# Building Resilience Through Construction Trade Education for Low-Income Individuals

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## Abstract

Access to housing is a basic need and is key to protection and well-being. Natural disasters cause damage and destruction in all communities, but particularly in low-income communities, which often live in informal settlements and are highly vulnerable due to social, economic, and physical inequities. Additionally, these communities frequently experience delayed disaster recovery. As a result, they informally rebuild their homes using their own resources and methods as a means to recover. This study aims to address these issues by investigating how these individuals and underserved communities can be educated and trained in construction trades to aid in more resilient post-disaster reconstruction while fostering social mobility and job equity. To achieve these goals, this study conducted a comprehensive literature review and surveyed 108 engineering and construction management students from Florida International University (FIU), one of the largest minority-serving institutions (MSIs) in the United States, to (1) investigate the main challenges, impacts, and common failures of informal construction; (2) identify gaps in construction trade knowledge among low-income individuals and underserved communities; and (3) evaluate the most effective teaching methods and instructional tools to effectively teach trade skills and basic construction knowledge. Civil engineering and construction students from the MSI, who often come from vulnerable communities, provide valuable insights related to the challenges of informal construction and the gaps in trade and construction knowledge. The findings of this study highlight the importance of educating and training low-income individuals and members of underserved communities in safe and effective construction methods to aid in more resilient post-disaster reconstruction while fostering social mobility. Furthermore, these results underscore the potential of construction trade programs (CTPs) that focus on workforce development to teach these individuals. The findings of this study benefit low-income individuals and communities by enabling them to rebuild more resiliently post-disaster, while fostering social mobility and providing job opportunities for the underrepresented workforce through education. Additionally, the findings benefit the construction industry by providing a diverse and skilled workforce, helping address the critical shortage of workers.

**Keywords:** Construction Industry, Construction Trades Education, Informal Construction, Low-Income Communities, Natural Disasters, Resilient Post-Disaster Reconstruction, Underrepresented Workforce, Workforce Development

## Background and Motivation

Over the past two decades, disasters triggered by natural hazards have caused \$2.97 trillions in economic losses, 1.23 million fatalities, and affected over 4.03 billion individuals [1], [2].. These impacts have manifested as severe threats to human health, injuries, mental health challenges, trauma, loss of income, destruction of infrastructure, homelessness, displacement, and diminished access to essential resources such as food, electricity, and water [1], [3], [4], [5], [6].

Natural disasters significantly affect all countries and communities, but their consequences are particularly devastating for developing countries and low-income communities, where inequalities in infrastructure, resources, and social systems heighten vulnerability and exposure [4], [7], [8], [9], [10], [11], [12]. Limited resources hinder their ability to prevent, prepare for, and respond effectively to disasters [9], [13]. In fact, low-income countries experience death rates per disaster that are more than four times higher than those of high-income countries [14]. A major contributor to these fatalities is the collapse of poorly constructed infrastructure [2], [15], [16], underscoring the importance of safer construction practices to mitigate future losses and fatalities. Worsening the situation, the frequency and intensity of natural disasters continue to rise, amplifying the challenges [17], [18].

Housing is a fundamental necessity for safety, protection, and well-being. However, many low-income [4], [19]. However, many low-income communities reside in informal settlements that are constructed without contractors, professional guidance, structural knowledge, proper quality controls, or adequate construction techniques. Such conditions make these settlements particularly vulnerable to disaster [8], [20], [21]. After a disaster, these communities often face delayed disaster response and recovery efforts and lack the resources to mitigate risks effectively [18], [22], [23], Consequently, families and individuals frequently rely on informal reconstruction to recover from the disaster, using their own limited resources and efforts to rebuild their homes by themselves [18], [21].

