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Moderating Effects of Individual Learning Ability and Resilient Safety Culture on the Relationship between the Educational Level and Safety Performance of Construction Workers

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Abstract: Having a higher educational level has been proposed to reduce workers' unsafe behavior. It remains unclear whether the improvement in safety performance can be enhanced by workers with higher education levels, an individual's learning ability, and a resilient safety culture. This study aims to examine the moderating effects of individual learning ability and resilient safety culture on the relationship between workers' educational level and safety performance. A questionnaire survey was conducted to assess the education level, resilience safety culture, safety learning ability, and safety performance of workers. The results indicated that the educational level of construction workers has a significant positive impact on safety performance. They confirmed that an individual's learning ability and a resilient safety culture have a positive moderating effect. This study supports the crucial relationship between worker education levels and safety performance. Thus, organizations and government entities can leverage this understanding to promote worker engagement in training programs and extend educational support. The study underscores the pivotal role of a resilient safety culture in bolstering the impact of worker educational level on safety performance. Finally, the study acknowledges the influence of an individual's learning ability on safety performance. Integrating educational levels with individual learning abilities can facilitate the development of targeted strategies to improve safety performance.

Keywords: construction workers; safety performance; educational level; individual learning ability; resilient safety culture; moderating effects

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1. Introduction

Despite a downward trend in recent years, the frequency of construction accidents in Hong Kong is still relatively high. Construction workers suffer the greatest number of occupational injuries and illnesses worldwide, out of all major industries [1,2]. Increased injury rates among construction workers continue to be a major concern for policymakers worldwide. Based on the report by the International Labor Organization (ILO), construction workers in developed countries are three to four times more at risk of fatal injury than those in other industries [3], while workers in countries that are less developed are three to six times more likely to suffer fatal accidents. Less than 8% of the global workforce is in the construction industry, however, 35% of all workplace fatalities happen on construction sites each year, causing the death of approximately 100,000 employees [4].

Construction sites provide unique risks due to working at height, crowded working areas, the extensive use of heavy machinery and equipment, and changing work environments and conditions on-site. Studies have been conducted to explore the key elements affecting the safety of construction sites and to investigate risky behaviors [5–7]. To decrease employee exposure to on-site risks, traditional safety measures emphasizing prevention and protection have been established by construction organizations [8,9]. These include risk assessment, the implementation of safety management systems, behavior-based safety schemes, and risk management and enhancing the safety culture in the organization; they are based on the underlying assumption that the workplace environment is free of unexpected events. There have also been studies conducted to explore the idea and conceptual framework of safety culture [10,11]. A safety culture based on traditional ways assists an organization in improving safety performance by preventing regular safety issues; however, they are unable to address dynamic and unforeseen safety risks [12]. Pęciłło proposed resilience engineering as a means of addressing the deficiency of conventional safety culture and management techniques to respond to the dynamic and unforeseen safety threats associated with the complex nature of sociotechnical systems [13]. In order to achieve an ultrasafe organization, a resilient safety culture, a safety culture developed based on resilience engineering, was presented as a potential idea [14,15]. Trinh et al. conducted a study on the various components of a resilient safety culture and confirmed the significance of a resilient safety culture in improving construction project safety performance [16].

The safety behavior of construction workers is influenced by a wide range of factors. According to Mnjula and De Silva, one of the most important factors is the workers' educational background and safety knowledge [17]. Construction accidents have been shown to occur often in China's construction industry as most workers and some managers lack a sufficient educational background and safety training [18]. Nawi et al. pointed out that the low educational levels of workers are the main cause of poor safety awareness in Malaysia's construction industry [19]. The low educational level of many construction employees has been seen to be a barrier to enhancing safety at construction sites in Sri Lanka as well [20]. The workers' educational level has a favorable impact on employees' safety practices; when the workforce is comprised of employees with solid educational backgrounds, it is easier to maintain high safety standards [21]. Workers with a high degree of knowledge and learning capacity are also necessary to foster a culture of safety [22].

Trinh et al. suggested that the degree of personal learning capacity is favorably correlated with the safety performance of construction projects [15]. Previous research has indicated that educational background has a substantial influence on safety performance, with higher-educated workers typically demonstrating better safety behaviors and fewer injuries [23,24]. This is supported by the literature implying that the education level of workers has an impact on their safety performance, but it remains unclear whether the effect of educational level on safety performance is positive or negative. Uncertainty exists regarding the extent to which the improvement in safety performance can be maintained by educational level under the different levels of individual learning ability and resilient safety culture. The intricate interrelationships between the educational level, individual learning ability, resilient safety culture, and safety performance of construction workers are still poorly understood despite some studies in this field. Therefore, the current study aims to fill the research gap by determining the relationship between resilient safety culture and an individual's ability to learn and how it affects the safety performance of construction projects. By drawing upon the current literature, the study proposes hypotheses about the impact of educational level, individual learning ability, and resilient safety culture on the safety performance of construction workers. The results of this study will aid in understanding the crucial roles that a resilient safety culture and an individual's ability to learn have in enhancing the safety performance of construction projects.

2. Literature Review

2.1. Safety Performance Affected by the Educational Levels of Workers

Several studies have provided support for the significant influence of workers' educational levels on safety performance [5,17,21,25]. As indicated by Nawi, the majority of construction workers lack a high level of education [19]. Although the employees have practical skills, they are lacking in theoretical understanding and application. The level of education affects how workers behave and perform in terms of safety on the job site [26].

According to Mnjula and De Silva's research, it is relatively simple to uphold safety standards when the workforce is made up of people with solid educational backgrounds [17]. Experts claim that people with a secondary education level or above understand the significance of adhering to workplace safety regulations. People with a secondary education are easier to manage and persuade to follow safety procedures, according to the interviewees, than those with a primary education or less [27]. Higher-educated workers tend to be more logical and cautious, whereas less-educated workers are more fearless and impulsive [28].

Worker education is recognized as a crucial aspect of construction safety [17]. The level of education has a positive impact on employees' safety behaviors, which in turn affects safety performance [29]. The likelihood that a worker will behave unsafely while working is increased if they have a low educational level, do not comprehend basic construction specifications, or even do not want to understand why or how important safety is in the industry [30]. Highly educated employees in the field are more likely to act safely while at work. For the construction industry to proceed safely, a high level of education and a strong foundation in safety are essential. Choudhry and Fang revealed that some workers were uneducated people, and they were not able to read safety information and training materials [31]. This implies that the educational level of workers could affect the outcome and effectiveness of safety training. In addition, Tam et al. pointed out that one characteristic of the Chinese construction industry is the presence of a sizable number of workers who are peasant laborers and are poorly educated, unskilled, untrained, and inexperienced [5]. Similarly, in Cambodia, construction workers are typically unskilled, uneducated, and untrained, coming from impoverished provinces, leading to low educational levels and inadequate worker skills, which are the primary contributors to poor construction safety performance [32].

