Developing a Pedagogy for the Underrepresented Construction Trade Workforce to Aid in Resilient Post-Disaster Reconstruction

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Abstract

Housing is of utmost importance for living, protection, and overall well-being. Natural disasters afflict all countries and communities, but especially low-income communities, families, and individuals. Additionally, these communities often receive delayed disaster recovery, which translates into informal post-disaster reconstruction. This exacerbates the housing crisis resulting from a natural disaster, as most informal construction is built by residents themselves, lacking structural knowledge, professional advice, quality control, and proper construction and trade techniques. The goals of this research are to identify the challenges and vulnerabilities of low-income communities, as well as gaps in construction trade knowledge and resources among them. Additionally, this research aims to investigate effective pedagogy to provide low-income individuals with appropriate education, training, techniques, and expertise to aid in resilient post-disaster reconstruction. To achieve these goals, this research conducted a survey to architecture, engineering, and construction (AEC) experts from Puerto Rico to identify: (a) the major challenges and vulnerabilities of low-income communities post-disaster, as well as the main issues of informal construction; (b) potential gaps in trade and construction knowledge, as well as the lack of resources of low-income individuals and the underrepresented workforce; and (c) pedagogy, including course delivery and instructional technologies, to effectively educate and train low-income individuals in trade and basic construction knowledge. The results of this study showed the urgency of educating and training low-income individuals highly susceptible to natural disasters in trades, construction techniques, and technologies that can be safely and effectively used to aid in post-disaster reconstruction while utilizing available resources. This will have a paramount impact on communities since informal construction not only exposes individuals to damages and loss of housing but, more importantly, puts their lives in great danger.

Keywords: Construction Trades, Informal Construction, Natural Disasters, Resilient Post-Disaster Reconstruction, Underrepresented Workforce

Background and Motivation

Globally, 7,348 natural disasters have been recorded over the last twenty years. These disasters have caused $2.97 trillion in economic losses and 1.23 million deaths. They have impacted 4.2 billion people through damage to human health and injury, loss of income, destruction of infrastructure systems, damage to property or homelessness, displacement, as well as reduced supply of food, electricity, and water (FEW) [1]–[3].

Natural disasters severely impact all countries and communities. However, developing countries, and particularly low-income communities, suffer more severe damage due to physical, social, and economic inequities. They not only have fewer resources to prevent, prepare, and adequately

respond to natural disasters, but also are more exposed and vulnerable to them [4]–[6]. In fact, low-income countries have, on average, more than four times as many deaths per disaster as high-income countries [7]. Most deaths occur due to poorly designed and built infrastructure that collapses. Thus, safer construction can prevent losses and future fatalities [2], [8], [9].

Housing is crucial for living, protection, and overall well-being. Low-income communities often reside in informal settlements built spontaneously by local workforce and residents without contractors, structural knowledge, professional advice, quality control, or proper construction techniques [10], [11]. Consequently, informal settlements are more susceptible to the impacts of natural disasters [5]. Furthermore, these communities, lacking resources to mitigate the risks after a natural disaster [12], often receive delayed post-disaster recovery [13]. This translates to informal housing reconstruction since affected individuals and families will rebuild their homes with their own resources and efforts to recover from the disaster [11].

Supporting low-income communities, which often lack the resources and expertise to build safer homes after a natural disaster, is pivotal for their well-being. Informal construction not only exposes individuals to damages and loss of housing but, more importantly, puts their lives in great danger [14]. A crucial means to support them and aid in post-disaster reconstruction is by providing low-income individuals with appropriate education, training, techniques, and expertise pertaining to construction trades and methods. The goals of this research are to: (1) identify the major challenges and vulnerabilities of low-income communities post-disaster, as well as the main issues of informal construction; (2) identify gaps in construction trades knowledge and resources among low-income communities and the underrepresented workforce; and (3) investigate effective pedagogy, including course delivery and teaching methods, to provide low-income individuals with the necessary education, training, techniques, and expertise to aid in resilient post-disaster reconstruction. To achieve these goals, Puerto Rico was selected as the region of focus due to its frequent exposure to natural disasters and heightened vulnerability to them, given its constrained financial resources, substantial poverty rates, and prevalence of informal construction. Educating low-income individuals in construction trades will greatly benefit them by supporting them in rebuilding their own homes after a natural disaster, thus contributing to more resilient post-disaster reconstruction. Furthermore, such education can promote social mobility and help the underrepresented workforce find better job opportunities.

