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To cite this article: Rahat Hussain, Akeem Pedro, Do Yeop Lee, Hai Chien Pham & Chan Sik Park (2020) Impact of safety training and interventions on training-transfer: targeting migrant construction workers, International Journal of Occupational Safety and Ergonomics, 26:2, 272-284, DOI: [10.1080/10803548.2018.1465671](https://doi.org/10.1080/10803548.2018.1465671)

To link to this article: <https://doi.org/10.1080/10803548.2018.1465671>



Published online: 12 Jun 2018.



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Impact of safety training and interventions on training-transfer: targeting migrant construction workers

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Despite substantial efforts to improve construction safety training, the accident rate of migrant workers is still high. One of the primary factors contributing to the inefficacy of training includes information delivery gaps during training sessions (knowledge-transfer). In addition, there is insufficient evidence that these training programmes alone are effective enough to enable migrant workers to transfer their skills to the jobsite (training-transfer). This research attempts to identify and evaluate additional interventions to improve the transfer of acquired knowledge to the workplace. For this purpose, this study presents the first known experimental effort to assess the effect of interventions on migrant work groups in a multinational construction project in Qatar. Data analysis reveals that the adoption of training programmes with the inclusion of interventions significantly improves training-transfer. Construction safety experts can leverage the findings of this study to enhance training-transfer by increasing workers' safety performance and hazard identification ability.

Keywords: migrant construction workers; safety interventions; training approaches; knowledge-transfer; training-transfer

1. Introduction and background

The construction industry is one of the most accident-prone industries worldwide, and involves multiple organizations and labourers working together in the same workplace. With increasing economic globalization and labour shortages, most construction firms employ a low-priced and low-skilled migrant workforce [1–3]. The whole industry's labour market has distinctive characteristics [4]. Various statistics from all over the globe indicate that the fatality and accident rates associated with migrant workers actually increase disproportionately [1,3,5–7]. Although migrant workers make up only 8% of the UK construction labour population, they account for 17% of total fatalities [8]. Statistical data indicate that migrant workers are nearly 30% more likely to have work-related injuries than those born locally [3]. These alarming statistics suggest that the construction industry needs further actions to combat the additional health and safety risks faced by migrant workers.

A number of efforts have been made by researchers and construction practitioners to reduce the high fatality rates of migrant workers. Construction safety training is widely regarded as an essential element in improving safety performance [9] and training practices are recognized as an important means to improve worker's knowledge and behaviour and to promote safety performance. Every year, thousands of dollars are invested to educate and train migrant workers, however, the expected return on

investment from these efforts has not been attained [10]. In contrast, many researchers claim that traditional training programmes are unidirectional with knowledge-transfer from instructor to worker [11]. However, some studies have critically analysed why training efforts for migrant construction workers fail. Most migrant workers' training efforts become less effective due to information delivery gaps resulting from language barriers, literacy issues [3,12] and the use of insufficiently engaging approaches during training sessions [13]. As a result, the knowledge acquired during training is not fully applied on the jobsite. Hence a gap always exists between knowledge and sustainable workplace performance in migrant workforces and this is the reason that efforts do not alter the overall performance and behaviour towards safety [14].

Several studies regarding migrant construction workers have focused on evaluating training methods and introducing interventions such as peer support and safety campaigns. However, the effectiveness of these interventions is still uncertain [15]. The ultimate goal of safety training is to maximize the worker's knowledge level and ability to transfer that knowledge to the workplace, from concept to practice [16]. In other words, the extent to which workers effectively implement the acquired knowledge, skills and attitude in their job.

Although issues related to training effectiveness and their outcomes are deeply discussed in many of the previous studies, the topic of training-transfer in the

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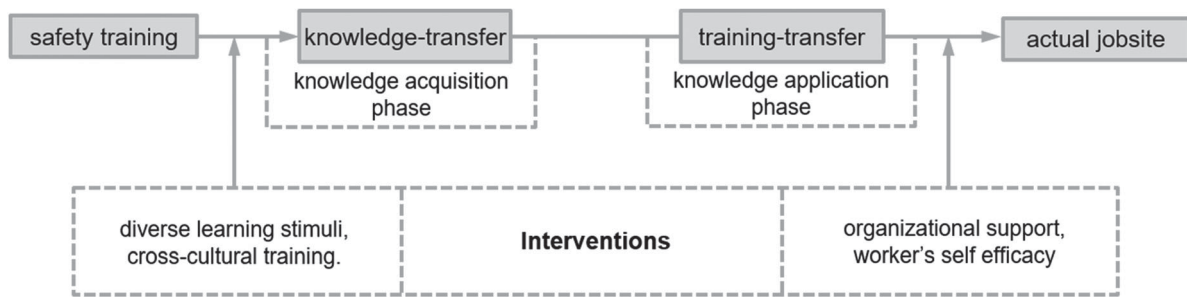


Figure 1. Journey of knowledge from classroom to jobsite.

construction industry remains unaddressed [14,17,18], particularly for migrant workers. Even trained migrant workers in multilingual work groups show poor safety performance, due to the presence of distinct gaps related to both acquiring and transferring knowledge in diverse working environments. Therefore, identifying the influential factors (interventions) that maximize knowledge delivery during training and transfer of training to the actual jobsite is an essential step in reducing occupational health disparities. The process of transferring knowledge from the classroom to the jobsite is explained through a simple flow diagram (Figure 1). During training sessions, training contents and training delivery methods may be the determining factors for effective knowledge acquisition. In addition, the application of that knowledge in the actual workplace can be increased by many factors, e.g., organizational support and worker motivation.

The purpose of this study is to assess the effect of interventions on safety training approaches for migrant workers based on two objective training outcomes: knowledge-transfer during training sessions and training-transfer during work on the actual jobsite. Section 2 describes the knowledge-transfer and training-transfer gaps which act as barriers and limit training effectiveness; and then discusses the current challenges, issues and deficiencies affecting the safety performance of migrant workers. Next, Section 3 explains the process adopted in the design of a field experiment for a construction site in Qatar. Section 4 presents an analysis of statistical data collected from experiments in two cases, knowledge-transfer and training-transfer. Results and insights regarding the actual implementation of the proposed method are discussed. Lastly, Section 5 presents the research finding as well as recommendations for construction practitioners and further research.