Numerous studies have demonstrated a positive correlation between higher educational levels among workers and improved safety knowledge, skills, and attitudes, ultimately leading to enhanced safety performance [31,33–35]. Choudhry and Fang found that workers with higher educational levels exhibited a better understanding of safety practices and regulations [31]. Hardison et al. explored the relationship between education and safety performance, noting that workers with advanced education displayed greater adherence to safety protocols [33]. Similarly, Van Dijk et al. and De Koster et al. reported that higher education levels were associated with improved safety knowledge and attitudes among workers [34,35]. Based on the above literature, this study posits that the educational level of workers may play an important role in improving the safety performance of construction works.

Although it is commonly documented that more experienced and well-educated individuals perform better in terms of safety [36–38], some earlier works revealed that there are still doubts about the role of educational level. Diaz and Cabrera pointed out that worker safety attitude and performance are not significantly associated with educational level, implying that a higher educational level does not imply greater worker safety [39]. Additionally, Zhou et al. found that the probability of engaging in safe behavior improved just marginally from 65.4% to 66.0% when educational experience moved from low to high [40]. The Bayesian network analysis in the research of Chan et al. revealed that the educational level of workers was relatively insignificant in improving safety performance [24]. According to Feng and Wu, employees with higher levels of education have a tendency to compensate for risk more often than those with lower educational levels [23]. Based on the above research, given the uncertainty of the educational influences, the relationship between education and safety performance will be further analyzed. This study therefore proposes the following hypothesis:

H1: *There is a positive correlation between the educational level of construction workers and their safety performance.*

2.2. Potential Moderating Role of Resilient Safety Culture at the Company Level

Resilience engineering has been suggested as a means of addressing the inability of conventional safety culture and safety management practices to respond to the shifting and unpredictable characteristics of safety hazards [13,15,41]. The research of Trinh et al. indicated that a resilient safety culture can be created in a construction organization by systematically responding to project hazards, unexpected failures, and improved safety performance in the construction environment [15]. The theories of safety culture and resilience engineering serve as the theoretical foundations for the concept of a resilient safety culture [14]. To address the weaknesses in safety culture, a novel concept called resilient safety culture has been put forth. It is a safety culture that values adaptability, education, ongoing development, and financial efficiency [41]. According to resilience engineering, an accident indicates that the systems have a failure to make the appropriate adjustments to deal with the complexity of actual situations [42]. Developing an organization's capacity for foresight and the recognition and anticipation of the changing nature of risks is a key component of resilience engineering [16,43].

Resilient safety culture is a multifaceted concept [44,45]. Pillay et al., based on a review of the literature, ascertained there are three dimensions of resilient safety culture: contextual, behavioral, and psychological [46]. Psychological resilience is the ability of a company to understand, analyze, and evaluate unexpected events in order to determine how to respond. The capacity of a company to learn and adopt new practices while maximizing the use of its resources is referred to as behavioral resilience. Relationships between employees, resource availability, and supply chains all contribute to contextual resilience, which enables a swift response in potentially hazardous environments for companies [45]. In construction research and practice, the idea of a resilient safety culture is becoming more popular. Recently, a number of studies have been published that emphasize the need for a paradigm shift in construction organizations' safety cultures [47,48]. These research results shed light on the ways in which construction organizations can establish a resilient safety culture. According to Feng and Trinh, construction companies can create a resilient safety culture in systematic response to both common and uncommon risks as well as unusual events that may occur [49]. Organizational safety performance has been shown to benefit from various aspects of a resilient safety culture [50]. The research by Trinh et al. demonstrated that a resilient safety culture can enhance the safety performance of construction workers on even a complex project [16]. Resilient safety culture, a subset of safety culture, can subtly alter construction workers' cognition by influencing the surrounding environment in a similar way, which in turn affects their behaviors and safety performance [51].

Higher Level of Education Associated with a Stronger Resilient Safety Culture

The concept of a resilient safety culture, along with the influence of educational level, presents valuable insights into promoting safety performance within organizations [41]. As discussed earlier, a resilient safety culture aims to achieve a consistently high safety performance, which is characterized by continuous improvements in safety performance and the capability to create foresight, recognizing and anticipating the changing shape of safety risks in complex sociotechnical systems. Furthermore, a strong resilient safety culture is necessary to enhance the positive impact of workers' educational level and offer insightful information for improving safety performance within enterprises and across different construction sites [13]. Some previous studies pointed out that contextual and psychological resilience are more strongly associated with safety performance in construction. Boughaba et al. suggested contextual and psychological resilience are the two major components of safety culture [52]. These two components of safety culture can be used to enhance safety performance in the construction workplace. This contextual safety culture can enhance the safety of the team, the work environment, and the organization as a whole. It has long been recognized that contextual safety culture plays an important role in maintaining organizational effectiveness [53]. Contextual safety culture is likely to play an important role in the maintenance of overall safety performance as well. Thus, this study focuses on the relationship between contextual and psychological resilience and safety performance. A hypothesis suggests that a resilient safety culture, which emphasizes safety learning, has the potential to enhance the influence of workers' educational level on safety performance in the workplace. By prioritizing safety learning and continuous improvement, a safety culture creates an environment that encourages workers to acquire and apply safety-related knowledge and skills [15,42,54]. Woods found that in an environment that emphasizes safety learning and continuous improvement, workers with higher educational levels demonstrated a greater inclination to integrate safety-related knowledge into their work practices, resulting in improved safety performance [42]. Guo et al. examined the relationship between safety culture and educational level, highlighting the creation of an environment that motivates workers to acquire and apply safety-related knowledge and skills through a focus on safety learning [54]. Trinh et al. indicated that within a resilient safety culture centered on safety learning, workers with higher educational levels displayed a stronger shared commitment to safety, reinforcing safety-related behaviors and practices in the workplace [15]. Therefore, when workers with higher education levels are exposed to such an environment, they are more likely to integrate safety-related knowledge into their work practices, leading to enhanced safety performance. Additionally, a resilient safety culture focused on safety learning nurtures a collective commitment to safety, reinforcing safety-related behaviors and practices [55]. Built on this, it is hypothesized that:

H2: *When there is a stronger resilient safety culture towards safety learning, the influence of educational level on safety performance becomes more significant.*

2.3. Potential Moderating Role of Individual Learning Ability at the Individual Level

Organizational learning occurs as a result of the actions taken by individuals, groups, and organizations [56]. An individual's learning ability, that is, the manner in which they gather and process information, formulate and prepare innovative ideas, and carry out modifications, serves as the foundation for the development of organizational knowledge and improving organizational learning ability. It is crucial to develop from the individual level and progress to the collective or group level before reaching the organizational level [57]. In order to prevent incidents and maintain construction productivity, labor learning ability from incidents and learning effectiveness become important issues [58]. It was suggested by Ho and Dzeng that the individual learning ability of workers is an important factor influencing learning effectiveness. Learning effectiveness can be influenced by the ability of workers to gain incident or safety information, understand the information, and make use of this information [58]. In the area of incident learning, it is necessary to not only "pass on" technical ideas and information to workers but also to increase risk awareness, ensure that the danger and risk are correctly understood, enhance the understanding of safety requirements, and modify the implementation of work based on all the information [59]. Thus, incident learning requires the development of "cross-disciplinary skills" in addition to technical and professional skills. These include the ability to share knowledge and skills, communicate, and make decisions. Thus, workers' individual ability to learn affects training outcomes, the effectiveness of understanding incident information, identifying unsafe behaviors, and modifying unsafe behaviors based on incident information [5]. Effective learning from workplace accidents can help employees gain new knowledge that will allow them to implement positive changes during the construction process, improving production and safety performance and reducing the likelihood of incident recurrence [60].