Methodology

This study is guided by four research questions: (1) What are the major challenges and vulnerabilities of low-income communities after a natural disaster? (2) What are the main issues of informal construction? (3) What are the gaps in construction trade knowledge of low-income individuals and what resources do they lack? And (4) how can we provide low-income individuals with appropriate education, training, construction techniques, technologies, and expertise to aid in more resilient post-disaster reconstruction while using the resources available?

This research addresses these four questions through surveying community stakeholders, including experts in the fields of architecture, engineering, and construction (AEC), as well as other professionals in Puerto Rico. The objectives are to: (a) understand the current situation of disaster recovery; (b) comprehend the major challenges and vulnerabilities of low-income

communities after a natural disaster, as well as the main issues of informal construction; and (c) identify gaps in construction trades knowledge and resources among low-income communities and the underrepresented workforce. Additionally, this study aims to explore the courses and teaching methods that could help low-income individuals acquire basic construction knowledge to safely and effectively aid in rebuilding their homes after a natural disaster, thus contributing to more resilient post-disaster reconstruction.

The administered survey included a total of 10 questions and a demographic section. The first four questions were designed to identify experts' experience with natural disasters. They were asked if they had experienced a major natural disaster, whether they had participated in disaster recovery, as well as the duration of disaster recovery in Puerto Rico. The fifth question aimed to identify the major challenges and vulnerabilities of low-income communities post-disaster. The following question intended to identify if AEC experts considered that educating and training low-income individuals, who often live in informal settlements due to lack of resources, in construction trades and basic construction knowledge could aid in more resilient post-disaster reconstruction. The next question intended to identify the main problems of informal construction. The following two questions aimed to determine the construction trades courses and teaching methods that should be used to effectively educate and train low-income individuals and the underrepresented workforce to aid in more resilient post-disaster reconstruction. The last question intended to identify the resources that low-income communities lack. Figure 1 presents the research overview.

