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RESEARCH ARTICLE

Integrating Green Building Technologies in Vocational Education: A Pathway Towards Sustainable Construction in Malaysia

A.A. Latif*, M.F. Muda, M.R. Zainudin and F.W.M. Latib

Civil Engineering Studies, College of Engineering, Universiti Teknologi MARA Pahang Branch, 26400 Jengka, Pahang Darul Makmur, Malaysia

ABSTRACT - This study investigates the critical incorporation of Green Building Technology (GBT) into the Construction Technology Program of Malaysian vocational colleges. The objective is to align educational frameworks with the urgent demands for sustainable construction practices in response to the escalating global warming crisis. Given the significant environmental changes driven by anthropogenic activities, such as increased atmospheric carbon dioxide (CO_2) levels from fossil fuel combustion, there is a pressing need for the construction industry to adopt green technologies to mitigate these impacts. This study utilises the Nominal Group Technique (NGT), with a panel of five field experts tasked to identify and prioritise the GBT elements for integration into the vocational curriculum. These elements are vital for equipping future professionals with the knowledge and skills necessary for contributing to environmental protection and sustainability in the construction sector. The findings highlight a consensus among experts on the importance of foundational GBT topics, such as energy efficiency, sustainable materials, and indoor environmental quality, while also noting a variance in opinions on more specialised subjects like Green Building Index (GBI) tools and case studies. Additionally, the study highlights the necessity for Malaysian vocational colleges to employ GBT in their curricula. This priority is crucial not only to address immediate educational requirements but also to contribute significantly to the overarching objectives of sustainable development and global warming mitigation within the construction industry. The integration of GBT in vocational education is regarded as a vital effort in nurturing a proficient workforce that is adequately equipped to address the challenges and opportunities of sustainable construction. This alignment corresponds with global best practices and demonstrates Malaysia's commitment to sustainable development goals.

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1. INTRODUCTION

The Global warming refers to the continuous temperature changes and regular weather patterns within the Earth's climate system. The leading cause of global warming can be traced to the elevated atmospheric carbon dioxide concentration from fossil fuel combustion. This occurrence is sometimes linked to the broader notion of global warming, which refers to the documented long-term increase in the average temperature of the earth's climate system and its accompanying consequences. Anthropogenic activities, including the combustion of fossil fuels and the clearing of forests, have augmented the inherent greenhouse effect, resulting in increased heat retention and subsequent elevation of surface temperatures. Besides, global warming can cause significant shifts in climatic patterns and induce heightened heat waves, increased precipitation levels, and a more frequent and severe occurrence of extreme weather phenomena. Furthermore, the issue has now been recognised as a major peril to human well-being, such as cardiovascular disease [1 - 2]. In recent decades, global and local climate change has seen a noticeable increase. These changes are evident through the increasing average temperatures, elevated sea levels, warmer oceans, and the degradation of coral reefs. Furthermore, changes in rainfall and snowfall patterns, an increase in flood disasters, depletion of natural resources, damage due to deforestation, excessive carbon emissions, more frequent droughts and wildfires, shifts in animal migration and life cycles, along with the accumulation of toxic and non-biodegradable waste from human activities, are some of the notable consequences [3].

Mitigation strategies for global climate change are diverse and require coordinated efforts at both international and local levels. These include reducing greenhouse gas emissions, transitioning to renewable energy sources like solar and wind power, and improving energy efficiency. Policies like carbon pricing, which imposes costs on greenhouse gas emitters, can also be employed to incentivise emission reductions [4]. Thus, it is crucial to involve and empower younger generations in the creation and execution of effective climate policies and solutions, as they are being increasingly affected by severe climate events like floods and droughts. This will ensure that their demands and perspectives on climate change mitigation strategies are taken into account. For example, the transformation of vocational schools into vocational colleges aims to produce highly skilled workers in Malaysia in various field including the sustainable construction or green construction sectors. However, the ability of vocational colleges to offer course specifically focused on Green Building

