Recognition and understanding of construction safety signs by final year engineering students

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ABSTRACT

This study assessed the recognition and understanding of construction safety signs among final-year Higher National Diploma, Building Technology (BT) and Electrical/Electronic Engineering (EE) students at a technical university in Ghana. The purpose was to evaluate their awareness of safety signs, addressing gaps in existing research and providing updated data to enhance occupational safety training. A descriptive statistical methodology was employed, utilizing purposive sampling to survey 137 students via structured questionnaires. Data were analyzed using SPSS v16 and compared against ISO 3864 and ANSI Z5353 standards. Results revealed varying comprehension rates: prohibition signs (61.71%), general warning signs (71.08%), mandatory signs (78.32%), emergency escape signs (81.4%), firefighting signs (86.9%), and chemical labeling signs (77.98%). While mean scores exceeded benchmark thresholds, low response rates for specific signs indicated significant knowledge gaps. The study concludes that unfamiliarity with safety signs persists due to insufficient training and curricular emphasis. Recommendations include revising academic syllabi under Ghana Tertiary Education Commission and National Board for Technical Examinations guidelines to integrate safety education, alongside industry partnerships for practical training during internships. These measures aim to reduce workplace accidents and improve safety compliance among future engineers.

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1. INTRODUCTION

A safety sign, according to the International Standard Organization (ISO), is a sign that displays a safety message and is necessary for preventing accidents and injuries [1]. These signs are often enhanced with colors, spatial figures, and pictorial symbols to convey specific safety instructions [2]. Safety signs serve as a method to inform and caution employees about the type and severity of workplace hazards. They are employed where necessary, taking into account the potential risks associated with specific dangers [3]. Health and safety (H&S) signs are shown wherever on building sites, from the site storing and entrance focuses to different areas all through the site. It is imperative to know the directions given to you by building site safety signs, they are shown to convey a reasonable H&S message [4]. Neglecting to comprehend and adhere to the directions offered by a hint may mean you lose your employment or your life [5].

Reliably, it is on record that the construction site is one of the most hazardous places and as such safety measures and practices need to be strictly adhered to [6], [7]. The Construction businesses in Ghana have high mishap rates because of the idea of the work, management systems, equipment utilized all the while, strategies used to play out the activities, speed of the work and other important mechanisms [8]. These construction industries record the most elevated number of work-related fatalities when contrasted with different working industries in the nation.

In all, about 56% of the complete 902 work-related wounds and mishaps recorded in 2,000 outcome in death. This means 77.6% of each 100,000 specialists die from endeavours nearby [9]. Regardless of these perils, the engineering graduate should have the option to perceive and comprehend these safety signs to remain alive. Familiarity with these signs is essential for accurately interpreting their meanings and fulfilling their responsibilities when exposed to potential dangers. In this way, to lessen the danger of misconstruing and increment the degree of sign comprehension, there is a need to plan safety signs with a significant degree of ease of use.

The ISO defines usability as the extent to which a product can be used by specific users to achieve defined objectives effectively, efficiently, and satisfactorily within a particular context of use [10]. Studies on safety sign observation highlight various factors that influence sign perception, including training, work experience, duration and nature of employment, types of safety signs, the contextual colors of the signs, and comprehension training [11].

A study was done by [2] on comprehension of workplace safety signs: A case study in Shiraz industrial park in Iran indicated a previous degree of sign cognizance among industrial laborers. There was a notable difference in the perception of safety signs, as the condition of the signs varied significantly. The average appreciation score for the tested signs was 65.95%, with a standard deviation of 28.7. Additionally, 40% of the tested safety signs scored below the minimum acceptable standards outlined in ISO 3864 and ANSI Z5353 guidelines.

Another by Amirhossein *et al*. [11] assessed the perception of workplace safety signs and the factors influencing it. The findings revealed a positive correlation between sign comprehension and variables such as age, knowledge, and effective training in safety signs ($p<0.05$). However, no significant relationship was observed between sign perception and gender. The study found that 72.72% of the signs were deemed acceptable based on ISO 3864 standards, whereas only 9% met the criteria of ANSI Z5353. These results indicate that the overall perception of safety signs among the sample group was relatively low, with only a few signs meeting acceptable standards.