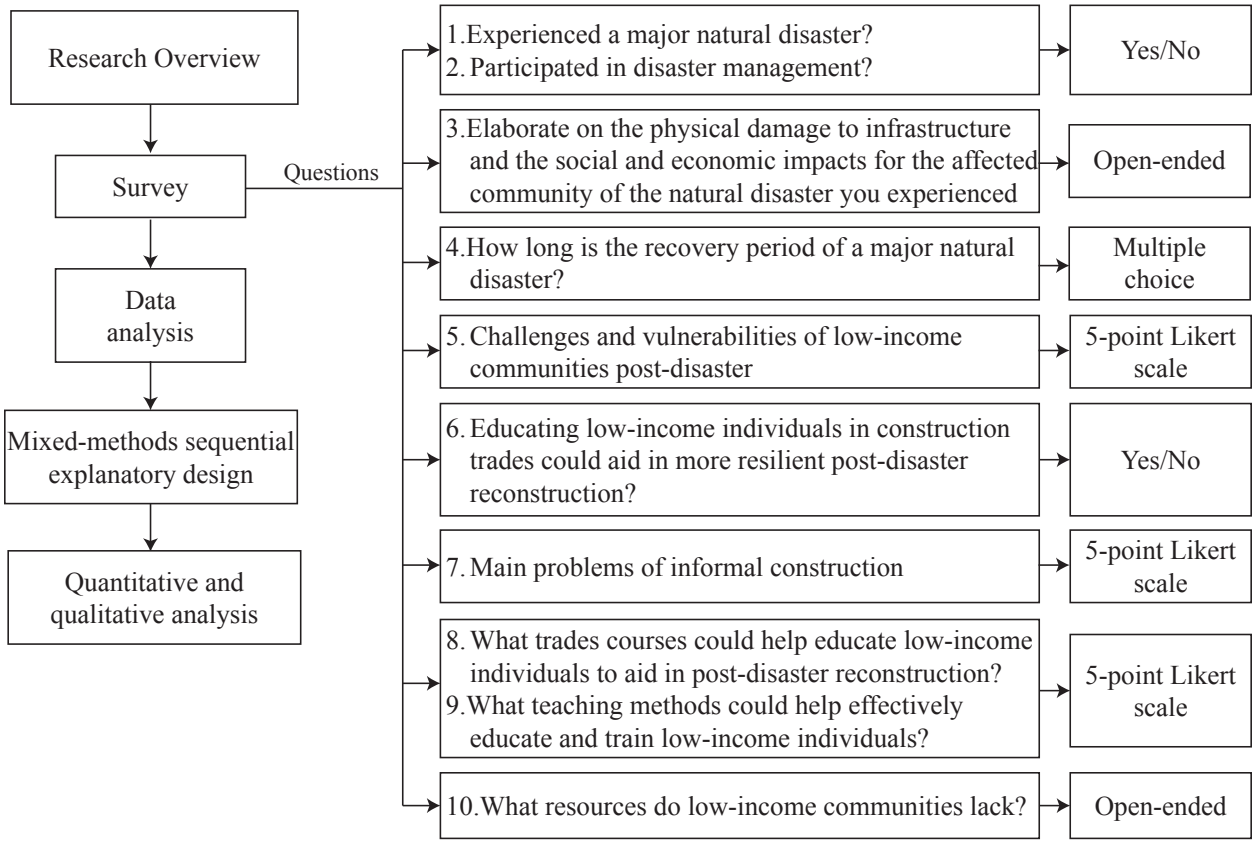

Figure 1. Research overview

Results and Discussion

This section presents the results associated with the responses of 38 experts from Puerto Rico in the fields of architecture, engineering, and construction (AEC), as well as other professions. These experts possess extensive knowledge of natural disasters and their impact on both infrastructure and communities, given the region's frequent exposure and heightened vulnerability to diverse natural disasters, including earthquakes and hurricanes. The experts' socio-demographic background is presented in Figure 2.