2. Literature review

Most previous research efforts to minimize accident and injury rates deal with importance of safety, training content design, worker's safety performance, learning approaches and training technology [3,7,19,20]. One of most important challenges that the industry is facing relates to how well workers can implement their knowledge in actual practice [21]. Although workers may acquire new knowledge

and information through different training approaches, the learning alone is not enough for training to be considered effective on the jobsite. The dominant influencing factor is the transfer of training, or the extent to which the learning is applied to the worksite and leads to positive changes in workers' safety performance. Although other domains have focused on the role of training-transfer, very few studies have highlighted this issue in construction [14]. Moreover, there is limited evidence in the literature that training programmes are effective enough for migrant workers to transfer their skills back to the jobsite.

To cover the context in depth and establish the point of departure for this research, a literature review is presented in the following two subsections. In Section 2.1, the knowledge-transfer gaps in traditional training approaches are highlighted and previous literature on training-transfer is reviewed. Section 2.2 demonstrates the current situation and issues related to migrant construction workers to address the barriers which inhibit training-transfer.

2.1. Knowledge-transfer and training-transfer

Recently, knowledge or information transfer concepts are appealing topics among researchers in health and safety training studies. Many of the previous studies established a relation between effectiveness of training programmes and knowledge gained; however, there is a dearth of research in identifying and evaluating the factors to improve the transfer of that knowledge to the actual jobsite.

Not all knowledge gained from the training can be expected to be applied on the jobsite and this is especially true in the case of foreign workers [22]. Zhao [23] claimed that the current training approaches result in transfer losses because they are not capable of maximizing information transfer. Information transfer losses during training are described to occur due to the weaknesses of traditional safety training modes and learning styles. The loss between knowledge to be expressed and delivered knowledge is due to inactive approaches used for training, e.g., providing text-heavy safety material to workers that need high reading competence [24]. This leads to gap 1.

Proceeding further, the knowledge acquired by the workers is considered less than the delivered knowledge.

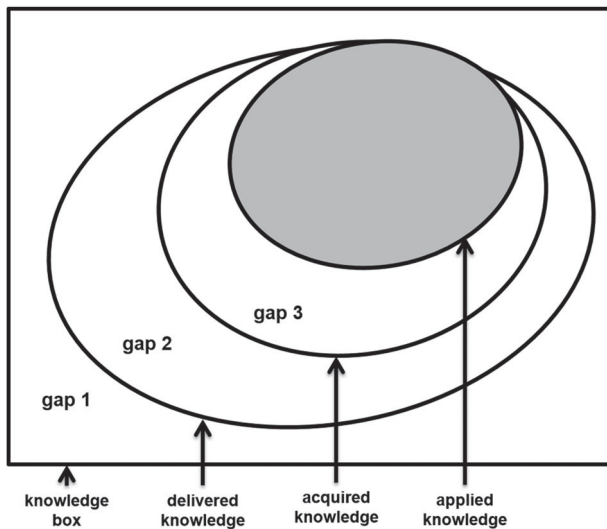


Figure 2. Knowledge-transfer gaps.

This is due to the lack of hands-on training, mock-up exercises, rehearsal and practice in real life. In turn, this leads to gap 2. Gap 3 is due to the presence of language differences and low literacy levels, which may cause communication gaps between trainee and trainer, less interaction between worker and instructor, and less managerial support. Finally, the knowledge applied to the actual jobsite by the worker is limited as compared to the complete knowledge box, as shown in Figure 2.

Knowledge-transfer is not equivalent to training-transfer [14]. Training-transfer can be defined as ‘the degree to which the learned knowledge from training is used in the workplace’ [16, p.32]; in other words, the process of successfully moving knowledge, skills and attitudes from training classes to workplaces, which is the ultimate goal of training. The training delivery style is considered a critical aspect for the overall quality of training [25]. Indeed, studies have shown that the level of engagement of training approaches influences a number of training outcomes like problem-solving and hazard identification [26,27]. Although workers can improve their safety knowledge through effective training approaches, it is not enough to yield the expected results because good performance during training sessions does not necessarily translate to good performance in the workplace. For the maximum training-transfer to the jobsite, is it sufficient to involve the workers in engaging training approaches? Certainly, it is a difficult task for a trainer to make the training effective in the perspective of maximizing the worker’s training-transfer skill.

To minimize the gap between training efforts and safety outcomes, it is necessary to facilitate training-transfer and eliminate the barriers to transfer. Barriers highlighted in the literature include a non-supportive environment, lack of management commitment and organizational culture [16]. Namian et al. [27] identified the transfer elements to

enhance the transfer skills of workers which included, but were not limited to, training design and material, workers’ motivation and safety culture. Study findings from 51 case projects revealed that training efforts may fail if the suggested training-transfer elements are not adopted as safety interventions [27].

Therefore, recognizing and implementing the interventions that can enhance training-transfer skills of workers is especially vital for the construction industry. Van der Molen et al. [15] assessed the effectiveness of different safety interventions from 13 previous studies and found evidence of long-term effects in terms of reducing injuries among workers [15]. In Section 2.2, the current status of migrant construction workers in terms of safety training approaches and further demands to acquire the desired training outcomes are discussed in detail.

2.2. Migrant workers and safety training

The construction industry has a characteristic of workforce migration from areas of surplus to areas of demand. In the past, these flows were enclosed within a country [3]; however, with the phenomena of globalization and advancement in construction, the whole industry’s labour market has become an amalgam of workers in low-skill and high-risk occupation with different nature, culture, tradition and language [28]. The issue of workforce diversity on jobsites is not localized for a single country. One quarter of the Australian workforce speak languages other than English [12] and more than 8% of UK construction workers consist of migrants [8]. Economically active labour in Korea consists of more than 3% of migrant workers [20]. The accident rate of migrant workers has been consistently higher than the rate of local workers. In addition, migrant workers are not only associated with high accident rates but also with more severe accidents than local labourers [5].