Research by Alara *et al.* [12] looks at how semiotics may be used to improve construction operatives' understanding of H&S signals in Yola, Nigeria, to enhance H&S management and reduce the number of accidents. Sixty construction experts and operators working on five government building projects were given an ISO (9186-1) questionnaire to assess their understanding of H&S signals. The results showed that 11 of the 15 H&S signs evaluated were extremely useful for preventing accidents on construction sites, while the remainder were relevant.

Chan and Ng [13] explored whether different methods of training influenced the viability of sign training and if there were any connections between sign image attributes and training viability. In all, 26 Mainland Chinese industrial safety signs were utilized and 60 members were arbitrarily relegated into four equivalent estimated gatherings of control, matched partner learning, review training and acknowledgment training. The outcome was that members from all the training groups showed altogether more noteworthy improvement in recognizing the signs than those in the control group, showing that the preparation techniques improved appreciation of the significance of safety signs.

Sun *et al.* [14] investigated the rationale of safety sign placement. The safety signs were placed in various locations and heights around the corridor, and 30 people were asked to participate in the experiment. In two study trials, the Tobii eye tracker was utilized to collect eye movement data that might indicate the distribution of individuals' attention. The findings show that there was no significant relationship between eye height and the duration of fixation on safety indicators in various settings. The height of the safety signs should be around 1.25m, and they should be posted on the wall without causing any additional disruptions.

Katunge *et al.* [15], examined the H&S of secondary school teachers in the Mbooni West region. The findings revealed that most teachers had not participated in training programs designed to equip them with workplace safety skills. Additionally, the majority were not actively involved in discussions related to workplace safety. This lack of engagement significantly jeopardized the safety of teachers in their work environment, leaving them ill-prepared to handle health risks and ultimately affecting their overall performance.

Bian *et al.* [16] used a questionnaire and an event-related potentials (ERPs) experiment using an implicit paradigm to evaluate how individuals interpret three types of safety indicators (prohibition, obligatory, and warning signs). Warning signals elicited a greater degree of a perceived hazard than prohibition and obligatory signs, while prohibition signs elicited a higher level of a perceived hazard than required signs in terms of behavior. When compared to required signals, prohibition and warning signs resulted in lower P2 amplitudes in the brain. Furthermore, warning signs evoked higher N2 and N4 amplitudes than prohibition and mandatory signs, while prohibition signs elicited higher N2 and N4 amplitudes than required signs, which corresponded to behavioral results.

A study in [17] used ERP technology to investigate the influence of shapes on the perception of warning signals to uncover evidence of the forms' hazard perception from an electrophysiological standpoint. They discovered four components produced by varied forms of warning indicators using the Oddball paradigm. P200 amplitude represents the attraction to the attention of surrounding shapes in the early stages of automatic perception, N300 components represented emotional valance and arousal, P300 and LPP components represented uneasy/unsafe information and reflected inhibition strength on the uneasy/unsafe information. The shape of the upright triangle exhibited a higher arousal strength and greater negative valence than the shape of the circle, according to experimental results.

Finally, using the scientometric analysis approach, researchers in [18] outline the study themes and hotspots in safety indicator research from 1990 to 2019. The CiteSpace visualization programme evaluated 3102 pieces of literature from the Web of Science core database, and the findings were shown in mapped knowledge areas. Safety signs are an emerging study topic in rapid development, according to the analysis of the overall features 81.4 percent of the literary works were produced in the last 10 years, with the United States leading the way, followed by China and Canada. Traffic signs and driving safety were the most popular study subjects, according to the keyword co-occurrence analysis, and have been merged with simulation technology in recent years.

Article reviews specify that very few studies have been researched in the field of safety sign awareness [11]. Therefore, this study aims to evaluate final-year Building Technology (BT) and Electrical/Electronic Engineering (EE) students' recognition and understanding of construction safety signs at Ho Technical University, assessing their preparedness for workplace safety requirements. The research seeks to examine how effectively safety sign education has been integrated into their coursework and its potential to mitigate the high incidence of workplace accidents. Motivated by the scarcity of current data on safety sign comprehension, this investigation contributes to existing literature while providing updated insights into safety awareness among technical students. The findings will inform curriculum revisions to strengthen H&S education, ensuring students develop proper hazard recognition skills. Additionally, the study underscores the importance of enhanced industry collaboration to improve safety training during student internships, bridging the gap between academic instruction and practical workplace safety demands.