Higher Level of Education Associated with Stronger Learning Abilities

The current study considered individual learning ability as the moderating variable between the education level of the workers and safety performance. Some previous studies provided evidence that an individual's learning ability has been utilized as a moderator in influencing safety performance. An individual's learning ability plays a crucial role in influencing the safety performance within organizations [61]. The ability of individuals to acquire, comprehend, and apply incident and safety-related knowledge is vital for preventing accidents and promoting a safer work environment. A high educational level of employees enhances the capability of a construction project to identify the potential threats to safety that should be prevented or avoided, respond to regular and irregular threats, and take lessons from experiences; in particular, how to learn useful lessons from the experiences of success and failure [62]. Developing cross-disciplinary skills and fostering effective learning from workplace incidents are essential for improving safety performance and ensuring the continuous improvement of organizational practices.

In construction projects, employees with stronger learning abilities may have better capabilities to manage safety risks, thereby mitigating the adverse impact of project complexity on safety performance. Workers with strong learning abilities have a greater capacity to comprehend and retain safety-related information, resulting in its effective application in the workplace [58,59]. Nevertheless, the studies did not go into great detail on how individual learning ability affects the association between educational level and safety performance, which is especially important in the construction industry. This suggests that individuals with higher safety learning abilities may experience a more pronounced influence of educational level on safety performance. The combination of advanced educational levels and strong safety learning abilities enables individuals to better understand and implement safety-related concepts and practices [57], resulting in improved safety performances and reduced injury risks. Consequently, our hypothesis states that:

H3: *When an individual's safety learning ability is better, the effect of educational level on safety performance becomes stronger.*

To summarize, Figure 1 illustrates the theoretical model and hypotheses formulated in this study.

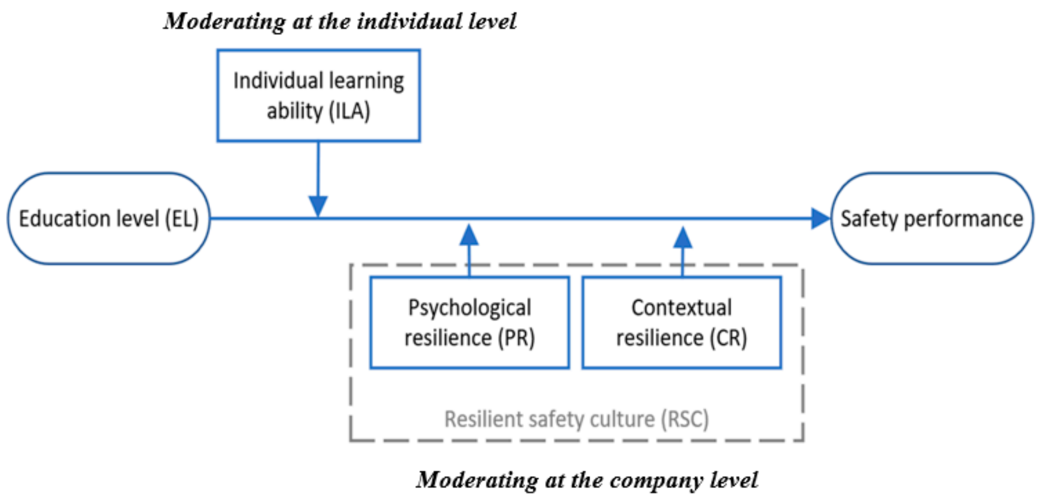

Figure 1. Theoretical model.

3. Methodology

3.1. Questionnaire Survey

To examine the proposed hypotheses, a questionnaire survey was conducted to explore the relationship between workers' safety performance, educational level, individual learning ability, and resilient safety culture. The design of the questionnaire was developed based on a comprehensive review of the existing literature, which was discussed in the literature review section. The structure of the questionnaire is shown in Table 1 and has four sections that are divided into categories relating to the worker's education level, safety performance, resilient safety culture, and safety learning ability. The first section aimed to investigate the main effect of the educational level of construction workers on their safety performance (H1). Another two sections were designed to explore the moderating effects of a resilient safety culture and an individual's learning ability (H2 and H3, respectively). The final section measured the safety performance level of construction workers. To measure the three dimensions of resilient safety culture, individual learning ability, and safety performance, 19 measurement items were developed (Table 1). Sections 2–4 of the questionnaire adopted a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) through which respondents were required to indicate the level of their agreement for each item found in these sections.

Table 1. Measurement dimensions of this study.

Educational Level	**Q1. Educational Level (1 = Below Primary; 2 = Primary; 3 = Secondary; 4 = Diploma or Above)**		**References**
Resilient safety culture	Contextual resilience	Q2. Management and supervisory staff implement appropriate corrective measures immediately following any changes to working conditions (i.e., new hazards identified, hazardous events occurring).	[63,64]
		Q3. Before working on any complex/unusual activities, my work group is briefed and trained on safety procedures.	[65]
		Q4. At my workplace, there is an atmosphere of trust and openness.	[66–68]
	Psychological resilience	Q5. In an effort to carry out a work task appropriately and safely, I know exactly what my coworkers are doing.	[69–71]
		Q6. I acknowledge that unexpected hazardous events (e.g., unobserved hazardous conditions, unintentional unsafe behaviors) can occur anytime and anywhere.	[44,70,71]
		Q7. I am aware of the negative consequences of noncompliance with safety rules.	[50]
		Q8. I consider past hazardous events as a useful source to formulate appropriate corrective measures.	[49]
		Q9. Managerial and supervisory staff know how to encourage workers to share their safety experiences.	[72]
Individual learning ability	Q10. I participate in incident learning through specialized training program.		[71]
	Q11. I am able to understand incident information based on my knowledge and technical capability.		[71,73,74]
	Q12. I am able to identify my workmate's or my unsafe behaviors from incident information.		[31,75]
	Q13. Safety corrective measures are not well implemented because people on this project (including management and workers) lack of motivation or concern about extra work.		[49,51,69,76]
	Q14. I modify my unsafe behaviors based on incident information.		[36]
Self-reported safety performance by frontline workers	Q15. I use all the necessary safety equipment to do my job.		
	Q16. I use the correct safety procedures for carrying out my job.		
	Q17. I ensure the highest levels of safety when I carry out my job.		
	Q18. I promote the safety program within the organization.		
	Q19. I put in extra effort to improve the safety of the workplace.		
	Q20. I voluntarily carry out tasks or activities that help to improve workplace safety.		