Although there have been numerous efforts to establish safety measures in terms of education and training [29], welfare and safety systems [2], the accident statistics for migrant workers are still high [5]. Therefore, in the context of migrant workers, both knowledge-transfer and training-transfer are difficult to disentangle. The migrant workers issues related to knowledge-transfer and training-transfer are highly precarious due to following reasons:

- Traditionally, English or country-specific languages are the medium of communication on sites and during training sessions, even if training is supposed to be for foreign workers [19,30].
- Low literacy also hinders the understanding of safety contents, since the text-based materials which are provided on multinational construction sites are ineffective for illiterate and low-literacy labour. As a solution, related studies suggest the use of images and posters to convey safety information to migrant workers [8,29].

- Foreign workers' communication skills for sharing safety interactions and reporting hazards with new work groups, supervisors and managers are limited due to cultural barriers [2].
- Relationships between workers and health safety and environment (HSE) supervisors are unclear [5].
- As migrant labourers are supposed to stay for a short period of time in a foreign country, they remain unfamiliar with the work environment on every new construction site. In many cases, the migrant workers' jobs and responsibilities remain unclear; and even employers fail to verify their job skills before the start of work [5].

Considering the aforementioned factors, most previous research efforts focus on improving education and training. The centre of attention of recent safety training studies is the engagement hypothesis; suggesting that more worker engagement in training results in improved safety performance [26,31]. On the contrary, it is also argued that safety training methods are not effective enough to cover all aspects of occupation safety and health (OSH) [11] and the learning from training programmes does not guarantee that knowledge will also be applied on site [22,32]. This is especially true in the case of international workers [22]. For the maximum transfer of training on the jobsite, is it enough to involve workers in engaging approaches? Or are there other factors to meet the objective outcomes? Therefore, aside from safety lessons and training, interventions are also required as additional remedies to maximize transfer onto the actual jobsite. Indeed, even a minor increment in training-transfer can significantly enhance workers' safety performance [14].

Section 3 elaborates on the methodology adopted for the field experiment that has been carried out to assess the potential of safety interventions to maximize the transfer of training onto actual jobsites in the case of migrant workers.

3. Research methodology

The overall methodology adopted to accomplish this study is depicted in Figure 3. This research comprises five distinct phases. A thorough literature review focusing on the migrant worker's current position in the construction industry and the concepts of knowledge-transfer and training-transfer is presented to establish the point of departure for this research. Based on literature, design criteria for the field experiment were established by defining the different training levels and interventions. The work population of a construction jobsite was analysed to create target work groups. Then, the defined levels of training were implemented and evaluated on different migrant work crews in a Qatar-based multinational construction project. The next phase evaluated knowledge-transfer and training-transfer levels.

The level of knowledge acquired was assessed by the number of hazards and risks recognized by workers on the actual jobsite. The proactive hazard recognition ability of a worker is crucial to maintain overall safety in construction. This ability can be examined by the worker's pre-training knowledge or knowledge gained through the safety training programme [33]. The next step was to evaluate the rate of training-transfer, considering how much workers apply their acquired knowledge. Results for the knowledge-transfer rate were analysed using the Tukey–Kramer procedure to find significant differences between groups from selected cases. The level of training-transfer was measured through the observation of work groups by safety inspectors using a Likert performance scale.

3.1. Defining training levels and interventions

In this section, different levels of training based on actual approaches deployed in industry along with interventions are strategically defined. A field experiment has been carried out on targeted work crews with the defined training levels.

To efficiently conduct the field experiment, a team comprising of four experienced safety experts including a certified safety professional (CSP) as a team leader was formed in a multinational construction project in Qatar. The project environment was suitable for this research as the project participants, owner, contractor and consultant were from different countries. The population was very diverse due to an amalgam of labour with different languages and countries on a single jobsite including Pakistan, India, Bangladesh and Nepal. From an initial survey of more than 79 migrant workers, 30 workers were selected. The selection criteria were based on their trade: 'erection and dismantling of scaffolding'. Scaffolding was selected since it has high accident rates and is considered the most hazardous job due to numerous risks such as falls from heights and scaffolding collapse [34].

The workforce demographics collected from an introductory survey are presented in Table 1. The important dependent factor for training-transfer is worker's experience and previous knowledge (pre-training knowledge). Higher worker experience and knowledge may increase workers' performance during the evaluation stage. In order to avoid the impact of this factor, the sample population of 30 workers was distributed further into three focused groups based on average experiences (5–5.5 years). The normality of data and homogeneity of each group based on their experiences were analysed by χ^2 and Levene's test in section 4.1. The workers were all men aged from 20 to 52. One-third of the survey participants had worked in Qatar for fewer than 2 years. The factors considered to acquire the survey results are differences in the country of origin, literacy level, jobsite experience in that specific trade as well as overall experience, languages and, finally, participation in training sessions during their working careers.