***CORRESPONDING AUTHOR | A.A Latif** | ✉ amminudin738@uitm.edu.my

Technology in Malaysia is still debatable, as they need to consider the circumstances and challenge encountered in the country. Hence, an evaluation of the curriculum for the vocational college course on Green Building Technology is necessary. In order to prepare skilled workers in the field of green building technology in Malaysia, one of the institutions that responsible to provide the training is the vocational college. Consequently, the Green Building Technology course was implemented in the Construction Technology Program in vocational colleges to incorporate green technology into the building constructions. This emphasis is critical, as their main goal is to secure a 70% employment rate for their graduates in this industry [5]. Overall, the students enrolled in Construction Technology Program will gain a comprehensive awareness of the prevailing trends in the building industry and develop a strong sense of environmental responsibility. In short, the program will familiarise students with the concept and practical application of green technology in the construction sector, with a specific focus on building construction.

Therefore, this study aimed to obtain expert viewpoints about the GBT syllabus contents in Construction Technology Programm in vocational college in Malaysia. The findings derived from this study will provide valuable insights that aid in effective planning for policymakers, designers of environmental learning programmes, and instructors in vocational colleges and the Technical Vocational Education and Training (TVET) Division of the Ministry of Education. The research's primary objective has been to address the following research inquiries which are i) According to the panel of experts, what elements of GBT are used in the Construction Technology Program in vocational colleges? and ii) What is the experts' ranking of the GBT elements for the Construction Technology Program in vocational college?

1.1 Technical Vocational Education and Training (TVET)

Technical and Vocational Education and Training (TVET) in Malaysia has undergone a significant transformation over the years, driven by the country's need to develop a skilled workforce for its expanding industries [6]. This transformation has been supported by government initiatives aimed at enhancing the quality of technical education and increasing student enrollment in vocational programs to align with the demands of the Malaysian Economic Transformation Program [7]. As a result, the government has focused on restructuring the vocational training system to not only provide alternative educational pathways but also to ensure that graduates possess the necessary skills to thrive in a rapidly evolving job market, thus addressing both historical perceptions and current workforce needs [7]. The increasing recognition of TVET as a viable and valuable educational path has contributed to a growing acceptance among students and parents alike, as the government actively promotes vocational training as essential for addressing the skills gap and fostering economic growth within the nation [8]. It originated from a need to create a skilled workforce for various industries in the country. Among the available TVET institutions in Malaysia, Vocational College stands out as an institution that offers various technical education courses. Historically, vocational education in Malaysia was often seen as a second choice aimed at students who were not academically inclined [9]. However, this perception has been changing over the years. The Malaysian government, recognising the importance of skilled labour in a growing economy, has been increasingly focusing on enhancing the quality and perception of TVET. Nowadays, the vocational college has been upgraded from a vocational school to offer more effective technical education options to Malaysians.

1.2 Current State and Structure of Vocational College

At present, the vocational college in Malaysia is considered critical in the national education system, where it is dedicated to producing skilled workers in various trades and technologies. Its importance can be seen from the multiple governmental bodies that are in charge of managing the institutions, such as the Ministry of Education, the Ministry of Human Resources, and the Ministry of Youth and Sports. This multi-ministry approach reflects the diverse nature of vocational training, which encompasses a broad spectrum of fields, from technical and engineering trades to hospitality and business. As of now, a wide range of programs at different levels, from certificate to diploma programs, have been offered at this institution.

1.3 Focus on Sustainable Development

In recent years, there has been a growing emphasis on incorporating sustainable practices and green technologies in vocational college programs. This shift is in response to global environmental challenges and Malaysia’s commitment to sustainable development goals. Vocational colleges are progressively incorporating courses centred on renewable energy, sustainable manufacturing processes, and environmental management. The effort is not only to prepare the students for careers in emerging green industries but also to instil a culture of sustainability in the workforce. One of the institution's initiatives is to introduce the GBT course in the Construction Technology Program.