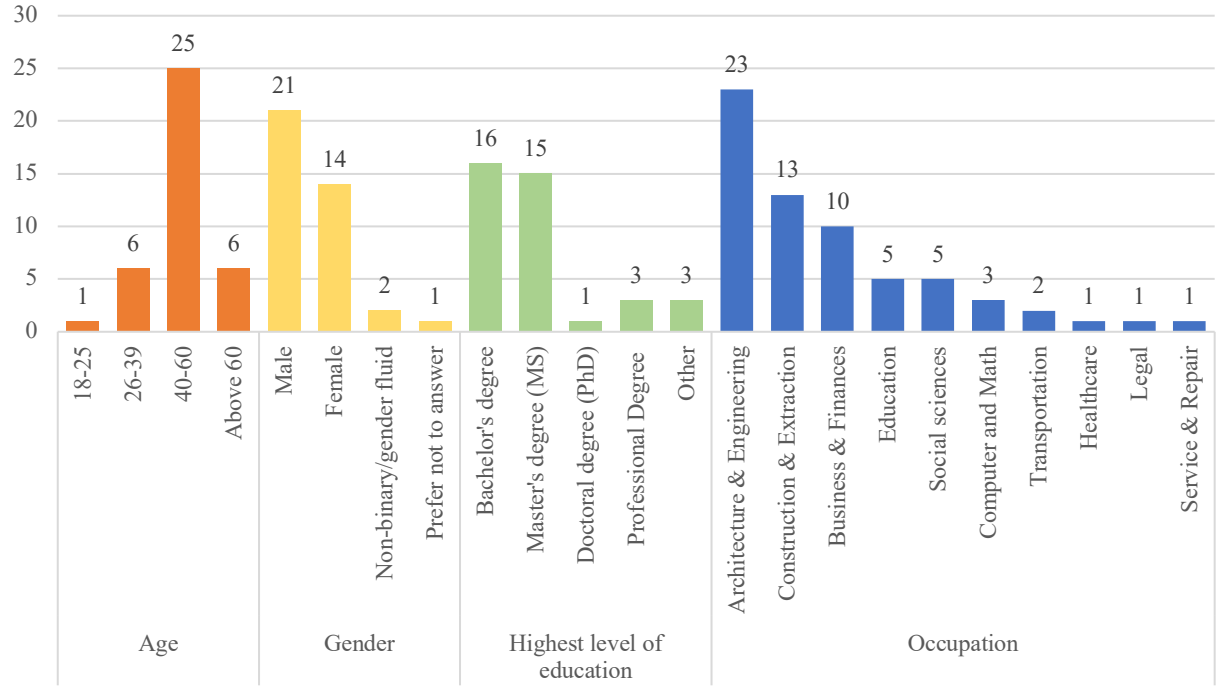

Figure 2: Experts' socio-demographic background, n=38

The first four questions were designed to identify professionals' experience with natural disasters. They were asked if they had experienced a major natural disaster, whether they had participated in disaster recovery, as well as the duration of disaster recovery in Puerto Rico. The results of this study, presented in Figure 3, show that (1) 37 out of 38 experts had experienced a natural disaster; (2) 22 experts (around 58%) had participated in disaster recovery; and (3) more than 60% of surveyed Puerto Rican experts (23 individuals) consider that the recovery period after a major natural disaster on the island exceeds one year. Furthermore, experts that had experienced a major natural disaster were asked to elaborate on the physical damage to infrastructure and the social and economic impacts for the affected community. To examine the insights, the authors used NVIVO. Figure 4 present the word cloud representation of word frequency derived from the data analysis conducted through NVIVO. As it may be observed in the word cloud, the words 'power', 'damage', and 'homes' had the highest frequency. Furthermore, the words 'roads', 'flooding', 'loss', 'lost', 'hurricane', 'water', and 'communications' had high frequencies as well. It can be inferred that Puerto Rico is highly affected by hurricanes, leading to flooding, power failure, as well as severe and long-lasting damage to homes, infrastructure, and roads.

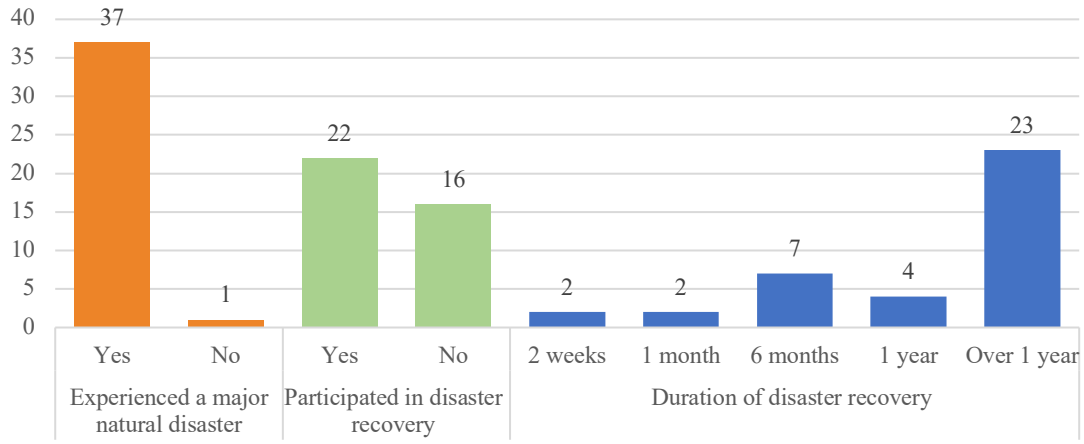

Figure 3. Experts' experience with natural disasters and opinion on disaster recovery

Figure 4. Word cloud of experts' experience with natural disasters

The following question intended to identify the major challenges and vulnerabilities that low-income communities face post-disaster. The results are presented in box plots, where the box ranges from the first quartile (Q1) to the third quartile (Q3) of the distribution, the median is indicated by a horizontal line, the mean is represented with an "x", and the whiskers highlight the minimum and maximum values. As evident from the box plots presented in Figure 5, the major challenges and vulnerabilities include: (1) lack of housing, yielding a mean of 4.69; (2) lack of water and food, reflecting a mean of 4.79; and (3) delayed disaster recovery, yielding a mean of 4.45.

