by combining experience, qualification, education, training, and reward and organized for 60 occupations [6]. However, uniform and formal education that ignores this classification system make it difficult for unskilled workers to acquire enough safety information in the actual construction site. Also, information delivered through uniform and formal education does not contain various types of customized delivery (text, illustration, photo, video, 360-based panorama) for each risk factor (work environment, materials, tools) that may occur in the work procedure. It is limited for unskilled workers to acquire essential information to recognize risks.

Despite the institutional strengthening of the education system, the number of deaths per 10,000 workers in the construction industry in 2018 was 1.65‰, up from the previous year [7]. Prior research on technology to ensure worker safety has been actively conducted, but various studies have not been conducted on whether workers have properly acquired and grasped safety information.

Therefore, this study aims to improve the safety awareness of risk factors by customized information and format. Through this, if customized education on safety information necessary for an unskilled worker to recognize risks is effective, it can be used as a new educational methodology.

2. LITERATURE REVIEW

According to the previous research, Kim [8] suggested that safety information reflecting personal characteristics such as occupation, experience, age, and accident experience for each type of construction should be classified into appropriate educational methods and educational contents, and a customized operating system for safety education should be established. In another study, Oh et al. [9] analyzed the educational content conducted in the construction site and the accident status by type of construction to evaluate the educational content and educational situation according to the intensity of the accident. In a study analyzing the results of a survey on the actual condition of safety education, Kim [10] analyzed workers' perceptions of education were investigated, and the quality of education was poor due to poor participation rate and poor participation rate due to non-detailed education content. In a study related to educational content, Oh et al. [11] suggested that interviews with construction site workers and safety managers did not reflect various construction site environments, and T.B.M. was the most effective time for safety education. It was suggested that workers change their consciousness through construction safety accidents and prevent accidents.

Previous studies proposed the actual condition and improvement plan of current education were conducted. However, there was no discussion on specific improvement measures for unskilled workers on safety data for each risk factor and delivery methods for each risk factor. In addition, detailed measures for information delivery methods to analyze the currently provided safety information and promote safety awareness of unskilled workers are insufficient. In other words, no research was conducted to organize and connect a delivery method for appropriate safety information, and the composition of safety information for the level of unskilled workers, not the existing safety education data, was not considered.

Therefore, it is necessary to analyze the delivery format of safety information that unskilled workers can effectively recognize risks so that customized safety education can be provided.

3. RESEARCH METHODOLOGY

As depicted in figure 1, this research comprised of four main areas. Firstly, ten construction work types were selected, and related risk factors such as work environment, materials, equipment, etc were analyzed. Next, a customized safety information delivery method was developed and appropriate information delivery formats for various scenarios were identified. In order to evaluate the proposed approach, in-depth interviews will be conducted with safety managers and construction managers having a minimum of 9 years experience on the jobsite. Through a series of delphi studies, an expert panel will critically analyze the customized information delivery method and work towards reaching consensus on the suitability of the proposed delivery mediums. In addition, a quasi-experimental research design will be applied to evaluate the effectiveness of each proposed information delivery format to improve knowledge acquisition and safety awareness in unskilled workers.Ten types of constructions will be selected in consideration of the characteristics of each type of construction to construct a relevant safety information analysis and delivery format for unskilled workers by type of construction. Risk factors (work environment, materials, equipment, tools, work order) for each type of work are analyzed, and relevant delivery formats (text, illustration, photo, video, animation, 4D-BIM, 360-Based panorama) for each risk factor are organized and customized in table 2.