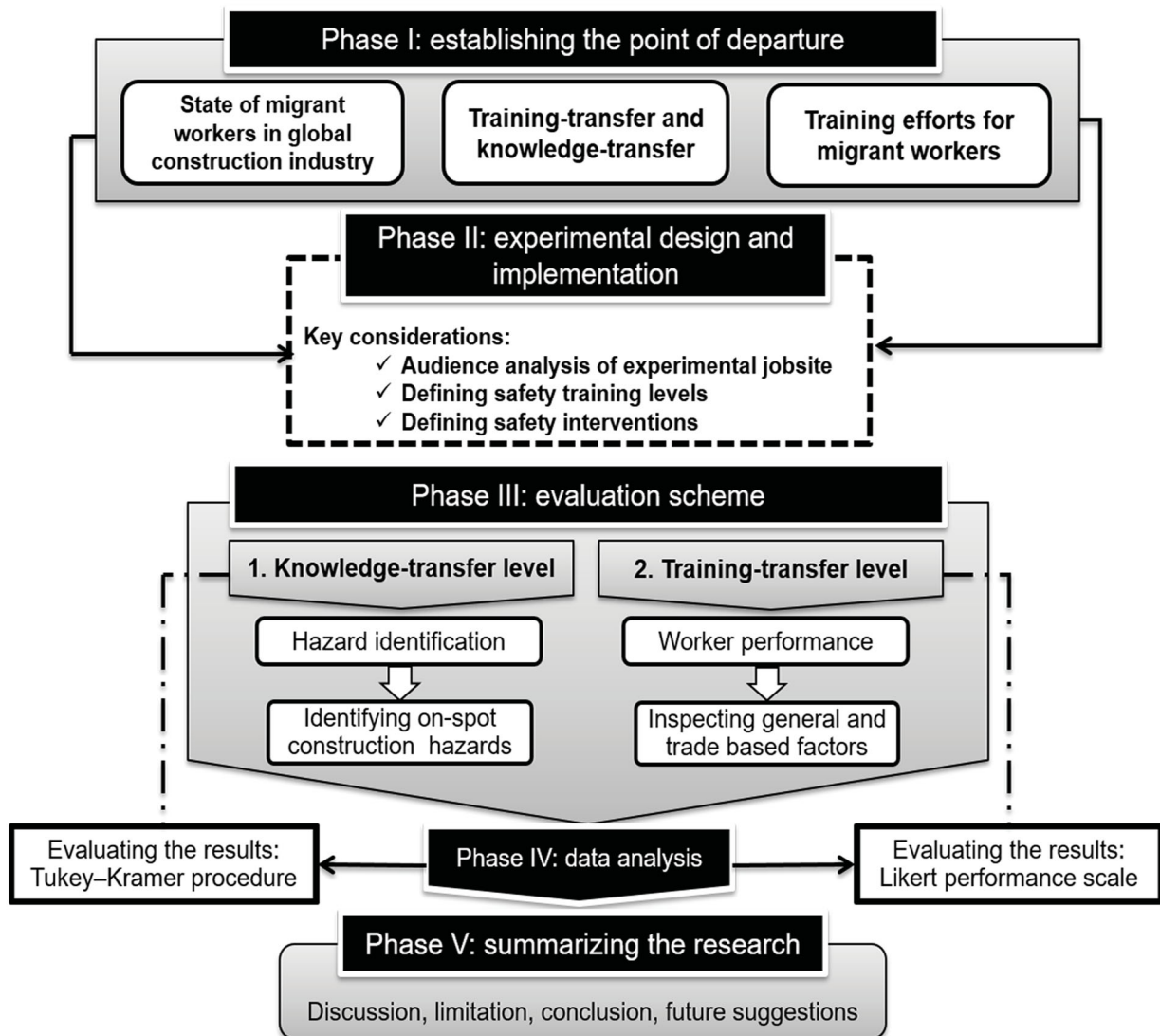


Figure 3. Explanation of phases for the research process.

The senior safety manager decided to carry out 2-h training sessions with each group over a 2-day period. The training content was kept consistent for each group with all of the approaches in order to improve the accuracy of results.

The criteria for training-level design were based on actual training methods deployed currently in construction workplaces and highlighted in the literature. These approaches were categorized into three different levels. First, traditional training was defined based on those that company or safety personnel were using for their new endorsed and old labour on the project. The training type which was introduced to the first group (WG-1) contained well-organized information for safety literature and was delivered with a PowerPoint presentation in a classroom. English was used as the medium of instruction and communication. Written content was also provided to each worker with safety posters and pictures.

Second, the contemporary approach introduced by many recent studies for migrant workers was used for the second group (WG-2). The contemporary approach is more reactive than traditional training, including frequent feedback and evaluation rather than just information delivery. The main difference between the traditional way and the contemporary method was the engagement of workers through bilingual instructions/communication and providing workers a chance to share their problems during learning sessions. To achieve better outcomes for this stage, two-way communication and conversations with instructors were allowed during the session. In addition, short paper-based tests were made mandatory, to provide workers with feedback and aid in long-term knowledge retention. At the end of training, 15 min were allocated for a special question-and-answer session so that workers could clear their queries regarding site safety matters.

Table 1. Workforce demographics ($N = 30$).

Characteristic	Number (%)
Age (years)	
20–30	14 (46.7)
30–40	9 (30.0)
40–50	6 (20.0)
>50	1 (3.3)
General experience (years)	
0–2	11 (36.7)
2–5	14 (46.7)
5–10	5 (16.6)
Trade-based experience (years)	
0–2	17 (56.7)
2–5	11 (36.7)
5–10	2 (6.7)
Language	
Urdu	6 (20.0)
Hindi	16 (53.3)
Nepali	8 (26.7)
Literacy level	
Illiterate	4 (13.3)
Middle school	17 (56.7)
High school	6 (20.0)
College	3 (10.0)
Language category	
Monolingual	18 (60.0)
Bilingual	8 (26.7)
>2 languages	4 (13.3)

The third type of delivery, called training with interventions, is a proactive bilingual approach. This approach is quite similar to the contemporary approach; however, additional interventions were added to improve the training outcomes. Based on the literature, various interventions were identified. These include diverse learning stimuli, organizational support, developing self-efficacy of workers and cross-cultural training. Implementation methods and practical examples for each are presented in Table 2.

The diverse learning stimuli concept includes various means of knowledge delivery. For instance, explaining the same safety rule through multiple mediums and styles with text, pictures, demonstrations and mock exercise. Various learning styles were adopted during knowledge delivery sessions, because by providing safety knowledge in several ways workers can get the training content conceptually as well as experimentally [22]. Organizational support in terms of providing different ways to achieve safety goals is an essential element for driving workers towards learning and applying knowledge [32]. Strong commitments by managerial staff and their behaviour in safety training programmes do not only provide financial benefits, but they contribute to maintaining realistic and achievable knowledge-transfer skills [35,36].