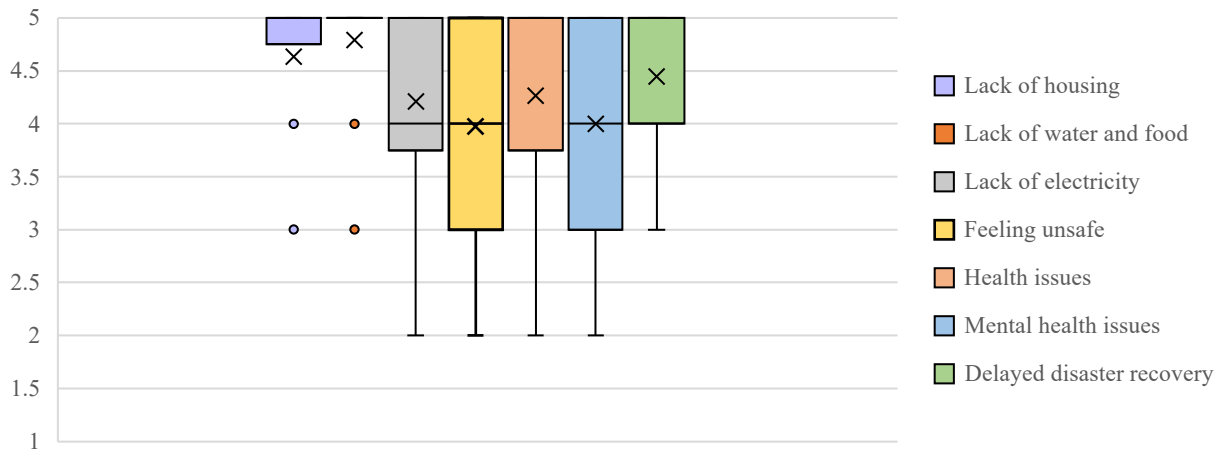

Figure 5. Major challenges and vulnerabilities of low-income communities post-disaster

Low-income communities often reside in informal settlements built by themselves without proper construction knowledge or skills. As a result, they are highly vulnerable to natural disasters. Furthermore, they receive delayed post-disaster recovery. This translates into informal post-disaster reconstruction, further increasing their vulnerability and aggravating the housing crisis that arises from natural disasters. Mindful of all this, 95 percent of experts in the fields of AEC consider that educating and training low-income individuals in trades and basic construction knowledge would aid in more resilient post-disaster reconstruction, as presented in Figure 6. Only two experts consider that it would not help, mentioning two reasons: (a) the requirement for a self-help culture that is currently non-existent; and (b) the reliance of people in Puerto Rico on government support.

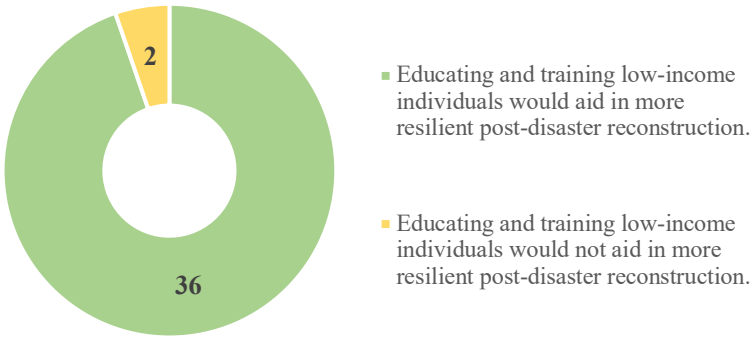

Figure 6. Experts opinion on whether educating and training low-income individuals in construction trades would aid in more resilient post-disaster reconstruction

The main problems of informal construction identified by this study are: (1) lack of structural knowledge, reflecting a mean of 4.63; (2) lack of quality control, yielding a mean of 4.61; (3) poor or inadequate construction methods, resulting in a mean of 4.58; and (4) lack of professional advice, reflecting a mean of 4.47. These results are presented in the box plots of Figure 7. Additional problems reported by experts include unfamiliarity and non-compliance with building codes or city ordinances, high cost of materials, health and safety concerns for

implementers, lack of economic resources, insufficient planning, and lack of government support.