Supporting low-income communities in constructing safer housing after disasters is essentials for reducing vulnerability and safeguarding lives. Informal construction practices not only lead to property damage and loss of shelter but also expose individuals to significant risks of injury or death [24]. Addressing this issue requires equipping these individuals and communities with the necessary education, training, and construction techniques to build safer homes. However, although construction trade education and training are crucial for achieving resilient post-disaster reconstruction, this topic has received limited research attention. To address this gap, the goals of this study are to (1) investigate the main challenges, impacts, and common failures of informal construction; (2) identify deficiencies in construction trade knowledge within low-income and underserved communities; and (3) assess the most effective teaching strategies for imparting trade skills and fundamental construction knowledge. To achieve these goals, the authors conducted a comprehensive literature review and surveyed 108 civil engineering (CE) and construction management (CM) students from Florida International University (FIU), one of the largest minority-serving institutions (MSIs) in the United States (U.S.).

Surveying CE and CM students at an MSI is particularly relevant for this study as it ensures representation of underrepresented groups, many of whom come from developing countries, minority populations, and vulnerable communities. These students provide valuable insights into the challenges faced by underserved populations in disaster management and construction, as well as the issues surrounding informal construction and the gaps in trade and construction knowledge within low-income communities. As future professionals in CE and CM, their perspectives are key to shaping effective teaching strategies and to enhancing existing or developing new construction trade programs (CTPs) specifically designed to educate and train low-income individuals and underrepresented groups. By empowering low-income and underrepresented communities to rebuild safer homes using available resources, this approach not only enhances post-disaster resilience but also has the potential to foster social mobility and create job opportunities for the underrepresented workforce.

## Methodology

This study is guided by three research questions: (1) What are the main problems, impacts, and common failures of informal construction after a natural disaster? (2) What are the gaps in construction trade knowledge of low-income individuals and what resources do they lack? And (3) how can we provide low-income individuals and underrepresented communities with appropriate education, training, and construction techniques to aid in more resilient post-disaster reconstruction?

### *Survey Design*

To address these three questions, this study surveyed 108 CE and CM students at one of the largest MSIs in the U.S. A mixed-methods sequential explanatory approach was applied, incorporating both quantitative and qualitative data collection and analysis.

The survey was created using the online platform Qualtrics and consisted of a demographic section along with five questions. A comprehensive literature review informed the design of the questionnaire. The first question aimed to determine whether CE and CM students consider that educating and training low-income individuals, who often reside in informal settlements built by themselves due to limited resources, in trades and basic construction knowledge could aid in more resilient post-disaster reconstruction. The second question focused on identifying the primary issues associated with informal construction. The next two questions sought to identify the most suitable construction trades courses, along with the teaching methods, that could effectively educate and train low-income individuals and underrepresented workforce to aid in resilient post-disaster reconstruction. The final question aimed to determine the resources that low-income communities lack.

The survey data were analyzed through a combination of quantitative and qualitative approaches. Quantitative methods included the use of bar and pie charts to represent categorical data as well as box plots to illustrate responses from Likert scale questions. Qualitative methods involved generating word clouds using NVivo 14, with the size of each word reflecting its frequency in the text. NVivo 14 is a specialized qualitative analysis software that enhances transparency and reliability of the findings by providing advanced tools for data syntheses [25].

To validate the consistency, reliability, and adequacy of the data, the authors conducted three key statistical tests. First, the Kaiser-Meyer-Olkin (KMO) test assessed the sample adequacy, with a threshold of 0.6 or higher signifying adequacy. Second, Bartlett's test of sphericity examined redundancy among variables, confirming the data's suitability for factor analysis when the significance level was below 0.05. Third, Cronbach's alpha measured the reliability of the questionnaire, with a threshold of 0.7 or higher considered acceptable [4], [26].

*Binary Logistic Regression*

To analyze the relationship between predictors and a binary outcome variable, the study employed binary logistic regression in SPSS. The predictors represent the independent variables, and the predicted variable corresponds to the dependent variable. Binary logistic regression was selected for its ability to analyze a dependent variable with two outcomes (i.e., yes/no), encoded as 1 or 0 [27]. In this study, the dependent variable is whether educating low-income individuals in construction trades would aid in more resilient post-disaster reconstruction.