In this study, supervisor and managerial support was ensured during training through several methods. These

Table 2. Explanation of interventions with examples.

Name of intervention	Method of implementation	Example/activity
Diverse learning stimuli	Text	The ladder should be leaning at a 75° angle from the ground (OSHA 1926.1053)
	Picture	Figures showing the angle and way to handle the ladder
	Demonstration	For every 1.2 m in height, the bottom of the ladder should be 0.3 m away from the structure
	Mock exercise	Workers' on-site exercise: selection of correct ladder type for different scaffolding tasks (see Section 3.1.1)
Organizational support	Evaluation and feedback	Question-and-answer sessions, short quizzes
	Managerial support	Providing essential safety resources to implement the knowledge on site, e.g., provision of personal protective equipment (PPE)
	Site/environmental support	Providing safety instructions by signage on site, e.g., a 'No trespassing' sign (danger)
	Supervisor support	Providing opportunity to apply knowledge: on-site practice for OSHA rule of platform construction 1926.451(b) (see Section 3.1.1)
Development of self-efficacy	Worker's motivation	Offering small rewards and incentives on noteworthy performance like full marks in quizzes
	Problem-based learning	Workers' on-site exercise: selection of correct ladder type for different scaffolding tasks (see Section 3.1.1)
	Providing feedback on-site	Encourage workers by providing continuous feedback to their queries on the jobsite
Cross-cultural training	Bilingual approach	Use of workers' language and common language during training (English)
	Language learning	Use of common phrases in different languages, e.g., 'safety first', 'stop', 'warning'
	Small crews	Making crews with multinational members (see Section 3.1.1)
	Field experience	Construction site visit and demonstration of work environment (see Section 3.1.1)

Note: OSHA = Occupational Safety and Health Administration.

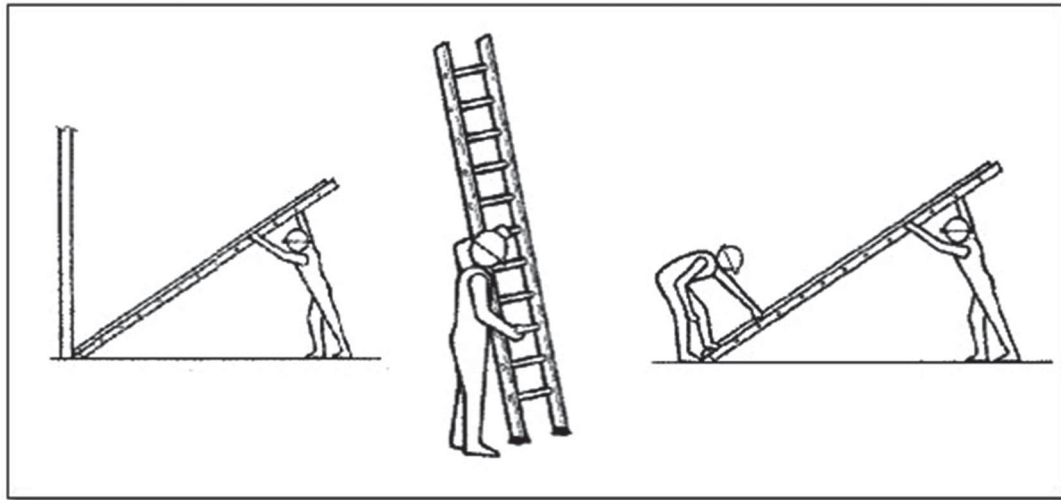


Figure 4. Example figure showing methods of working with a ladder.

included discussing how to utilize training knowledge, providing continuous feedback and mentoring, permitting practical application of gained knowledge and consistently reminding workers to apply their skills.

The confidence of performing tasks at a certain level is called one's self-efficacy. Transfer of training is highly dependent on the worker's self-efficacy [37]. Also, workers with high self-efficacy show more interest in learning and can apply their knowledge confidently [38]. For this purpose, small site problems were assigned to every worker during training and they were asked to suggest their opinion about solutions. The main focus was to improve workers' interest and encourage them to follow the instructions.

Cross-cultural training, can improve one's capability to survive and work in an ever-changing environment [39], therefore, it was considered an important intervention for this experiment. Although this training is critical and conceptual in construction due to the amalgam of migrant workers, it reduces the cultural shock that workers face while working in a new environment [40,41]. Introducing commonly used safety words and phrases of local languages, allocating specified times for cultural talks, short breaks for prayers, two-way communication, inter-group conversation and interactions were considered as the influential factors for cross-cultural training.

3.1.1. Site activity

A site visit of the scaffolding area was arranged for the third group (WG-3). This group was further divided into two small crews with five workers each, to concentrate more on every individual. Each worker was asked to select the correct ladder type for the different scaffolding locations. The criteria for ladder selection were based on four different steps; ladder style, height, performance and material. In

the case of correct selection, hands-on training for Occupational Safety and Health Administration (OSHA) rules from Section 1926.1053 was implemented [42]. An example case for the practice of leaning of ladders is shown in Figure 4. Similarly, a mock exercise for platform construction was performed to provide an opportunity to apply OSHA rule 1926.451-b [42]: maintaining a gap between the scaffolding plates. All of these exercises were done under the supervision of safety supervisors who provided continuous guidelines and feedback.

After the training sessions with each work group, a field experiment was carried out to evaluate the impact of the training approaches.

3.2. Evaluating training approaches through a field experiment

In addition to delivering safety knowledge through various training methods, it is necessary to measure workers' knowledge levels. Training method evaluation would involve assessing how much trainees apply their knowledge during actual work on the jobsite. The evaluation of training approaches has been done in two distinct stages.