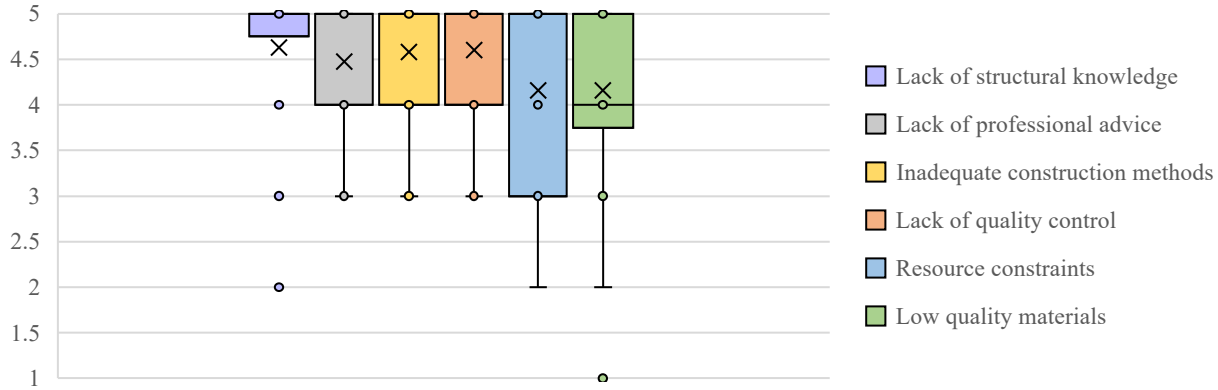

Figure 7. Main problems of informal construction

According to the results of this study, presented in Figure 8, several courses pertaining to construction trades and construction methods should be taught to low-income individuals and the underrepresented workforce to aid in post-disaster reconstruction. These courses include carpentry, electrical, roofing, basic construction methods, and plumbing. Additionally, AEC experts reported that courses related to basic structural knowledge, building permits and requirements, sustainable construction, inspection, foundation, material resistance, health and safety, and heating, ventilation, and air conditioning (HVAC) should also be taught. Furthermore, experts consider that the most beneficial and effective methods for teaching and training low-income individuals and the underrepresented workforce include (a) hands-on experience and on-the-job training, enabling individuals to acquire knowledge through practical application rather than traditional lectures or readings; and (b) problem-based learning, involving the resolution of open-ended problems either individually or in groups. Other instructional tools and teaching methods that could be beneficial are individual and/or group projects, in-person lectures, and co-curricular activities. These results are shown in Figure 9. In addition, experts mentioned that group education sessions for communities, seminars organized by non-profit organizations, and brainstorming sessions where low-income individuals can learn about educational opportunities would be beneficial in reaching more individuals and enhancing learning.

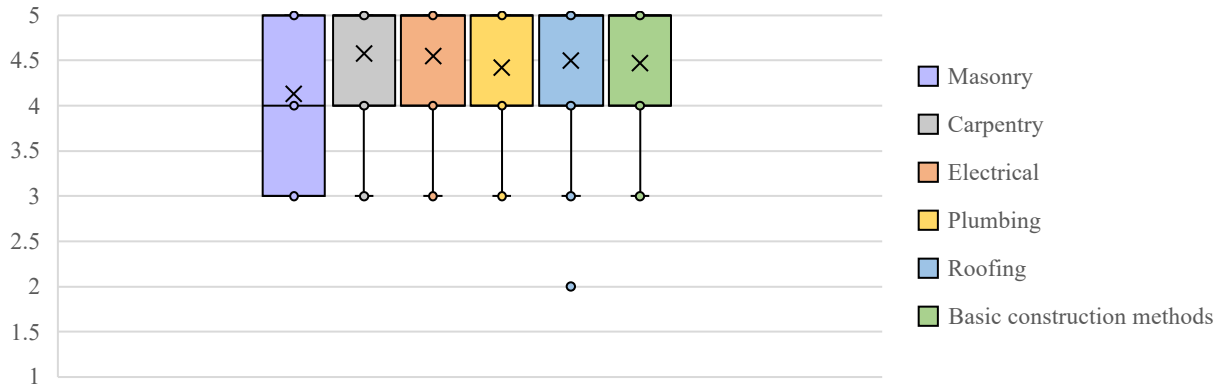

Figure 8. Courses that should be taught to low-income individuals and underrepresented workforce to aid in post-disaster reconstruction