The parameters are defined as follows: $X_{BJ}$ indicated whether educating low-income individuals in construction trades would aid in more resilient post-disaster reconstruction; 'M' stands for masonry should be taught to low-income individuals to aid in post-disaster reconstruction; 'C' for carpentry masonry should be taught to low-income individuals to aid in post-disaster reconstruction; 'E' for electrical should be taught to low-income individuals to aid in post-disaster reconstruction; 'P' for plumbing should be taught to low-income individuals to aid in post-disaster reconstruction; 'R' for should be taught to low-income individuals to aid in post-disaster reconstruction; 'BCM' for basic construction methods should be taught to low-income individuals to aid in post-disaster reconstruction; 'LS' for lack of structural knowledge is a main maim problem in informal construction; 'LP' for lack of professional advice is a main problem in informal construction; 'PCM' for poor construction methods are a main problem in informal construction; 'LQC' for lack of quality control is a main problem in informal construction; 'RC' for resource constraints are a main problem in informal construction; and 'LQM' for low-quality materials are a main problem in informal construction. The binary logistic regression model includes these parameters through the following equation:

$$X_{BJ} = \beta_0 + \beta_1 * M + \beta_2 * C + \beta_3 * E + \beta_4 * P + \beta_5 * R + \beta_6 * BCM + \beta_7 * LS + \beta_8 * LP + \beta_9 * PCM + \beta_{10} * LQC + \beta_{11} * RC + \beta_{12} * LQM + \varepsilon$$

Where $\beta_i$ denotes the regression coefficients correlating the independent variables to the dependent variable ($X_{BJ}$). The error term ($\varepsilon$) accounts for the uncertainty in predicting whether educating low-income individuals in construction trades would aid in more resilient post-disaster reconstruction. The binary logistic regression was validated using a significance test with a z-score to assess the sample mean. Statistical significance was determined using a 90% confidence interval, with p-values below 0.10 considered significant.

**Results and Discussion**

This section presents the results associated with the responses of 108 CE and CM students. The participants represented a diverse group, including (a) 77 males, 28 females, 2 non-binary/gender fluid, and one student who identified as other; (b) individuals from multiple age groups; and (c) students from multiple racial and ethnic backgrounds. The sociodemographic background is shown in Figure 1.