The questionnaire survey included employees working on construction projects in China between July and October 2021. A Chinese translation of the questionnaire was adopted. Respondents accessed the electronic survey through a QR code link. Through the network of the research team, the questionnaires were distributed to management staff who helped coordinate the participation of front-line employees. In order to increase the response rate, respondents were given the option to obtain a report when the data analysis was completed. A total of 210 completed surveys were received from frontline workers. Informed consent was obtained from all participants, and strict confidentiality was maintained throughout the study.

The participants were divided into four groups according to their educational background, "Below primary", "Primary", "Secondary", and "Diploma or above". In Table 2, the distribution and percentage of participants in each category are shown. Approximately 41% of the sample comprised individuals with a secondary education or below, which indicates that nearly half of frontline workers in the construction industry may not have completed post-secondary education. Conversely, around 59% of the participants possessed a diploma or above, which indicates that many workers in the construction industry have undergone vocational training or college-level courses.

Table 2. The educational level of participants in this study.

Educational Level of Respondents	Number of Respondents	Percentage (%)
Below primary	2	1.0%
Primary	12	5.7%
Secondary	73	34.8%
Diploma or above	123	58.6%

Note: "Diploma or above" refers to the respondents who completed post-secondary education, such as college or university degrees.

3.2. Data Analysis

This study initially employed a one-way ANOVA to compare the means of four independent groups, determining if there were statistically significant differences among them [77]. This method is effective for hypothesis testing to ascertain statistical differences among multiple groups [78]. The Safety Performance Score was derived by summing the scores of the six items from Table 1's safety performance scale. Survey participants were categorized into four groups based on their educational level. By comparing the means and conducting an F-test on the educational level and safety performance, the study explored the influence of workers' educational levels on safety performance in construction projects. This approach is applicable for examining whether there are significant differences in safety performance scores among construction workers with varying educational levels. To conduct the F-test, assumptions about equal variances in different samples need verification. The Levene test was employed to assess the equality of variances across different samples [79].

A two-way ANOVA test was conducted in accordance with the hypotheses outlined in the previous sections. This statistical analysis assesses how two categorical independent variables in combination impact a continuous dependent variable, specifically examining how the mean of the dependent variable changes relative to the levels of the two independent variables [80]. This study was employed to examine the moderating effects of an individual's learning ability and a resilient safety culture on the relationship between the educational level and safety performance of construction workers (H2 and H3). Following the identification of significant interactions, post hoc analyses of the simple main effects of each independent variable were conducted to delve into the specific differences between these variables. The main effects refer to the influence of each independent variable on the dependent variable, in isolation from the other independent variable [81]. The interaction effect refers to the joint effect of the two independent variables on the dependent variable. The interaction effect between the safety performance score, educational level, individual learning ability, and resilient safety culture was examined. The research method adopted in the current study was developed based on previous research. Stoilkovska et al. [82] adopted a two-way ANOVA to demonstrate that job satisfaction has a strong effect on the perceived management commitment to work safety and that this relationship was moderated by respondents' age. The sample comprised 155 workers from eight construction companies and sites located in the Republic of Macedonia. Kang et al. [83] examined pre-project planning efforts for green and conventional building projects by using a two-way ANOVA. Data from a total of 124 projects were collected, 71 from conventional building projects and 53 from green building projects. The data were then divided into four categories based on project type for analysis. Jin et al. [84] utilized a *t*-test and a two-way ANOVA to determine whether crash rates are statistically higher during construction than during non-construction periods using 202 highway work sites. These highway locations were classified into four highway classes. Based on past research, the 210 completed questionnaires from frontline workers were considered to be sufficient to yield a representative and valid outcome. All statistical analyses were performed by the Statistical Package for Social Sciences (SPSS) Version 26.0.

4. Results

4.1. Positive Correlation between the Educational Level of Construction Workers and Safety Performance

To compare the educational levels of construction workers and their safety performance, a one-way ANOVA was employed. The homogeneity of variance is a crucial assumption for the F-test in a one-way ANOVA, and the Levene test was used to determine whether this assumption holds. As indicated in Table 3, the p-value of the Levene test was 0.267, which is greater than 0.05. Hence, it can be considered that the between-group variances are equal, and the F-test can be applied. Under the assumption of equal variances, the F-test yielded a result of $F = 4.541$, with $p = 0.004$, which is less than the significance level of 0.05 (Table 4). Therefore, the null hypothesis of no significant difference in the mean scores between the two datasets can be rejected. This implies a significant difference in the overall means across multiple groups, signifying notable variations in safety performance scores among workers with different educational levels. The direction of this difference (whether higher education leads to higher safety performance scores) can be determined by examining the means of the two groups. According to the Bonferroni multiple mean comparison results in Table 5, it can be further inferred that educational level has an impact on the safety performance scores of construction workers. The "Below Primary" group exhibited significant differences in safety performance scores compared to the other three groups (with p-values of 0.003, 0, and 0, respectively). The "Primary" group showed a significant difference in safety performance scores compared to the "Diploma or above" group ($p = 0.001$), while no significant difference was found between the "Primary" group and the "Secondary" group ($p = 0.093$). There was no significant difference in the safety performance scores between the "Secondary" group and the "Diploma or above" group ($p = 0.089$).

Table 3. The equality of safety performance scores in groups with differing levels of education.

		Levene Statistic	df1	df2	Sig.
Safety performance score	Based on the mean	1.325	3	206	0.267
	Based on the median	1.552	3	206	0.202
	Based on the median and with an adjusted df	1.552	3	199.567	0.202
	Based on the trimmed mean	1.411	3	206	0.241

Table 4. The impact of different educational levels on workers' safety performance scores.

Educational Level	Safety Performance Score ($\bar{x} \pm S$)	F-Test Result	
		F	*p*
Below primary	17 ± 2.829	4.541	0.004
Primary	23.929 ± 5.4279		
Secondary	26.583 ± 3.885		
Diploma or above	27.95 ± 2.783		

Table 5. Bonferroni multiple comparisons results across different educational levels.