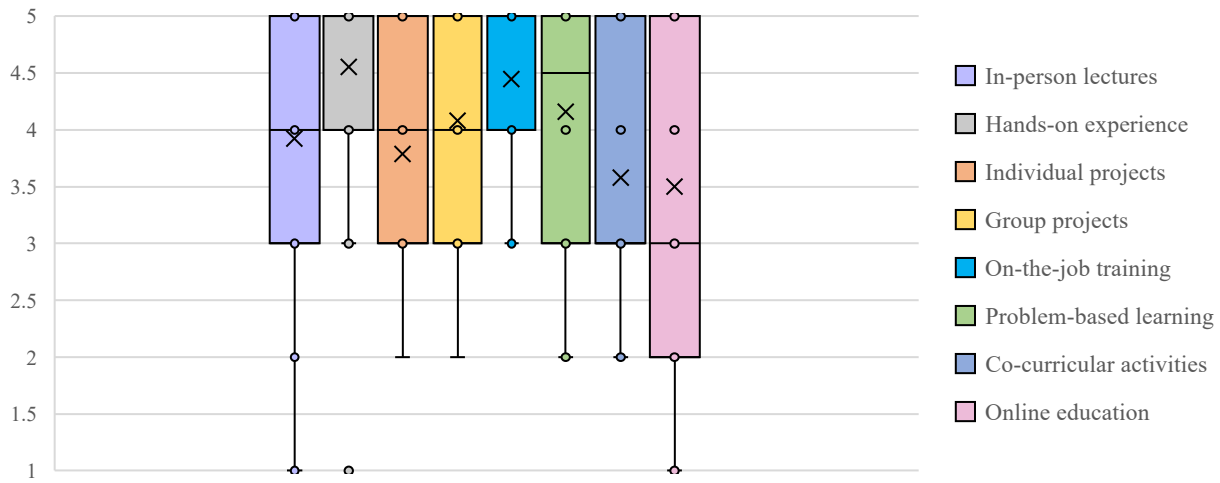

Figure 9. Effective teaching methods and instructional tools to educate and train low-income individuals

Finally, AEC experts were asked one open-ended question that intended to identify the resources that low-income communities lack. The results are presented in Figure 10 using a word cloud. As previously mentioned, the size of words represents the frequency of their usage. Unsurprisingly, the most common words are 'knowledge', 'materials, 'money', 'education', 'resources', 'information', and 'construction'. That said, experts agree that education and knowledge are paramount resources that low-income communities lack.

Figure 10. Resources that low-income communities lack

Limitation and Future Work

This study acknowledges some limitations: (1) The survey responses may be subjective to self-assessment and biases; and (2) the study has only been conducted in Puerto Rico, which may affect its scalability. Future studies could focus on investigating the research in other regions. Furthermore, future studies could focus on developing pedagogical approaches, including courses, modules, seminars, workshops, and teaching methods to effectively educate and train low-income individuals and the underrepresented workforce in construction trades. Existing

construction trades programs offered at various academic institutions could serve as valuable guides for such efforts. Educating and training low-income individuals will not only help them build safer and more resilient homes after a natural disaster but also greatly contribute to social mobility by allowing the underrepresented workforce to find better job opportunities and salaries.

Conclusions

The results of this study highlight the urgency to educate and train low-income individuals, who are highly vulnerable to natural disasters, in construction trades and methods. Providing such education and training can assist these communities, often residing in informal settlements and experiencing delayed post-disaster recovery, in building more resilient homes and better coping with natural disasters. According to this study's results, the main issues of informal construction include a lack of structural knowledge, lack of quality control, poor or inadequate construction methods, and lack of professional advice. Consequently, it is paramount to provide low-income individuals with education and training in construction trades, methods, and basic structural knowledge, while also instructing them on optimizing the use of affordable resources available to them. Additionally, this study highlighted effective teaching methods and instructional tools for educating and training low-income individuals and the underrepresented workforce. These methods encompass hands-on experience, on-the job training, and problem-based learning. Other potentially beneficial methods include individual and/or group projects, in-person lectures, and co-curricular activities.

Lack of housing and delayed disaster recovery are the major challenges and vulnerabilities of low-income communities' post-disaster, according to the results of this research. Housing is fundamental for living and protection. Informal construction not only exposes individuals to damages and loss of housing but also puts their lives in grave danger. Therefore, providing low-income individuals with construction knowledge will significantly contribute to their well-being. Furthermore, this knowledge will help them find better job opportunities and obtain higher salaries, contributing to social mobility and enabling them to build more resilient homes with increased access to resources.

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