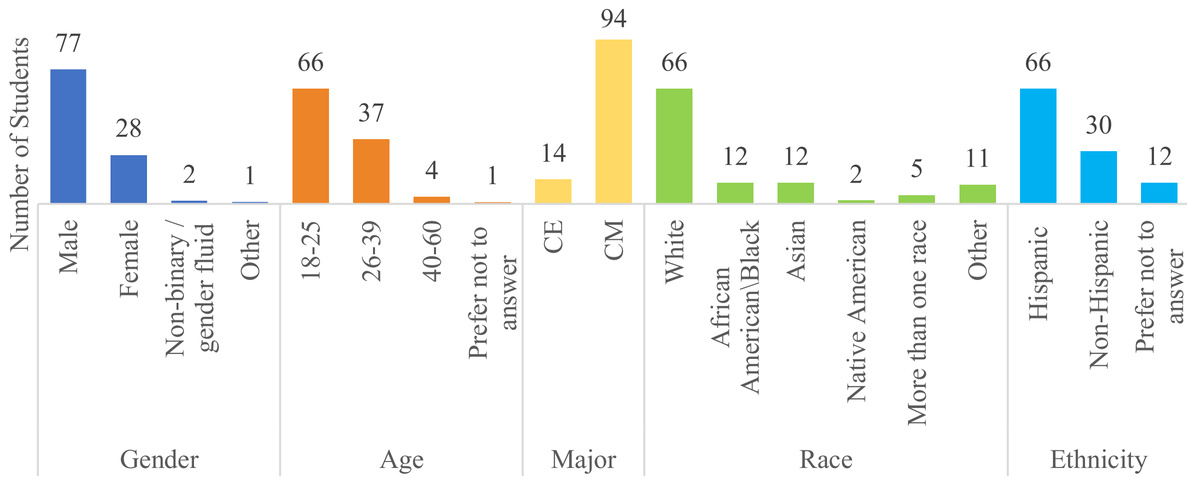


**Figure 1.** Sociodemographic background (n=108)

Low-income communities often reside in informal settlements constructed without adequate construction knowledge or skills, making them highly vulnerable to natural disasters. Furthermore, these communities typically experience delays in post-disaster recovery, leading to informal reconstruction efforts as an attempt to recover from the disaster, which heightens their vulnerability. Recognizing these challenges, 89% of students (96 individuals) believe that educating and training low-income individuals in trades and basic construction knowledge could contribute to more resilient post-disaster reconstruction. Only 11% (12 individuals) disagree, providing various reasons: (a) they express concerns about funding and resources, emphasizing that individuals may still lack the financial means to rebuild their homes even after training; (b) they argue that it would be more efficient to allocate resources to setting up dedicated post-disaster reconstruction teams rather than training individuals; (c) they believe it is impractical and illogical to assume that many low-income individuals will effectively learn and apply construction skills; (d) the perception that once individuals acquire construction trade skills, they may leave low-income areas in pursuit of higher-paying jobs, which could undermine local recovery efforts; and (e) they consider that this approach may not be an adequate solution. Figure 2 illustrates these findings.


**Figure 2.** Student responses to whether educating low-income individuals in construction trades would aid in more resilient post-disaster reconstruction

Figure 3 highlights the main problems of informal construction. The results are presented using box plots, with the box extending from the first quartile (Q1) to the third quartile (Q3) of the data distribution. A horizontal line represents the median, an “x” marks the mean, and the whiskers show the minimum and maximum values. The primary issues identified include (1) poor or inadequate construction methods, reflecting a mean of 4.29; (2) lack of quality control, with a mean of 4.22; (3) low-quality of building materials, yielding a mean of 4.12; and (4) lack of structural knowledge, reflecting a mean of 4.11. Notably, all factors had mean ratings close to or above 4, emphasizing their relevance.

These findings highlight a strong acknowledgment among students of the issues hindering effective construction practices in low-income communities attempting to recover from disasters. The high scores for “poor or inadequate construction methods”, “lack of quality control”, and “lack of structural knowledge” emphasize the critical need for education and training to address deficiencies and contribute to more resilient reconstruction. Similarly, the high importance given to “low-quality materials” points to the necessity of providing affordable yet durable materials for reconstruction efforts. Teaching low-income individuals about proper material selection and usage could play a key role in improving construction quality and resilience. These results underscore the need for holistic interventions, including education, access to materials, and quality control mechanisms, to enhance the resilience of post-disaster reconstruction efforts.