1.4 Current Research Finding and Future Research Direction on GBT in Malaysia

GBT is increasingly recognised as a suitable approach to constructing and managing buildings that prioritise sustainability, energy efficiency, and reduced environmental impact. This field is particularly relevant given the growing global concern over environmental issues like climate change and resource depletion. Several studies have discussed the current state, challenges, and future directions of green building technology in Malaysia, offering valuable insights into its development and implementation within the construction industry [10]. A key aspect of green building technology is its potential to significantly lower greenhouse gas emissions through sustainable building designs, assessments, and practices. The emergence of Building Information Modelling (BIM) has revolutionised the construction industry by enabling the digital construction of complex buildings. This transformation facilitates more precise and efficient design,

construction, and assessment processes. When integrated with sustainability rating tools like the Malaysian Carbon Reduction and Environmental Sustainability Tool (MyCREST), BIM can greatly enhance the sustainability analysis and decision-making process at the early stages of green building projects. However, the absence of a standardised workflow for BIM-based modelling in green building design reveals the need for a more structured approach to harness its potential fully.

Table 1. Previous research findings on Green Building Technology

References	Research Findings	Future Research
[13]	A conceptual model of opportunity creation in green technology has been developed.	A more refined and validated model with broader empirical data is required.
[14]	Green certification significantly affects the sales price of residential properties.	Explore the impact of specific green features on property values and market acceptance.
[15]	Identified the standards and governmental roles in the green building industry.	Further research on overcoming barriers to green construction industry adoption is necessary.
[16]	Developed a suitable design for Sarawak motifs in ventilation models.	Explore the adaptation of traditional designs in other modern sustainable housing elements.
[16]	PCWW reduced total heat gain by 7.84kWh in a classroom and could save 658.972kWh/month, translating to RM 3352.26/month savings.	Explore the application of PCWW in different building types and climates.
[17]	Highlighted the necessity of integrating BIM criteria in green highway construction for better performance assessment.	Develop an integrated assessment framework for BIM and sustainable design in green highway construction.
[18]	Indoor environmental quality and energy efficiency were identified as the most significant criteria for evaluating green building universities.	Extend research to include more stakeholders and cover broader sustainability aspects in university buildings.
[19]	"Energy Efficiency" and "Indoor Environmental Quality" were the most important criteria for assessing green building manufacturing.	Further research on optimising practices in green building manufacturing based on identified indicators is critical.
[20]	External wall cladding made of composite aluminium provided advantages in thermal comfort.	Develop design principles for office buildings that address ecological issues and provide comfortable environments.
[21]	The research identified twelve regulatory requirements necessary for formulating green regulations and building codes.	Implement and evaluate the effectiveness of proposed regulatory requirements in promoting green building practices.
[22]	The key influencers were location factors, financial considerations, and neighborhood and housing attributes.	Explore the influence of these factors in other regions and for other types of green buildings.
[23]	BIM can support various sustainability analyses and potentially enhance buildings' sustainability performances.	Develop a detailed framework or model for using BIM in greening existing buildings.
[24]	Identified that awareness, technology, social elements, and legislation can influence the GBI's effectiveness.	Address identified gaps to improve GBI adoption and practice among stakeholders.
[25]	Strategies for rejuvenating existing buildings into green buildings using low-lying fruit strategies before active technologies.	Validate and assess the effectiveness of outlined strategies in real-world applications.
[26]	Green technology is widely understood, but its implementation and knowledge development are lacking.	Develop educational programs and training to enhance green technology knowledge and its application in construction projects.
[27]	Identified practices and strategies for reducing carbon footprint in the supply chain.	Suggest the development of comprehensive policies and incentives to promote low-carbon practices in manufacturing supply chains.

The challenges in evaluating the effectiveness of green buildings, particularly concerning the Green Building Index (GBI) in Malaysia, highlight the need for more accessible and transparent information to encourage wider adoption of GBI practices. Strategies outlined in the Low Carbon Society (LCS) blueprints for Iskandar Malaysia and Kuala Lumpur emphasise the importance of including existing buildings in green initiatives, suggesting practical steps for transitioning towards greener urban environments [11]. Additionally, the awareness and application of green technology within the construction industry workforce reveal a gap between understanding and practical implementation. The situation suggests

the need for targeted educational programs and training initiatives [12]. The implementation of green maintenance practices, particularly in specialised settings like hospitals, faces obstacles such as a lack of awareness and financial constraints. These challenges signify a broader issue within the maintenance sector. Furthermore, the energy efficiency practices for green office building occupants in Malaysia underline the importance of occupant-oriented strategies in reducing energy consumption. The overview of multiple research outcomes in GBT is shown in Table 1.