Educational Level	Educational Level	Mean Difference (I–J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Below primary	Primary	−6.92857 *	1.94127	0.003	−12.1001	−1.7571
	Secondary	−9.58333 *	1.72327	0	−14.1741	−4.9926
	Diploma or above	−10.94958 *	1.70103	0	−15.4811	−6.4181
Primary	Below primary	6.92857 *	1.94127	0.003	1.7571	12.1001
	Secondary	−2.65476	1.08837	0.093	−5.5542	0.2446
	Diploma or above	−4.02101 *	1.0528	0.001	−6.8257	−1.2164
Secondary	Below primary	9.58333 *	1.72327	0	4.9926	14.1741
	Primary	2.65476	1.08837	0.093	−0.2446	5.5542
	Diploma or above	−1.36625	0.55633	0.089	−2.8483	0.1158
Diploma or above	Below primary	10.94958 *	1.70103	0	6.4181	15.4811
	Primary	4.02101 *	1.0528	0.001	1.2164	6.8257
	Secondary	1.36625	0.55633	0.089	−0.1158	2.8483

Note: * The mean difference is significant at the 0.05 level.

4.2. Moderating Effect of Individual Learning Ability on the Relationship between Educational Level and Safety Performance

From the results of the two-way ANOVA in Table 6, the main effect of an individual's learning ability was significant (F (4, 198) =3.387, p = 0.01, η2 = 0.064). Therefore, it can be concluded that the impact of a worker's education level on safety performance is more significant in the case of a high individual learning ability (mean = 29.666, SD = 1.274; mean = 29.807, SD = 0.666) compared to low individual learning ability at an average level (mean = 23.8, SD = 4.857; mean = 25.166, SD = 4.687). The descriptive statistics of an individual's learning ability and safety performance scores are presented in Appendix A. This pattern holds true for each educational level group. The interaction effect is illustrated in Figure 2. As shown in the figure, the difference in the mean values of the safety performance scores for a high individual learning ability and a low individual learning ability was substantial. The impact of the educational level on safety performance scores was moderated by the levels of an individual's learning ability. This implies that the effect of educational level on safety performance scores is greater for workers with high levels of individual learning ability.

Table 6. Two-way ANOVA of individual learning ability and the safety performance score.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1993.204 a	11	181.2	22.17	<0.001	0.552
Intercept	15,160.92	1	15,160.92	1854.925	<0.001	0.904
education_level	38.913	3	12.971	1.587	0.194	0.472
individual_learning_ability	1448.52	4	362.13	44.306	<0.001	0.023
education_level * individual_learning_ability	110.742	4	27.685	3.387	0.01	0.064
Error	1618.32	198	8.173			
Total	156,162	210				
Corrected total	3611.524	209				

Note: a indicates R Squared = 0.552 (Adjusted R Squared = 0.527); * Denotes the combination of education level and individual learning ability.

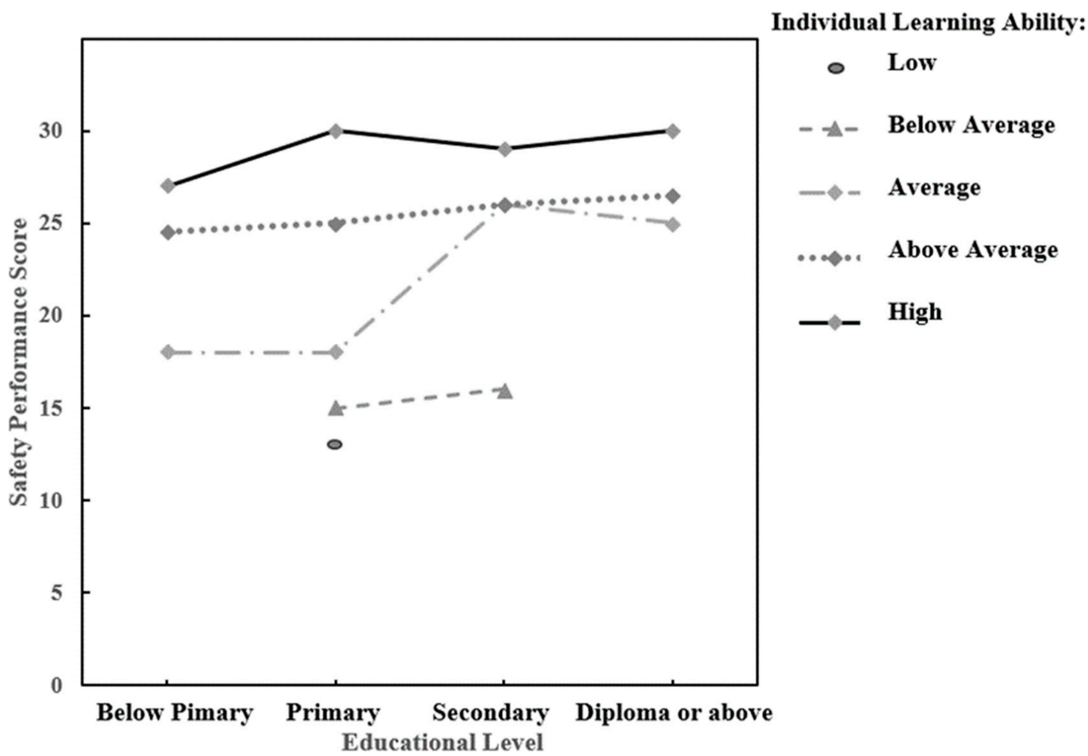

Figure 2. The interaction effects of an individual's learning ability and the safety performance score.

4.3. Moderating Effect of Resilient Safety Culture on the Relationship between Educational Level and Safety Performance

The main effect of contextual resilience was significant (F (7, 195) = 5.881, $p < 0.001$, η2 = 0.174) (Table 7). It showed that the influence of the workers' education level on safety performance is more pronounced in situations characterized by high contextual resilience (mean = 29.827, SD = 0.539; mean = 29.812, SD = 0.639) compared to those with average contextual resilience (mean = 22.3, SD = 4.571; mean = 24.461, SD = 3.843). The descriptive statistics of contextual resilience and safety performance score are presented in Appendix A. This pattern remains consistent for each educational level group. Furthermore, the interaction effect between educational level, safety performance, and contextual resilience is significant (Figure 3). This indicates that the effect of the educational level of workers on safety performance was different among high-level and low-level contextual resilience in the construction industry.

Table 7. Two-way ANOVA of contextual resilience and the safety performance score.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2479.822 a	14	177.13	30.521	<0.001	0.687
Intercept	8046.41	1	8046.41	1386.452	<0.001	0.877
education_level	137.123	3	45.708	7.876	<0.001	0.108
contextual_resilience	1294.861	4	323.715	55.778	<0.001	0.534
education_level * contextual_resilience	238.903	7	34.129	5.881	<0.001	0.174
Error	1131.702	195	5.804			
Total	156,162	210				
Corrected Total	3611.524	209				

Note: a indicates R Squared = 0.687 (Adjusted R Squared = 0.664); * Denotes the combination of education level and contextual resilience.