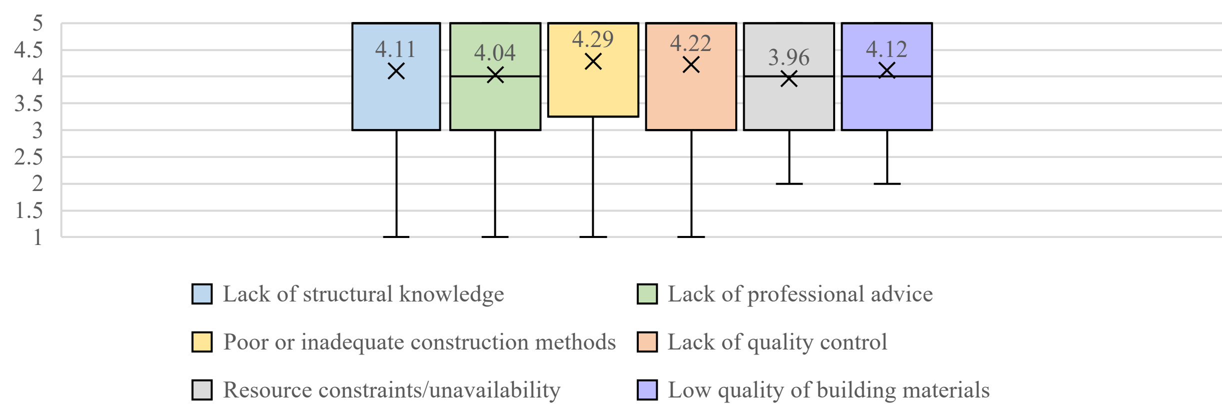


**Figure 3.** Main problems of informal construction

The following two questions sought to identify the most suitable construction trade courses and teaching methods that could effectively educate and train low-income individuals and underrepresented communities to aid in resilient post-disaster reconstruction. According to the results of this study, presented in Figure 4, the main trade courses for this purpose include (1) basic construction methods, reflecting a mean of 4.35; (2) roofing, yielding a mean of 4.34; (3) electrical, with a mean of 4.28; (4) plumbing, reflecting a mean of 4.17; (5) masonry, yielding a mean of 4.14; and carpentry, with a mean of 4.04. Additionally, students suggested including courses covering safety, quality control, welding, basic structural knowledge, remediation, and heating, ventilation, and air conditioning (HVAC).

Regarding the most beneficial teaching methods, the highest-rated ones are (1) hands-on experience, reflecting a mean of 4.50; (2) on-the-job training, with a mean of 4.45; and (3) problem-based learning, yielding a mean of 4.23. These results, presented in Figure 5, highlight the preference for practical and applied learning methods that encourage active participation, provide real-world experience, and foster critical thinking. That said, a combination of experiential and traditional teaching methods may provide the most effective training for this context.

These results emphasize the critical importance of equipping low-income individuals with knowledge and skills in construction trades. Tailored education and training in these trades, addressing the specific needs and vulnerabilities of low-income communities, are key to ensuring effective and resilient disaster recovery.