2. METHOD

The primary aim of this study was to assess the recognition and understanding of construction safety signs by final year BT and EE engineering students. One hundred and thirty-seven (137) respondents participated in this research survey. The study adopted a purposive sampling technique and structured interviewer-administered questionnaire as the research instrument. The chosen design enabled the researchers to collect data effectively to address the research questions.

The various responses from the questionnaire were checked for errors, inaccuracies, and inconsistencies. Following this step, responses were coded to use the Statistical Package for Social Sciences (SPSS, v.16.0) to process the collected data through the internet and the understudy's reactions to the safety signs cognizance test were contrasted with the acceptable scopes of the American National Standards Institute (ANSI) Z5353 (21) and ISO 3864 (22) standards.

3. RESULTS AND DISCUSSION

The study sought to investigate the recognition and understanding of construction safety signs by final year engineering students, comprising of BT and Electrical and Electronics Engineering Students only. In doing so the questionnaire was administered to the students to be answered via the internet (Google Docs) during the period of lockdown from the Covid 19 pandemic across the world. Sections which include Bio-data, experience and accidents, prohibition, general warning, mandatory, emergency escape, firefighting and warming chemical labelling safety sign identifications were the questions answered by the students on the questionnaire through the internet and their results are presented.

From the study as depicted in Table 1, out of 137 respondents, 92.7% of them were male and the rest (7.3%) were female. In addition, 54%, 38%, and 8% of the subjects were 20-25, 26-45, and >45 years old respectively. Again, 71.5% of the study's participants had experience in the construction field in less than 3 months to 1 year, a little over 9.5% in 1-2 years, and 19% in over 2 years. Finally, 33.6% had gotten accidents whiles working in the construction field whereas 66.4% had not.

Table 1. Demographic characteristics of respondents

Gender		Age (Years)		Experience		Accidents	
Male	92.7%	20-25	54.0%	<3months – 1 year	71.5%	Yes	33.6%
Female	7.3%	26-45	38.0%	1 – 2 years	9.5%	No	66.4%
		>45	8.0%	Over 2 years	19.0%		

3.1. Prohibition safety signage

Table 2 presents the tested prohibition signage along with the respondents' comprehension rates. The overall mean score for correct responses was 61.71±18.08. The highest accuracy rate was observed for "Smoking and naked flames forbidden" at 73.6%, while the lowest was for "Do not touch" at 33.3%. It can be argued that from the table "No access for industrial vehicles" had an accurate response of 78.8% which is higher when compared to "Smoking and naked flames forbidden" (73.6%). But concerning the total number of responses (frequencies) accurately answering the two respective questions the first had a high response. The highest response for incorrect comprehension was related to "No access for unauthorized persons" (61.4%).

Table 2. Results of tested prohibition signs by respondents

Sign No.	Safety sign	Meaning	Frequency	Correct for YES	Incorrect for YES
1.		No access for unauthorized persons	101	39 (38.6%)	62 (61.4%)
2.		Smoking and naked flames forbidden	129	95 (73.6%)	34 (26.4%)
3.		Do not extinguish with water	113	66 (58.4%)	47 (41.6%)
4.		No access for pedestrians	104	59 (56.7%)	45 (43.3%)
5.		No access for industrial vehicles	85	67 (78.8%)	18 (21.2%)
6.		Do not touch	78	26 (33.3%)	52 (66.7%)
7.		No smoking	81	62 (76.5%)	19 (23.5%)
8.		Not drinkable	63	49 (77.8%)	14 (22.2%)
Total		Mean		61.71	38.29
		Standard deviation		18.08	18.08

3.2. General warning safety signage

Table 3 summarizes the results for general warning signage. The overall mean score for correct comprehension was 71.08±18.15. The highest accuracy rate was associated with "Flammable material or High temperature" at 90.7%, while the lowest was for "corrosive material" at 35.1%.