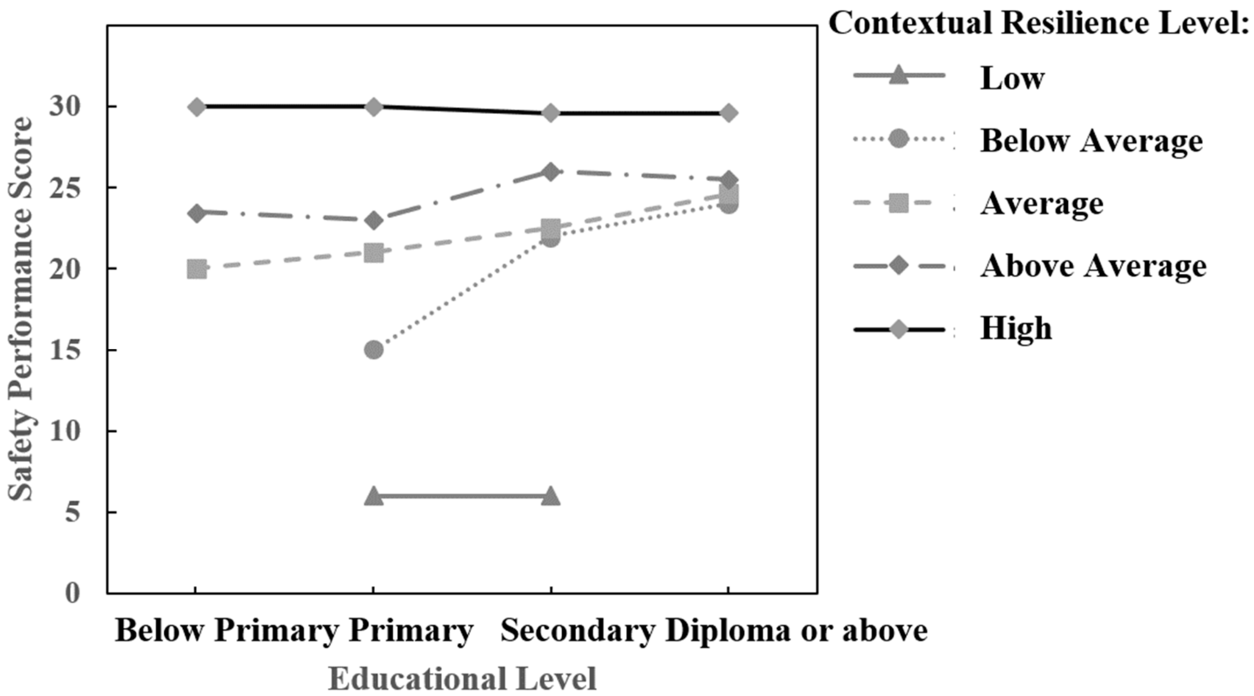

Figure 3. The interaction effects of contextual resilience and the safety performance score.

On the other hand, the main effect of psychological resilience was also significant (F (7, 195) = 4.259, $p < 0.001$, η2 = 0.133) (Table 8). Specifically, the influence of the workers' education level on safety performance is more significant in situations where high psychological resilience is present (mean = 29.920, SD = 0.4; mean = 29.890, SD = 0.416), compared to situations with average psychological resilience (mean = 22.250, SD = 3.934; mean = 24, SD = 3.484). The descriptive statistics of psychological resilience and the safety performance score are presented in Appendix A. This pattern holds true for each education level group. Additionally, the interaction effect between the educational level, safety performance, and psychological resilience is also significant (Figure 4). A high level of psychological resilience moderates a stronger impact of educational level on the safety performance scores of workers in comparison to those with low levels of psychological resilience.

Table 8. Two-way ANOVA of psychological resilience and the safety performance score.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2385.638 a	14	170.403	27.106	<0.001	0.661
Intercept	9530.658	1	9530.658	1516.029	<0.001	0.886
education_level	121.372	3	40.457	6.435	<0.001	0.090
psychological_resilience	1163.737	4	290.934	46.278	<0.001	0.487
education_level * psychological_resilience	187.419	7	26.774	4.259	<0.001	0.133
Error	1225.886	195	6.287			
Total	156,162	210				
Corrected Total	3611.524	209				

Note: a indicates R Squared = 0.661 (Adjusted R Squared = 0.636); * Denotes the combination of education level and psychological resilience.

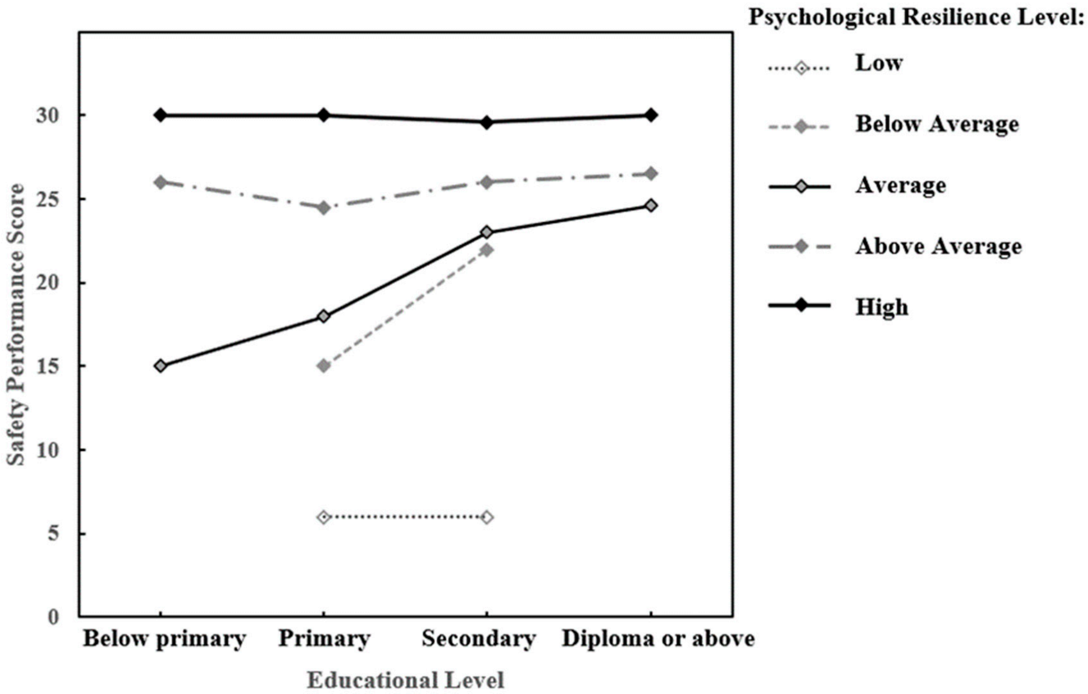

Figure 4. The interaction effects of psychological resilience and the safety performance score.