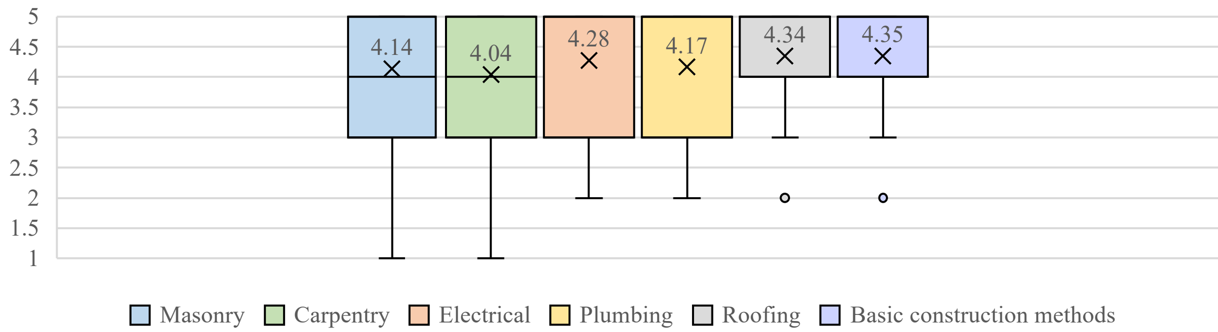


**Figure 4.** Construction trade courses for educating low-income individuals

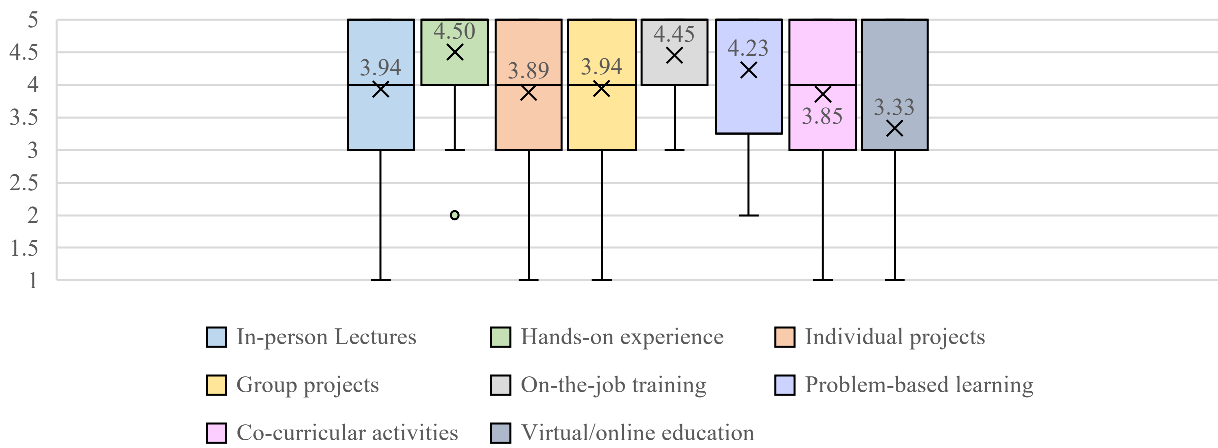


**Figure 5.** Effective teaching methods

To validate the consistency, reliability, and adequacy of the data, the authors conducted three key statistical tests in SPSS. First, the KMO value was 0.844, indicating sample adequacy. Second, Cronbach's alpha was calculated at 0.901, confirming the reliability of the data. Third, Bartlett's test of sphericity produced a significance level below 0.001, verifying that the variables are not orthogonal.

Table 1 summarizes the results of the binary logistic regression model. In the study, the dependent variable is whether educating low-income individuals in construction trades would aid in more resilient post-disaster reconstruction. The results show that 'carpentry should be taught to low-income individuals to aid in post-disaster reconstruction', 'lack of professional advice is a main problem in informal construction', and 'low-quality materials are a main problem in informal construction' have p-values of less than 0.1. These findings support the hypothesis of a meaningful relationship between the dependent and independent variables.

The regression coefficient (β) values for carpentry should be taught to low-income individuals to aid in post-disaster reconstruction', 'lack of professional advice is a main problem in informal construction', and 'low-quality materials are a main problem in informal construction' are -1.500, 0.785, and 1.076, respectively. These values suggest that addressing issues related to low-quality materials and the lack of professional advice, as well as education in carpentry, may contribute to resilient post-disaster reconstruction.

**Table 1.** Coefficient and p-values from binary logistic regression

| Variables | Coeff. (β) | Sample Error | Wald | p-value | Exp (β) |
|---|---|---|---|---|---|
| Masonry should be taught to low-income individuals to aid in post-disaster reconstruction | 0.549 | 0.694 | 0.627 | 0.429 | 1.732 |
| Carpentry should be taught to low-income individuals to aid in post-disaster reconstruction | -1.500 | 0.850 | 3.116 | 0.078 | 0.223 |
| Electrical should be taught to low-income individuals to aid in post-disaster reconstruction | -0.403 | 0.687 | 0.344 | 0.558 | 0.668 |
| Plumbing should be taught to low-income individuals to aid in post-disaster reconstruction | 0.866 | 0.661 | 1.715 | 0.190 | 2.376 |
| Roofing should be taught to low-income individuals to aid in post-disaster reconstruction | 0.303 | 0.641 | 0.223 | 0.637 | 1.353 |
| Basic construction methods should be taught to low-income individuals to aid in post-disaster reconstruction | -0.526 | 0.483 | 1.187 | 0.276 | 0.591 |
| Lack of structural knowledge is a main problem in informal construction | -0.499 | 0.471 | 1.123 | 0.289 | 0.607 |
| Lack of professional advice is a main problem in informal construction | 0.785 | 0.473 | 2.751 | 0.097 | 2.193 |
| Poor construction methods are a main problem in informal construction | -0.587 | 0.619 | 0.898 | 0.343 | 0.556 |
| Lack of quality control is a main problem in informal construction | 0.391 | 0.554 | 0.497 | 0.481 | 1.478 |
| Resource constraints are a main problem in informal construction | -0.208 | 0.512 | 0.164 | 0.685 | 0.813 |
| Low-quality materials are a main problem in informal construction | 1.076 | 0.562 | 3.674 | 0.055 | 2.934 |
| Constant | 1.726 | 2.325 | 0.551 | 0.458 | 5.618 |