1.5 Research Aims

This research explores the perspectives and suggestions of experts regarding the current syllabus contents of the GBT course offered in Construction Technology Program in vocational colleges. Furthermore, it sought to draw conclusions and provide recommendations on the best practices of sustainability and green technologies in the building construction sector using the insights provided by the experts.

2. METHODOLOGY

This study employed the NGT (Nominal Group Technique) as its main methodology, involving a panel of five (5) experts who specialise in teaching and delivering education at higher education institutions. The specific focus was to identify the optimal syllabus content for GBT courses designed for Construction Technology Program in vocational college in Malaysia. These professionals gathered for face-to-face NGT sessions, which lasted 2 hours each, to generate ideas and solutions through collaborative brainstorming collectively. The NGT framework enabled a systematic exchange of ideas that utilised the combined knowledge and expertise of the participants. After the session, the researchers employed NGT to obtain the rank categories for each item in syllabus contents. According previous research, the optimal number of participants for NGT (Nominal Group Technique) is between the range of five (5) to nine (9) individuals [28 - 29].

2.1 Nominal Group Technique

The NGT is a collaborative method that facilitates the exchange of ideas among a group of individuals over a specific subject. Initially, all individuals proceed to record their thoughts in a calm and silent manner. Then, each individual presents their thoughts without engaging in any conversations. Afterwards, the group engages in a discussion to enhance their comprehension of the ideas. Individuals cast their votes or assign rankings to indicate their preferences for the concepts they favour the most. The ideas that receive the highest number of votes are selected as the top options.