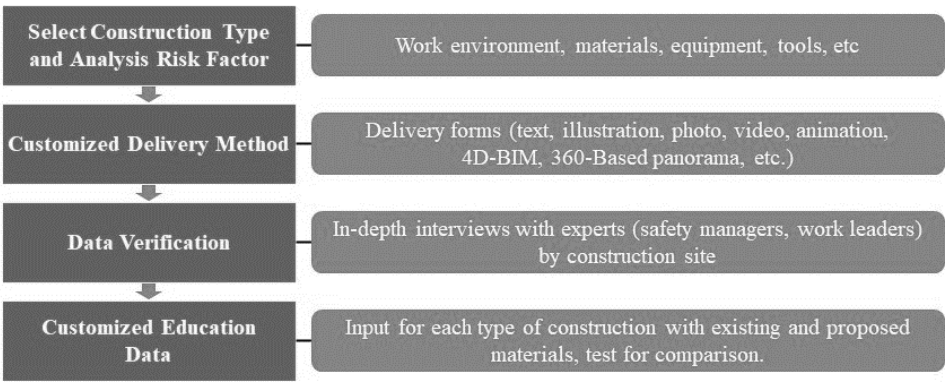


Figure 1. Research framework

Based on customized information, data will be verified through in-depth interviews by Delphi method with experts (safety managers, work leaders in constrction site who total number of days of conversion experience is over than 9 years) at the construction site. The role of the experts in this type of study is to critically analyse the factors underlying the subject of study and give their opinion based on their past numerous experiences in the subject matter to reach an agreement [12].

And then, the difference is analyzed by educating unskilled workers before an input for each type of construction with existing and proposed materials.

Table 2. Characteristics of information delivery format

Classification	Description
Text	Accurate delivery of regulations. (related to laws and rules)
Photo	Information that can be identified through images, such as damage of tools and equipment, conditions of the site such as specifications, safety facilities.
Illustration	Information that cannot be directed, such as disaster cases.
Video	It is identifying the overall work method or work sequence that is difficult to implement actual cases or examples of accidents.
4D-BIM	In the case when it is necessary to identify the overall situation. (construction status and surrounding situation information are required)
360-based Panorama	In the case where it is necessary to know the overall condition of the site or the surrounding elements before starting work.
Animation	Checking the details and methods of each task, or it is necessary to check the overall sequence, such as the task method and order.

4. CASE STUDY

One of the types of constructions was selected, and fatal risks were classified among accidents on the construction site. It was prepared to identify a more effective delivery format when an unskilled worker received classified hazards and existing safety information before putting in each type of construction.

First, as shown in Table 3, among the construction works that are carried out in the site, ten types of constructions with a high probability of accidents due to specific original cause material or environments, such as spatial work environment, materials used by workers, tools, equipment, and materials, are selected.

Table 3. Classification of dangerous work by original cause material.

Types	Detailed process	Risk factors
Using the equipment	Window installation (curtain wall)	Risk of using curtain wall weighting equipment
	Piling	Risk of equipment used in piling
	Steelwork	Risk of equipment used for weighing and transporting steel
Working environment	Elevator shaft	Risks when working in the opening
	Earthwork (H-Pile earth plate)	External environment
Using materials	Celling	Risk of ladders and temporary facilities for work at height
	Temporary facilities (outdoor scaffolding)	Risk of installation and transportation of temporary facilities
	Reinforced concrete	Risks when working with rebars and molds
	Deck plate	Risk of using a deck plate
	Waterproof work (waterproof coating)	Risk of using waterproof materials

Second, safety materials such as work sequences, accident cases according to the type of construction, and safety measures are comprehensively collected and analyzed by referring to specifications and risk assessment tables for each type of construction. By associating safety information for each risk factor for the defined features, the analysis results that unskilled workers

can most effectively understand are presented. For example, training using 360-based panorama that shows photos of the site in real-time rather than oral delivery or lecture-style training, and video and animation on the work order or precautions can more effectively deliver risk factors to workers. Among the selected type of construction, a proposal was prepared with waterproofing work. Waterproofing work can cause suffocation and toxicosis due to the materials used. The examples are presented in Tables 4, 5, and 6.

As shown in Table 4, information on wearing personal protective equipment should be delivered to prevent suffocation caused by material or environmental problems during waterproofing work. However, it is judged that unskilled workers with relatively little experience will acquire little information on wearing personal protective equipment. Therefore, the information about wearing and using personal protective equipment needs to be delivered using audiovisual materials that can clearly explain the information.

Table 1. Analysis of Safety Information Transfer on the Waterproofing

<table>
<tr><td rowspan="4">Method of taking care each equipment in Waterproofing</td><td colspan="2">Existing safety information</td></tr>
<tr><td>Risk factors</td><td>Safety measures</td></tr>
<tr><td>Asphyxiation is the closed space</td><td>Wearing an air respirator when working in an enclosed space.</td></tr>
<tr><td colspan="2">New information with considering delivery format(video)</td></tr>
<tr><td colspan="2">  
Safety suit that protects the worker! PPE Manual(KOSHA)
[YouTube: https://www.youtube.com/watch?v=TJbimt3OGNQ]</td></tr>
</table>