5. Discussion

5.1. Impacts of Worker's Educational Level on Safety Performance

The results indicated that, as hypothesized in H1, there is a strong positive relationship between construction projects' safety performance and the education level of their workforce (Tables 3 and 4). In addition, a high educational level could enhance the safety performance of workers. Increasing the educational level is thought to be an efficient and straightforward strategy to increase worker skills and risk avoidance in many industries [31,33,34]. Workers may be more at risk if they lack expertise or have insufficient experience [35]. A high educational level of personnel is crucial for fulfilling the objectives of organizational safety management, according to Zhang and An [85]. Poorly educated workers typically have a brief term of education and are likely to have a limited comprehension of safety-related theory and knowledge. As a result, they might not possess the necessary knowledge and skills for successful mutual aid or a sufficient grasp of risk avoidance during the work [86]. The research results are supported by Liang et al.'s study regarding the construction safety model [38]. According to this model, education has a considerable impact on safety outcomes. Individuals' safety engagement has been shown to be favorably associated with their education level, i.e., low-educated workers were less likely to participate in voluntary safety programs [38] and higher-educated employees are more inclined to take part in on-site voluntary safety activities and support safety measures. To establish a safer working environment, the higher educated employees could be chosen and trained as role models or leaders within construction workers [5].

The research of Feng et al. also pointed out that workers' educational levels have a greater impact on how they perceive the safety of the work environment, which, in turn, affects how well the site is operated in terms of safety [87]. Employees with higher levels of education, particularly those who have obtained qualifications from a community college or university, tended to agree more with the benefit of incentives on safety behavior, thus, they will be more motivated by incentives to behave safely [88]. Meng and Chan's research demonstrated that workers' safety consciousness and behavior are significantly positively influenced by their educational background [89]. Workers with low education levels may not understand safety-related concepts well or be able to perform safely in teams [90]. The research findings confirmed the influence of the educational level of workers on construction safety performance. The results of this study are in line with previous studies which indicated that the educational attainment of workers had a significant impact on how safely construction projects were performed. Based on the findings, the construction industry should be more active in establishing training programs to educate workers and improve safety performance.

5.2. Moderating Effects of Individual Learning Ability

Hypothesis H2 was concerned with the associations between the educational level of workers, safety performance, and an individual's safety learning ability (Table 5). The results revealed that an individual's safety learning ability may affect the impact of the educational level of workers on safety performance. In this research, an individual's learning ability was measured by several dimensions, for example, the ability to understand incident information based on their knowledge, to identify unsafe behavior from incident information, and to modify their unsafe behavior based on incident information. In accordance with previous studies in construction industries, this research strongly confirmed that the individual learning ability of workers is a critical factor influencing construction safety [58,59]. Individual learning ability is the basis for creating organizational knowledge and strengthening organizational learning capacity [57]; it is a significant aspect influencing a worker's ability to share information and skills, communicate, and make decisions. Individual workers' learning abilities influence training outcomes, as well as the effectiveness of their understanding of incident information, detecting risky behaviors, and altering unsafe behaviors based on incident information [5].

Workers' individual safety learning ability has a major influence on the success of safety training [91]. An individual's safety learning capacity and the educational level of workers are considered essential by Mallett et al. and Hood and Littlejohn because they can affect the efficiency and efficacy of safety training and, consequently, affect worker safety performance [92,93]. According to Xu et al., learning abilities are affected by a variety of external and internal factors such as work characteristics, complexity, a worker's educational level, age, experience, knowledge, and enthusiasm [92]. While safety knowledge is obtained through safety training and information, these elements might also have an influence on knowledge attainment. Knowledge attainment in the context of construction can be defined as the workers' capacity for learning, level of expertise, and awareness of safety. The construction workers in this study believed that having a high educational level and strong individual learning ability would have a beneficial impact on their safety performance.

Despite not impacting how hazards or accident scenes are seen by personnel, workers' educational level may have a more significant impact on how the site perceives safety, and, ultimately, how well safety is achieved [94]. With the facilitating effect of the high individual learning abilities of workers, the positive effects of high educational levels on safety performance can be enhanced. From this perspective, a worker's ability to learn may be an essential facilitator for helping construction workers modify their habits and ultimately enhance safety performance.

5.3. Moderating Effects of Resilient Safety Culture Dimensions

The findings of this study demonstrate that the influence of workers' educational degrees on safety performance varies at different levels of resilient safety culture. According to the findings, the educational level is likely to have provided a solid foundation for a favorable effect on safety performance. The findings imply that a resilient safety culture may play a role in further strengthening the effect of educational level. When there is a higher level of strong resilient safety culture present, the beneficial effect of workers' educational levels on safety performance becomes more significant. These findings suggest that a more resilient safety culture could strengthen the impact of worker education on safety performance in the contextual resilience and psychological resilience aspects.

The moderating influence of psychological resilience on safety performance in this study implies that, in projects with a higher psychological resilience, the company has a greater ability to recognize, analyze, and assess unexpected events in order to determine how to respond (Table 7). Research has found that psychological resilience plays a significant role in safety and risk management in construction companies, improving the safety performance in construction projects [15,42,54]. The findings of Carter and Smith indicated that employees' decision capability to understand, analyze, and evaluate unexpected events and determine how to respond was highly dependent on their educational level [55]. According to Choudhry and Fang, employees who have more education are more aware of safety concerns [31]. They may have a better capability to learn lessons from past mistakes, make the right conclusions, and adapt their behavior to deal with unforeseen circumstances. Khorsandi and Aven provided evidence in support of the idea that construction employees with better educational backgrounds may use past events as a beneficial source for developing appropriate corrective actions [95]. Based on the research results, it can be concluded that projects with higher degrees of psychological resilience were more likely to sustain an increase in construction safety performance. Meanwhile, the impact of education level on safety performance becomes stronger when psychological resilience to learning from incidents is stronger.

The moderating influence of contextual resilience on safety performance implies that, in projects with better contextual resilience, the company has a better relationship between employees, resource availability, and supply chains (Table 6). Contextual resilience lays the groundwork for swift decisions in unpredictable environments where companies face possible hazards [45]. The underlying notion behind resilience engineering, according to Pecillo, is that an organization should manage risks proactively and promote safety in the workplace in a world of limited resources, irreducible unpredictability, and various conflicting aims [13]. Contextual resilience was applied in this study to describe a company's capacity to offer a background for responses to incidents and detect potential safety issues. As a result, projects with higher degrees of contextual resilience had a better likelihood of maintaining improvements in construction safety performance. The top management creates safe settings by formulating the safety policy and allocating resources. The attitude of top leaders is critical in creating good contextual resilience [96]. According to Lengnick-Hall et al., managers and frontline employees with a higher educational level may view past incidents as a beneficial source to build appropriate measures and assign appropriate resources to facilitate their reactions to safety concerns [45]. Through the use of a construction accident causation model, Mitropoulos et al. highlighted the fact that there are numerous situations where the actual conditions are different from what was anticipated or where resources (such as knowledge, tools, or materials) may be lacking [8]. Numerous studies that place emphasis on a company's ability to recognize unforeseen changes and dangers as well as requiring reliable planning to enhance safety performance on construction sites are consistent with this finding [41,97].