3.3. Mandatory safety signage

The test and results for mandatory signage are presented in Table 4. From the results, the overall mean score of the accurate comprehension of these signs was 78.32±16.02. The highest and lowest rates of accurate response were associated with "safety gloves must be worn" (90.6%) and "general mandatory sign" (41.7%) which also recorded the highest response for incorrect answers.

3.4. Emergency escape safety sign

Results for the comprehension of emergency escape signage are shown in Table 5. The final mean score as presented for the comprehension of this signage was 81.4±7.21 with the highest correct response related to "first aid poster" (82.7%) due to the number of respondents that attempted to answer. The lowest comprehension rate for that category was "stretcher" (71.4%).

3.5. Firefighting safety sign

Firefighting signage was also tested and the results are presented in Table 6. The final mean score for correct comprehension was 86.9±4.90. As the table depicts, the highest and lowest rates of correct comprehension were associated with “fire extinguisher” (89.8%) and “fire hose” (9.60%) respectively. For incorrect responses, the highest was “emergency fire telephone” (21.0%).

Table 3. Results of tested general warning signs by respondents

Sign No.	Safety sign	Meaning	Frequency	Correct for YES	Incorrect for YES
1.		Flammable material or high temperature	97	88 (90.7%)	9 (9.3%)
2.		Explosive material	75	68 (90.7%)	7 (9.3%)
3.		Toxic material	85	61 (71.8%)	24 (28.2%)
4.		Corrosive material	74	26 (35.1%)	48 (64.9%)
5.		Radioactive material	65	54 (83.1%)	11 (16.9%)
6.		Overhead load	72	32 (44.4%)	40 (55.6%)
7.		Industrial vehicles	65	62 (95.4%)	3 (4.6%)
8.		Danger electricity	90	68 (75.6%)	22 (24.4%)
9.		General danger	84	52 (61.9%)	32 (38.1%)
10.		Laser beam	46	23 (50%)	23 (50%)
11.		Oxidant material	63	42 (66.7%)	21 (33.3%)
12.		Non-ionising radiation	73	45 (61.6%)	28 (38.4%)
13.		Strong magnetic field	82	72 (87.8%)	10 (12.2%)
14.		Obstacles	65	37 (56.9%)	28 (43.1%)
15.		Drop	39	30 (76.9%)	9 (23.1%)
16.		Biological risk	56	53 (94.6%)	3 (5.4%)
17.		Low temperature	46	30 (65.2%)	16 (34.8%)
Total		Mean		71.08	28.91
		Standard deviation		18.15	18.15

Table 4. Results of tested mandatory signs by respondents

Sign No.	Safety sign	Meaning	Frequency	Correct for YES	Incorrect for YES
1.		Eye protection must be worn	109	98 (89.9%)	11 (10.1%)
2.		Safety helmet must be worn	119	93 (78.2%)	26 (21.8%)
3.		Ear protection	104	95 (91.3%)	9 (8.7%)
4.		Respiratory equipment must be worn	102	88 (86.3%)	14 (13.7%)
5.		Safety boots must be worn	125	112 (89.6%)	13 (10.4%)
6.		Safety gloves must be worn	106	96 (90.6%)	10 (9.4%)
7.		Safety harness must be worn	44	26 (59.1%)	18 (40.9%)
8.		Face protection must be worn	86	76 (88.4%)	10 (11.6%)
9.		Safety overalls must be worn	107	84 (78.5%)	23 (21.5%)
10.		Pedestrians must use this route	28	19 (67.9%)	9 (32.1%)
11.		General mandatory sign	72	30 (41.7%)	42 (58.3%)
Total		Mean		78.32	19.72
		Standard deviation		16.02	16.15

Table 5. Results of tested emergency escape signs by respondents

Sign No.	Safety sign	Meaning	Frequency	Correct for YES	Incorrect for YES
1.		Escape route	106	78 (73.6%)	28 (26.4%)
2.		First aid poster	104	86 (82.7%)	18 (17.3%)
3		Stretcher	49	35 (71.4%)	14 (28.6%)
4.		Eyewash	57	50 (87.7%)	7 (12.3%)
5.		Safety shower	79	67 (84.8%)	12 (15.2%)
6.		Emergency telephone for first aid or escape	68	60 (88.2%)	8 (11.8%)
Total		Mean		81.40	18.60
		Standard deviation		7.21	7.21