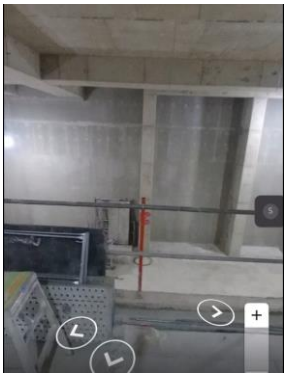
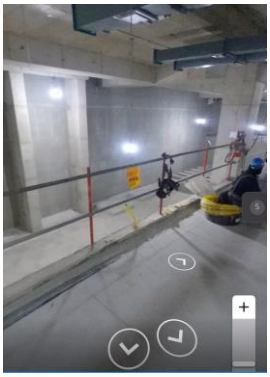
As shown in Table 5, it is necessary to instill awareness of the accident and deliver information that can be shown fragmentarily by using photos that can directly show the accident case. For example, in table 5, accidents caused by the inability to distinguish between the liquid material and beverage properly can be educated using accident case by photos.

Table 5. Analysis of safety information delivery when handling waterproof materials

<table>
<tr><td rowspan="3">Handling waterproof materials</td><td colspan="2">Existing safety information</td></tr>
<tr><td>Risk factors</td><td>Safety measures</td></tr>
<tr><td>Poisoning caused by mistaking the repellent</td><td>Thorough material health and safety education on waterproof materials</td></tr>
<tr><td colspan="2">New information with considering delivery format(photo)</td></tr>
</table>

Table 6. Analysis of safety information delivery when working in an enclosed space.

Waterproofing in closed space	Existing safety information	
	Risk factors	Safety measures
	Asphyxiation during Waterproofing	Ventilation and oxygen concentration measurement.
	New information with considering delivery format(360-based panorama)	
	  	

As shown in Table 6, information on the site should be delivered in advance so that safety measures for the workplace can be prepared before the beginning of site activity. And then, workers can prepare about take their equipment before getting into work. Accordingly, a 360-based panorama photograph capable of transmitting information on a related site is used.

5. DISCUSSION AND LIMITATION

In this study, the authors defined the delivery format for each risk factor in the construction for unskilled workers and proposed an appropriate delivery method. Moreover, information analyzed the delivery format for each information to effectively recognize safety information for each risk factor currently provided for unskilled workers in a short period.

However, data were not verified through in-depth interviews with expert workers and safety managers for the analysis system presented in the flow of the study. Based on this, it was not confirmed whether the delivery format for each risk factor was appropriate. In addition, only the currently produced safety information was analyzed, and the analysis was limited to unskilled workers without considering personal characteristics (age, accident experience, etc.) in the worker occupation. A detailed analysis of delivery methods or safety information considering various characteristics and delivery formats should be conducted.

6. CONCLUSION

Various studies have been conducted on securing worker safety, and the importance of education has also emerged. Accordingly, to improve the safety awareness of risk factors by customized information and format, an analysis method for appropriate delivery methods for each risk factor was proposed for unskilled workers who do not know the most about safety information for each risk factor among workers. Training using the revised safety information will be verified through in-depth interviews in future studies. If appropriateness is determined by comparing, verifying, and correcting the interview contents and analysis results, it can be used as a customized safety training material for unskilled workers. And various types of education can occur based on the proposed system and can be used as a frame for creating customized education systems for workers who analyzed each characteristic.

Furthermore, it is possible to propose more diverse educational methods that deviate from the existing formal educational process, and efficient operation according to the specific time composition for shortening existing academic hours or reinforcing education is possible. Based on this segmentation, it is expected that the perception of existing education can be improved through customized education for each construction site worker and that workers themselves can expect to reduce unstable behavior and accident rates through voluntary participation.

This study presented data analysis using in-depth interviews, surveys, and statistical analysis. However, later reflections on the generation of predictive models for safety education data linked to workers' characteristics may be conducted using specific data analysis such as text mining.

ACKNOWLEGEMENTS

"This research was conducted with the support of the "National R&D Project for Smart Construction Technology (No.22SMIP-A158708-03)" funded by the Korea Agency for Infrastructure Technology Advancement under the Ministry of Land, Infrastructure and Transport, and managed by the Korea Expressway Corporation."

And “This study was financially supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government Ministry of Science and ICT (MSIP) [No.NRF-2022R1A2B5B02002553]”

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