These results suggest that the favorable benefits of worker education on safety performance were more likely to be enhanced in construction sites with higher degrees of resilience in safety culture. The ability of a construction project's contractors and personnel to handle safety risks on the job site strongly correlated with how negatively project complexity influenced a project's safety performance. In addition, projects with strong capacities to handle safety risks, as indicated by resilient safety culture levels, had a higher likelihood of sustaining an enhancement in construction safety performance.

6. Conclusions

This study examined the interactive effects of individual learning ability and resilient safety culture on the safety performance of construction projects. The findings of this study contribute to the knowledge of safety management by highlighting the significant impacts of a worker's educational level on construction safety performance and the moderating role played by the worker's individual learning ability and resilient safety culture in the working environment. First, the results supported that the educational level of workers has a strong positive impact on safety performance. They implied that the high educational level of workers could enhance the safety performance of workers and reduce the chance of incident occurrence. Therefore, the recommendation is for construction organizations and related government departments to encourage workers to actively participate in training programs and offer more educational support for workers with low educational levels.

Second, the findings supported the concept that when a higher level of resilient safety culture is present, the beneficial effects of worker education on safety performance become more significant. These findings implied that a more resilient safety culture may enhance the influence of worker education on safety performance in terms of contextual and psychological resilience. Based on this finding, this research recognized a set of resilient safety culture indicators that had a high impact on safety performance. Construction organizations should analyze and enhance their ability to manage risks by utilizing these resilient safety culture measurement items. In addition, the results indicated that an individual's safety learning ability may affect the impact of the educational level of workers on safety performance. As mentioned in Section 5, the individual learning ability of employees can be measured by several dimensions. The favorable impacts of a high educational level on safety performance can be further enhanced by the facilitating influence of workers' high individual learning ability.

The current research revealed how safety performance can be enhanced by workers with higher education levels, individual learning ability, and resilient safety culture. Having recognized the interrelation between educational level and the individual ability to learn and the value of resilient safety culture in construction safety management by using a two-way analysis of variance (ANOVA), the findings of this study are valuable in understanding the critical role that a resilient safety culture and individual's learning ability play in improving the safety performance of construction projects. Therefore, improvement in all these factors is important and effective to improve safety performance. This research will bring great contributions to construction project management by improving project safety. Some possible recommendations to support individuals with low educational levels have been highlighted. The findings can be applied to establish effective strategies for improving the safety performance of construction projects within an organization. The methodology can also be used as a framework for establishing comprehensive organizational approaches as well as an evaluation tool.

7. Limitations and Future Studies

The sample size was a major limitation of this research study. The data were obtained from 210 frontline workers. In order to perform a more representable analysis, more sets of data can be gathered in future studies. It is proposed that the current study can be replicated using a similar research methodology to assess the safety performance of other work trades in the construction sector. Comparative studies of developed countries with higher educational levels and developing countries with lower educational levels can also be carried out. This research area could give significant insight into the construction industry. Future research can be focused on strategies for improving practitioners' educational levels and developing resilient safety cultures inside construction organizations. Such research directions may contribute to the development of construction organizations that achieve a sustained improvement in the safety performance of construction projects.

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Appendix A

Table A1. The interaction effects of individual learning ability and the safety performance score.

Educational Level		Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Below primary	Contrast	200.208	1	200.208	29.963	0	0.353
	Error	367.5	55	6.682			
Primary	Contrast	472.5	1	472.5	70.714	0	0.563
	Error	367.5	55	6.682			
Secondary	Contrast	113.437	1	113.437	16.977	0	0.236
	Error	367.5	55	6.682			
Diploma or above	Contrast	11.837	1	11.837	1.772	0.189	0.031
	Error	367.5	55	6.682			

Table A2. Descriptive statistics of individual learning ability and the safety performance score.

Dependent Variable: Safety Performance Score				
Educational Level	Individual Learning Ability	Mean	Std. Deviation	N
Below diploma	Below Average	14	7.118	4
	Average	23.800	4.857	15
	Above Average	26.136	2.791	44
	High	29.666	1.274	24
	Total	26.149	4.606	87
Diploma or above	Low	15	12.727	2
	Average	25.166	4.687	12
	Above Average	26.038	3.035	52
	High	29.807	0.666	57
	Total	27.520	3.722	123

Table A3. The interaction effects of contextual resilience and the safety performance score.

Educational Level		Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Below primary	Contrast	40.5	1	40.5	3.079	0.086	0.064
	Error	591.982	45	13.155			
Primary	Contrast	340.909	1	340.909	25.914	0	0.365
	Error	591.982	45	13.155			
Secondary	Contrast	229.147	1	229.147	17.419	0	0.279
	Error	591.982	45	13.155			
Diploma or above	Contrast	42.25	1	42.25	3.212	0.08	0.067
	Error	591.982	45	13.155			

Table A4. Descriptive Statistics of contextual resilience and safety performance score.

Dependent Variable: Safety Performance Score				
Educational Level	Contextual Resilience	Mean	Std. Deviation	N
Below diploma	Low	6.000	0	1
	Below Average	10.000		1
	Average	22.300	4.571	10
	Above Average	25.456	2.979	46
	High	29.827	0.539	29
	Total	26.149	4.606	87

Table A4. *Cont.*

Dependent Variable: Safety Performance Score				
Educational Level	**Contextual Resilience**	**Mean**	**Std. Deviation**	**N**
Diploma or above	Low	6.000	0	1
	Below Average	15.000	0	1
	Average	24.461	3.843	13
	Above Average	25.522	2.992	44
	High	29.812	0.639	64
	Total	27.398	3.883	123

Table A5. The interaction effects of psychological resilience and the safety performance score.

Educational Level		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Below primary	Contrast	198.914	1	198.914	17.473	0	0.315
	Error	432.595	38	11.384			
Primary	Contrast	321.694	1	321.694	28.258	0	0.426
	Error	432.595	38	11.384			
Secondary	Contrast	215.511	1	215.511	18.931	0	0.333
	Error	432.595	38	11.384			
Diploma or above	Contrast	15.022	1	15.022	1.32	0.258	0.034
	Error	432.595	38	11.384			

Table A6. Descriptive statistics of psychological resilience and the safety performance score.

Educational Level	**Psychological Resilience**	**Mean**	**Std. Deviation**	**N**
Below diploma	Low	6.000	0	1
	Below Average	15.000	7.071	2
	Average	22.250	3.934	12
	Above Average	26.042	2.977	47
	High	29.920	0.400	25
	Total	26.149	4.606	87
Diploma or above	Low	6.000	0	1
	Below Average	22.000	0	1
	Average	24.000	3.484	15
	Above Average	26.372	3.091	51
	High	29.890	0.416	55
	Total	27.455	3.748	123

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