Table 6. Results of tested firefighting signs by respondents

Sign No.	Safety sign	Meaning	Frequency	Correct for YES	Incorrect for YES
1.		Fire hose	52	47 (90.4%)	5 (9.6%)
2.		Fire extinguisher	108	97 (89.8%)	11 (10.2%)
3.		Ladder	53	46 (85.2%)	8 (14.8%)
4.		Emergency fire telephone	62	49 (79.0%)	13 (21.0%)
5.		Fire alarm	71	64 (90.1%)	7 (9.9%)
Total		Mean		86.9	13.1
		Standard deviation		4.90	4.90

3.6. Warming chemical labelling safety sign

The final tests and results for warming chemical labelling signage are shown in Table 7. As can be gleaned from the table, the overall mean score for correct comprehension was 77.98±24.09. Besides, the highest and lowest rates of correct response for each sign were related to “flammable” (95.4%) and “health hazard” (21.9%).

Table 7. Results of tested warming chemical labelling signs

Sign No.	Safety sign	Meaning	Frequency	Correct for YES	Incorrect for YES
1.		Gas under pressure	21	18 (85.7%)	3 (14.3%)
2.		Explosive	65	64 (98.5%)	1 (1.5%)
3.		Oxidising	61	36 (60.0%)	24 (40.0%)
4.		Flammable	87	83 (95.4%)	4 (4.6%)
5.		Corrosive	60	51 (85.0%)	9 (15.0%)
6.		Health Hazard	64	14 (21.9%)	50 (78.1%)
7.		Acute toxicity	108	81 (75.0%)	27 (25.0%)
8.		Serious Health hazard	28	24 (85.7%)	4 (14.3%)
9.		Hazardous to the environment	37	35 (94.6%)	2 (5.4%)
Total		Mean		77.98	22.02
		Standard deviation		24.09	24.10

The present study shows the results from Tables 1 to 7. Table 1 displays the demographic characteristics of the respondents. The participants were allowed to answer questions related to years of experience. It can be seen that students barely had enough experience in the engineering industry and over

70% of the respondents had about a maximum of 1 year of experience, making it difficult to identify these safety signs. Another part reported information about the accident occurrence. About less than half of the group under study, representing 33.6%, responded “Yes,” while 66.4% responded “No.” Most of these accidents were found to be objects falling, objects being stepped on, cuts, and individuals falling. Similar research done by [19] discovered that the three (3) most commonly occurring kinds of mishaps in Thailand were workers being struck by falling items, stepping on or striking against things, and individuals falling.

Most of these respondents got the opportunity to visit the industries during the internship period, and most of these industries do not have safety officers to perform inductions for them. Preventive accidents occur due to this problem. Even though some students are mature before gaining admission into the university, they might have engaged in industrial activities, but due to a lack of experience in H&S training, they end up with these accidents. It should be noted with great concern that accident prevention starts with having a clear understanding of the factors that play a key role in their causation [20]. The researchers [12], [21], [22], the fatalities recorded in Nigeria on construction sites are more devastating than those in advanced countries due to a lack of concern, precise records, inadequate planning, H&S regulation enforcement, and H&S awareness among operatives.

Tables 2-6 display the analysis of the questionnaire survey, which assesses respondents’ knowledge of various safety sign categories. Prior to identifying the signs, participants were asked whether they had seen the safety sign before, where they had encountered it, and to explain its meaning. The results indicated that comprehension of these safety signs varied significantly across different categories, with each showing a distinct pattern. Overall, the mean comprehension scores for the studied safety signs were relatively high, accompanied by a low standard deviation, suggesting that participants could accurately identify the signs. According to ISO 3864 (22) and ANSI Z5353 (21) standards, the mean correct response rate for safety signage should be at least 67% and 85% of the study group, respectively. Comparable research done by [2] found that among 53 randomly selected groups, 40% of the tested safety signs fell below the minimum acceptable values set by the ISO 3864 and ANSI Z5353 standards, highlighting a significant difference in comprehension of the verified safety signs.