During the first stage, workers from each group participated in the experiment. The safety committee and researchers decided to consider multiple locations on the construction site to cover all identifiable hazards. Three locations were selected to reduce any bias that may diminish the number of hazards if only a single location was considered. The identifiable hazards were acquired from the Construction Solution online database for hazards by the Centre to Protect Workers' Rights (CPWR) [43]. These inputs were based on the OSHA guidance and requirements for scaffolds and fall protection under 29 CFR Part 1926 in safety and health regulations for construction [42]. The task 'erect and dismantle scaffolds' included fall from heights, overhead work, lifting and carrying of manual

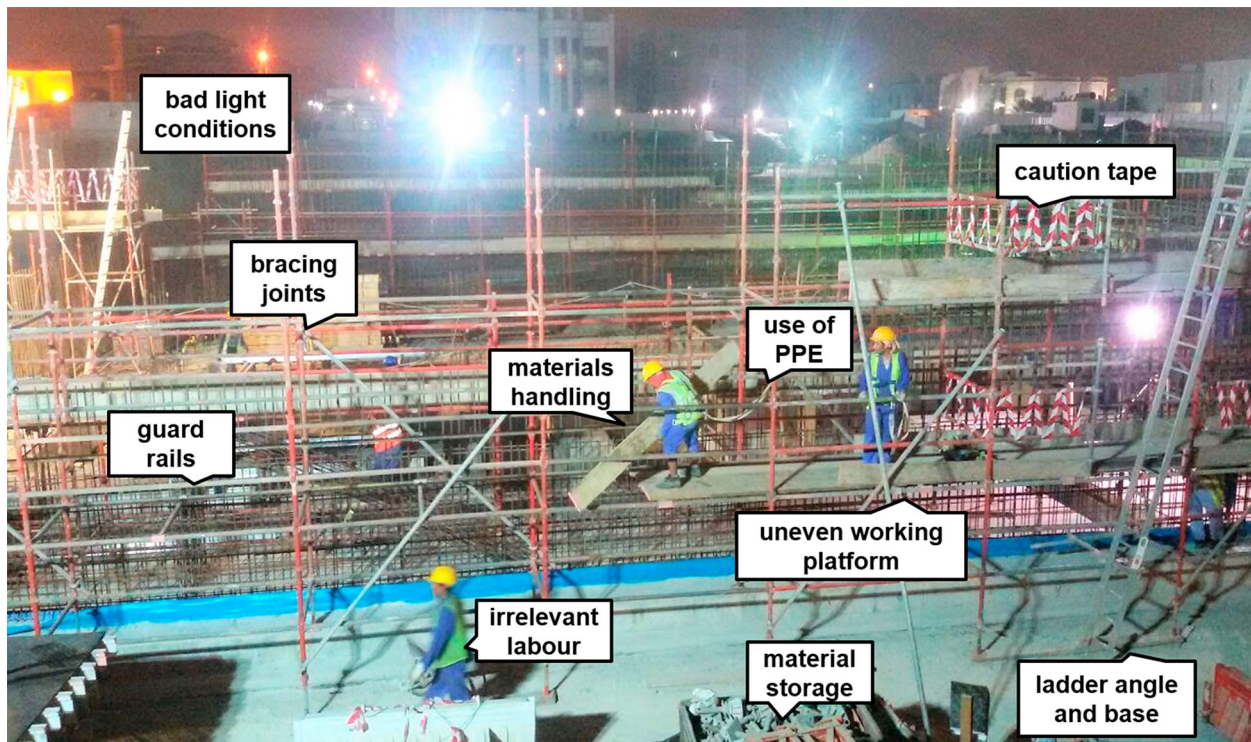


Figure 5. Hazard identification on an actual jobsite.
Note: PPE = personal protective equipment.

materials hazards associated with the current case. In order to assess the immediate knowledge-transfer, workers were required to mark hazards associated with the tasks they were going to perform on site. For example, a worker could mark a fall hazard if he/she observed an unprotected edge within 1.8 m or more above ground level, as specified in OSHA's standard for fall protection (OSHA 1926.501 Subpart M) [42]. An example case for one of the locations from the construction site is shown in Figure 5.

For the second stage, each crew was continuously observed by safety inspectors (specially allotted for this job) for 3 weeks, and other HSE supervisors also performed their duties as usual. A comprehensive evaluation form was provided to the inspector at the start of the inspection period. Principally, the evaluation form was prepared on the basis of risk assessment information collected from the construction solution database of the CPWR and general site appraisals to evaluate the level of training-transfer for individual workers. Based on the CPWR database and site appraisals, 26 factors were identified. Among these, 15 factors highly related to erection and dismantling of scaffolding were selected to get precise experimental results. This selection was done through an electronic survey with 12 safety experts working in different countries. These evaluation factors were then divided into two parts. First, the general part was designed to observe the inclination of workers' behaviour towards general safety rules during the inspection period. Inspectors of each crew continuously observed the following key

Table 3. Workers' performance evaluation factors.

Notation	Description
General factors	
GF-1	Extent of reporting about expected risk
GF-2	Follow-up on supervisor's instructions
GF-3	Awareness of accidents (frequency of near miss)
GF-4	Inquiry about safety information/rule
GF-5	Coordination level with coworkers
GF-6	Attention/use of PPE
GF-7	Response to safety alerts (tags, signs, symbols, etc.)
Trade-based factors	
TF-1	Ensure joints again after fixing
TF-2	Ensure base/foundation of scaffolding
TF-3	Check stability of scaffolding platform
TF-4	Safe method for shifting of safety material (pipe, joints, etc.) from height to ground and from ground to height
TF-5	Use of safe access to height (use of ladder, pipes, etc.)
TF-6	Avoid use of mobile devices, smoking and other irrelevant acts during work
TF-7	Manage the storage of scaffolding material (material handling)
TF-8	Remove hazardous items in working area (electric wires, nails, screws, etc.)

Note: GF = general factor; PPE = personal protective equipment; TF = trade-based factor.

reactions of workers: extent of reporting, compliance with instructions, awareness of accidents, coordination level,

proper use of personal protective equipment and response to safety alerts.