The final open-ended question aimed to determine the resources that low-income communities lack. To analyze the students' responses, the study used NVivo to create a word cloud, as shown in Figure 6, which visually represents the frequency of recurring terms. The words *knowledge*, *education*, and *money* had the highest frequency, emphasizing the critical need for access to quality learning opportunities and financial stability. Additionally, terms such as *opportunities*, *resources*, *income*, *food*, *material*, *quality*, *lack*, *access*, *funding*, and *transportation* are also prominent, highlighting the diverse and multifaceted challenges these communities face.

The analysis of the word cloud reveals several important insights. The prominence of *knowledge* and *education* underscores the urgent need for construction trade knowledge and skills as a pathway to improving living conditions and fostering more resilient post-disaster reconstruction. The frequent appearance of terms such as *money*, *funding*, and *income* illustrates the financial struggles faced by low-income and underrepresented communities. These economic constraints impede access to essential resources, such as *food*, *quality materials*, and *transportation*. Furthermore, the inclusion of terms like *material*, *quality*, and *tools* points to the physical challenges these communities face, reinforcing the need for accessible and affordable resources to build safer and more resilient homes. Teaching low-income individuals about proper material selection and usage could also play a key role in enhancing construction quality and resilience.


**Figure 6.** Word cloud representation of word frequency generated using NVivo, highlighting the resources that low-income communities lack

**Limitations and Future Work**

This study recognizes some limitations. First, the survey responses may be subject to self-assessment and biases. Second, this research was conducted only at FIU. Future studies could extend the scope of the study by including additional academic institutions worldwide and developing regions. This expansion would deepen the understanding of the challenges low-income communities face, address the main issues of informal construction, and explore how to help these communities rebuild safer and more resilient homes post-disaster. Additionally, future studies could investigate effective pedagogy, including course delivery methods, curriculum design, hands-on training, and community-based learning approaches, to educate and train low-income individuals and members of underrepresented communities. This would not only empower these communities to rebuild safer and more resilient homes post-disaster but also foster social mobility by equipping them with skills that lead to better job opportunities and higher wages.

## Conclusions

This study underscores the critical importance of educating and training low-income individuals and members from underserved communities in construction trade knowledge and skills. These efforts can empower vulnerable populations, often living in informal settlements and facing delays in disaster recovery, to build safer and more resilient homes. Informal construction, characterized by poor methods, low-quality materials, and lack of structural knowledge, heighten the vulnerability of these communities. Addressing these deficiencies through tailored education and CTPs can help low-income individuals rebuild more resiliently while fostering social mobility and creating job opportunities.

The results highlight the effectiveness of practical, hands-on teaching methods and real-world training for trade courses such as basic construction, roofing, masonry, plumbing, carpentry, and electrical work. Additionally, findings from the binary logistic regression suggest that education in carpentry, along with addressing issues related to low-quality materials and the lack of professional advice, may significantly enhance resilient post-disaster reconstruction efforts. Teaching individuals about proper material selection and usage further supports construction quality and resilience.

Housing is fundamental to safety and well-being. Equipping low-income and underrepresented individuals with construction knowledge not only improves their living conditions but also reduces the risks associated with informal construction practices. The findings of this study benefit low-income communities and the construction industry by enhancing post-disaster resilience, fostering social mobility, creating job opportunities, and addressing labor shortages with a diverse and skilled workforce.

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