Taking the respective mean values of each sign and the overall mean values of each table, the relatively high mean score across the categorized safety signs cannot represent the actual standard mean requirement by either ISO or ANSI due to the limited attempts by respondents on each categorized question. It could be seen that out of 137 respondents, most of them, based on accumulated frequencies, could not attempt these questions, and those that attempted with correct answers were not encouraging, raising concern about the knowledge of these signs. Few students knew the overall concepts of the safety sign. Therefore, the results presented do not truly reflect the standard requirement with the accumulated sample size for each attempted question. Again, most of the respondents who could not understand and recognize these signs in the various studies might have been related to poor understanding during teaching hours and also to poor or no training and the commonness of the signs in various industries where they take up their internship programmes. A great study by [23] in 2008 on H&S practices among construction SMEs in Ghana exposed severe problems. One (1) of the main problems admitted was the inefficiency of institutional frameworks responsible for H&S standards. Another by [24], [25] clearly indicated that factors such as education level, work experience, working hours, the type of safety sign, the background and color of safety signs, and training significantly influence an individual’s ability to understand and recognize these signs.

The university should establish Academic and Industry Partnerships (AIPs) with the construction industry and its relevant professional organizations to address the prevailing unsafe practices among stakeholders. These partnerships should prioritize delivering high-quality training on continuous safety development (CSD), emphasizing student-centered approaches rather than course-focused strategies [26]. Teacher-handlers handling courses related to the study must ensure that more attention is given to this area of interest during teaching and must review their entire syllabus to include H&S per the Ghana Tertiary Education Commission (GTEC) and National Board for Technical Examinations (NABTEX) criteria. Workplace supervisors with good training can also help by providing induction and training to improve perception rates of safety signs as it is apparent that training raises awareness of hazards and safety risks [27], [28]. Although education and training may not be sufficient to address all issues related to construction H&S, they can serve as effective instruments for instilling safety awareness in students beginning in elementary school [26]. Again, “familiarity”, which is the level of exposure to various safety signs for students, should be encouraged more. It is critical to re-engineer the current safety signage in the various departmental laboratories [29]. Frequent exposure enhances the learning and retention of these signs [30]. Although the study failed to reveal a substantial connection between gender, age, and the perception of these signs, there was a slight yet noticeable correlation in sign comprehension. This was influenced by the sample size for each question attempted, despite the high overall mean score.

4. CONCLUSION

This study aimed to evaluate the recognition and understanding of construction safety signs among final-year BT and EEE students at Ho Technical University, Ghana, and to assess their alignment with ISO 3864 and ANSI Z5353 standards. The findings revealed significant variations in comprehension across safety sign categories, with mean accuracy rates ranging from 61.71% (prohibition signs) to 86.9% (firefighting signs). While overall scores met or exceeded benchmark thresholds, low response rates for specific signs such as "Do not touch" (33.3%) and "Health hazard" (21.9%) highlighted critical gaps in safety awareness. The results underscore the influence of limited practical exposure and insufficient curricular integration of safety training. Notably, students with minimal industry experience (71.5% had <1 year) struggled with sign recognition, reinforcing the need for structured safety education.

This study makes significant scientific contributions by providing empirical evidence on the effectiveness of current safety training in technical education, particularly in the recognition and comprehension of construction safety signs. It identifies high-risk signs such as "Do not touch" and "Health hazard" that require targeted instructional interventions to improve student awareness. Additionally, the research validates the role of standardized frameworks like ISO 3864 and ANSI Z5353 in enhancing safety sign comprehension, offering a benchmark for future educational and industrial training programs. To address the identified gaps, the study recommends revising academic curricula to embed mandatory safety modules aligned with GTEC and NABTEX guidelines. Strengthening industry-academia collaborations for hands-on training during internships is also essential to bridge the gap between theory and practice. Furthermore, regular safety workshops and certification programs should be implemented to reinforce awareness and ensure continuous learning. These measures will enhance safety compliance among future engineers and contribute to reducing workplace accidents in the construction industry.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
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I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

This study involving human participants adhered to all relevant national regulations and institutional policies. Approval was obtained from the Electrical/Electronic Engineering (EEE) and Building Technology (BT) Departmental Academic Committee of Ho Technical University (HTU).

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [EM], upon reasonable request.

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