The second part of the form was specifically designed for trade-related OSHA rules that had been taught during training sessions. Specific trade-based assessment consists of technical applications of OSHA rules, e.g., the practice of workers to ensure the stability of scaffolds by verifying the minimum 30.48 cm overlap of platforms (OSHA 1910.28a) [44]. The general and trade-based factors are presented in Table 3.

After the 3-week observation period, all of the data were collected and analysed statistically. The analysis of data and results from both knowledge-transfer and training-transfer sections are discussed in Section 4.

4. Data analysis and results

Cases for knowledge-transfer and training-transfer are presented in this section with the various outcomes of the implemented training methods. Results collected from different work groups are also compared statistically.

4.1. Case 1: knowledge-transfer

As the criteria for dividing groups were based on workers' experience, the homogeneity of groups was already ensured by Levene's test. Therefore, hazard identification performance among the three groups was compared in this section to evaluate the impact of different training levels.

The raw data from experiments were analysed to measure the level of knowledge gained by the workers. The group which experienced training with interventions showed good performance in terms of hazard identification. Table 4(a) presents the summary of the experimental data in terms of the sum for identified hazards, mean and variance. Among the migrant worker participants, it can be seen that WG-3 recognized the most hazards (285 out of 360), while WG-2 with the contemporary approach marked 247 out of 360 correct hazards. WG-1 with the traditional

approach identified only 189 out of 360 total identifiable hazards from the assigned locations.

To find the statistical difference between the mean values of each work group, the one-way analysis of variance (ANOVA) test was performed. The results presented in Table 4(b) show that the p value is less than the α value (0.05), which means that there is a statistically significant difference between the mean values of the group. Therefore, the knowledge-transfer rate during the training session was affected by training levels and interventions.

There is a need for the additional exploration of the data differences among groups to inquire about the specific information on which means are statistically different from each pair, i.e., $\mu_a < \mu_b < \mu_c$. Thus, the Tukey–Kramer multiple comparison procedure was used on the results collected from the ANOVA test. This method was used to identify whether there are significant differences in the mean values of the groups [45].

This procedure allows the comparison of different pairs of means and the level of confidence is precisely equivalent to α , which is normally set at 0.05 [46]. Results showed that absolute differences of the different pairs of groups are higher than the whole critical range of respective groups. The critical range of the given data was computed using the following equation:

$$\text{Critical range} = Q_u \sqrt{(S_{\text{pooled}})^2 / n_o} = 4.90,$$

where Q_u = degree of freedom ratios; S_{pooled} = mean of variances of all the groups; n_o = number of population within a group. By comparing the absolute values of each group, it can be concluded that the means for WG-1, WG-2 and WG-3 are all significantly different from each other in the following manner: $\mu_a < \mu_b < \mu_c$.

Although the first group with traditional training has a mean score in the hazard recognition phase, the next practice case for examining workers' training-transfer indicates that it was not for long-term effectiveness. Therefore, before finalizing the results about workers' level of safety knowledge, the level of knowledge application was tested.

Table 4. (a) Experimental data in terms of sum for identified hazards, mean and variance and (b) single-factor ANOVA results.

(a)						
Group	Count	Sum	M	Variance		
WG-1	10	189	18.90	38.99		
WG-2	10	247	24.70	13.57		
WG-3	10	285	28.50	6.28		
(b)						
Source of variation	SS	df	MS	F	p	F_c
Between groups	467.47	2	233.73	11.92	0.0002	3.35
Within groups	529.50	27	19.61			
Total	996.97	29				

Note: ANOVA = analysis of variance; F_c = F critical.

4.2. Case 2: training-transfer

The degree of application of knowledge on site was measured based on workers' performance and attention towards safety initiatives based on construction safety rules. An evaluation form comprising of a general part with six safety factors and a trade-based part with nine factors was provided to each group inspector. The inspectors were asked to rate each question using a Likert performance scale of 1 = *very poor*, 2 = *poor*, 3 = *regular*, 4 = *good* and 5 = *very good*.

No causality or accident happened during the entire observation period. Also, the near-miss accident ratio was not too high in this case. The overall divergence of each group against each factor is demonstrated by the radar chart shown in Figure 6. This graph shows the inclination of each group against each factor. The chart for general factors shows similar behaviour for both WG-1 and WG-2 in many factors. The overall trend for WG-3 is considerably higher as compared to the other groups. For example, the extent to which workers reported the safety hazards to the group supervisor was higher in WG-3 (mean score 4.5). In other words, workers with additional interventions were more conscious of their safety as compared to the other groups.

The next portion of the evaluation document was focusing on trade-based factors and concentrated more on health and safety rules pertaining to scaffolding works. Unsafe acts during erecting, dismantling and working on scaffolding work were assiduously observed. For instance, workers' attention to ensure the stability and strengthening of scaffolding and platform after completing the job

was very low in WG-1. Similarly, even though ladders were provided for safely accessing heights, most migrant workers tried to follow a short and risky way to access the height.

In summary, these results showed that the overall trend of safety knowledge application in WG-3 is considerably higher than in WG-1 and WG-2 in both general as well as trade-based factor charts. The group with the temporary approach (WG-2) also achieved satisfactory performance in both cases. While the group with the traditional approach (WG-1) showed less interest in implementing safety rules that they had learned during training sessions.

5. Discussion

The findings from the experimental results suggest that training with additional interventions can impact both knowledge-transfer during training sessions and training-transfer on the actual jobsite. More specifically, effective training sessions can improve workers' knowledge but the application of that knowledge can be maximized through the addition of special training-transfer elements. A dramatic increment can be seen in the worker performance with just a minor increment in training-transfer. The use of diverse learning styles, inclusion of bilingual training, additional organizational support and cultural exchange motivate migrant workers to apply the acquired knowledge on site confidently.

This article presents a preliminary study, which will serve as a foundation for large-scale future studies. Hence, the experiments with small participant groups can serve

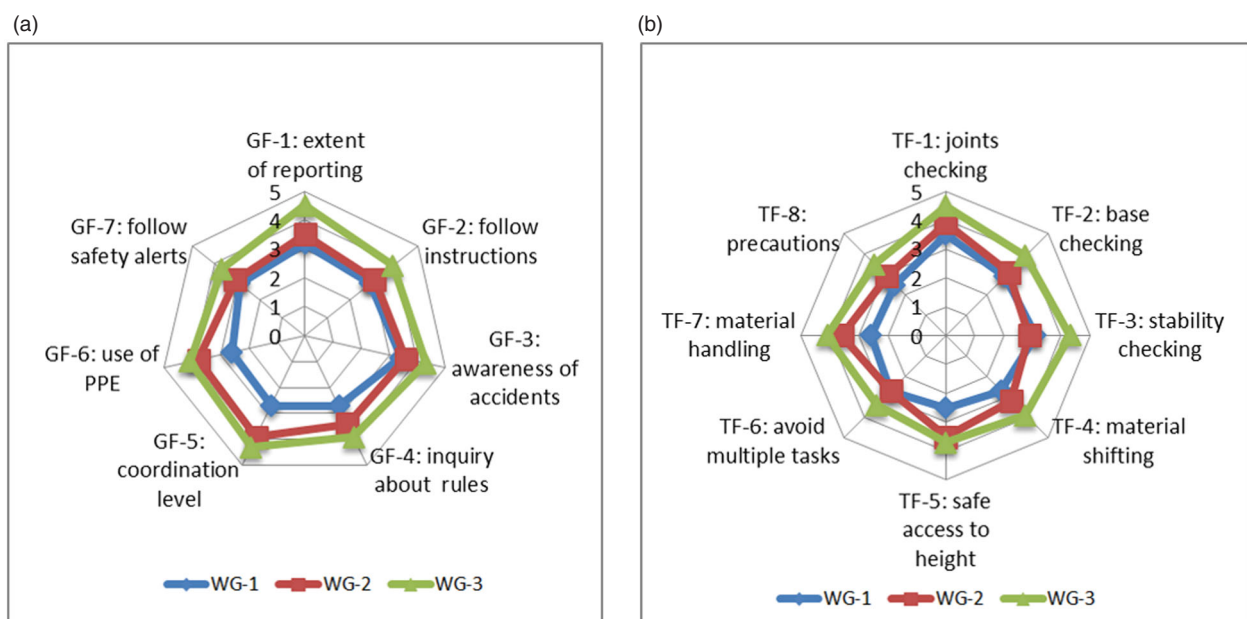


Figure 6. Comparison of group results against each evaluation factor: (a) general factors; (b) trade-based factors.

Note: The full colour version of this figure is available online. Likert performance scale: 1 = *very poor*; 2 = *poor*; 3 = *regular*; 4 = *good*; 5 = *very good*; GF = general factor; PPE = personal protective equipment; TF = trade-based factor; WG = work group.

as a basis upon which researchers studying large migrant workers groups can build. Furthermore, to get more reliable and precise results from the experiment, three different locations on the same project site were selected for worker performance evaluation.

Notwithstanding, even though the culturally diverse nature of the work crews is a valuable aspect to evaluate migrant worker safety performance, it is hard to engage labourers for such practice. Similarly, the extent of interventions being implemented during and after training sessions is difficult to control. To address these challenges, the experiment design phase of this research has focused more on the reasons for training failures from both the literature and current migrant worker issues in industry. The approach presented in this study measures the combined impact of all interventions in a field experiment; however, in order to improve the reliability and validity in measurement, the individual effects of interventions should also be considered in further studies.

Regarding the experimental set-up, the Hawthorne effect posed a threat to the validity of study results. During the inspection period, worker behaviour could be altered in response to continuous observation. This change may result in either positive or negative behaviour towards safety. For example, a worker may show an efficient and mannered work performance while being observed by an inspector. In order to minimize the Hawthorne effect, the worker observation period was extended (3 weeks of continuous observation) and discreet observations were carried out (observing workers without them knowing).

Finally, the study results indicate that workers with contemporary training approaches show better safety performance as compared to crews with traditional training methods. However, the sole adoption of these approaches without the inclusion of special interventions may not yield better outcomes. These findings are significant because a dramatic increment can be seen in workers' safety performance, just by a minor increment in training-transfer. Therefore, construction practitioners must focus on the additional interventions in order to maximize training outcomes.

6. Conclusion

Migrant workers are more likely to have work-related injuries than those born locally. Even though a variety of training approaches have been adopted, foreign workers still experience unreasonably high accident rates because workers fail to transfer the knowledge to the actual jobsite. The purpose of this study was to assess the impact of different training levels and additional interventions on two objective training outcomes, namely knowledge-transfer by individual's ability of on-site hazard recognition and training-transfer by continuous observation of workers' safety performance.

Two key recommendations can be derived from results of this research for construction practitioners to apply the safety training designs and approaches to migrant workers for the achievement of successful and safe construction operations. First, the adoption of training programmes with the inclusion of interventions significantly improves training-transfer, which in turn improves overall safety performance of workers. These interventions are a necessary precursor to the transfer of acquired skills to the real jobsite. Therefore, organizations should endeavour to focus on improving training-transfer skills rather than focusing solely on knowledge delivery through training sessions. Second, on-site evaluation of worker's knowledge level after training can improve their confidence to work safely during actual tasks. Instructors should attempt to foster on-site evaluation techniques instead of traditional paper-based assessments. Following the promising results, the interventions tested with the contemporary approach are now being applied in practice on the same site in Qatar, as part of the daily construction training and inspections.

Future studies will focus on finding suitable and safe methods for on-site evaluation of worker knowledge acquired through training. In addition, it would be worthwhile for future research efforts to evaluate the impact of interventions on plant and civil engineering projects. Furthermore, scaffolding was the only task considered in this study; hence, the presented training-transfer results are not fully representative of the broad scope of construction work. Therefore, the consideration of other tasks for training evaluation will give more authenticity to the identified interventions.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by a National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIP) [No. NRF-2016R1A2B3016694].

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