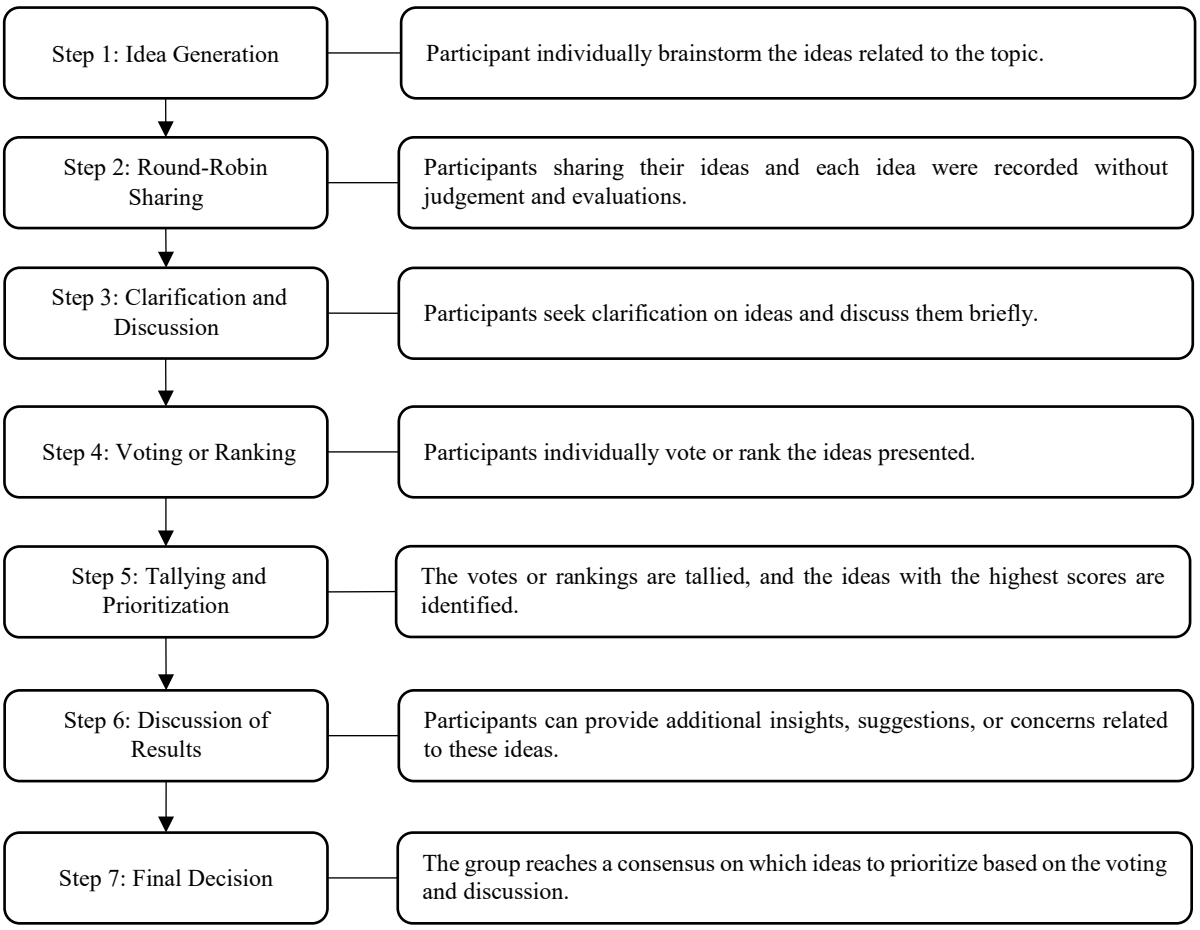

Figure 1. Typical steps in the NGT process

Moreover, the group discusses the top ideas and subsequently determines the ones that are superior in quality. NGT facilitates equal participation and prevents monopolisation of the discourse. It functions as a systematic approach to collect ideas and make collective decisions. Figure 1 depicts the customary stages of the NGT procedure. This method was chosen to solicit the initial expert opinion from selected individuals in the academic sector specializing in GBT.

2.2 Panel of Experts

The participants, aged between 30 and 45 years, were selected based on their expertise in teaching and learning in engineering departments. Although the current study is based on the small sample of experts, the findings are in line with recommendations made by Van de Ven and Delbecq (1971) and Anderson (1988), with the optimal number of participants for NGT is between five(5) and nine(9) individuals [28 - 29]. In this study, 5 experts were selected to participate in the NGT process. All experts have more than 10 years of experience teaching and learning engineering subjects and direct and indirectly involved in the areas of studied. The researchers emphasised the significance of participants' perspectives and assured that these viewpoints would be extensively shared while maintaining anonymity. The primary inclusion criteria for the experts were based on ; (i) knowledge on the field of studied [30]i.e at least to have a Bachelor's Degree; (ii) experience in the field studied for at least five years [31]; (iii) able to give full commitment until the study is completed and; (v) have no personal interest in this study as to avoid bias in the study [32]. The panel of experts selected is stated in Table 2 below.

Table 2. Panel of experts

	Expert's Position	Institution
1	Head of Department (Ts.)	Civil Engineering Studies UiTM Pahang Branch
2	Senior Lecturer (Ts.Dr)	Civil Engineering Studies UiTM Pahang Branch
3	Head of Division (Dr.)	Civil Engineering Studies UiTM Pahang Branch
4	Senior Lecturer	Civil Engineering Studies UiTM Pahang Branch
5	Senior Lecturer	Civil Engineering Studies UiTM Pahang Branch

3. RESULT

The scores for each GBT course incorporated in the Construction Technology Program in vocational college were added, and then the elements were ranked based on the total score obtained. Generally, all the GBT elements tested were suitable to be embedded in the program to reduce environmental problems. [33] discovered that most experts felt that integrating GBT into this course might help mitigate the effects of global warming. According to this NGT analysis ranked by 5 experts, fifteen (15) elements of GBT were ranked by experts and a consensus was made among them regarding the top-priority green technology elements in construction sectors. The GBT elements include:

a) Introduction to Green Technology in Construction;
b) Green Technology for energy efficiency in building constructions;
c) Green Technology for indoor environmental quality;
d) Sustainable site planning and management;
e) Sustainable materials and water resources in constructions;
f) Sustainable components in Green Building constructions;
g) Green Building Index (GBI);
h) Issues and problems in Green Technology in buildings construction;
i) Introduction to Green Building measurement and assessment;
j) Green Building assessments criteria;
k) The current needs and applications of Green Technology in constructions;
l) Environmental, social and economic benefits of implementing Green Technology in constructions;
m) GBI measurement tools and guidelines;
n) Filed measurement of GBI for residential new construction; and
o) Case study of Green Technology implementation in construction in UK, USA and Asia.

The result from the NGT analysis indicated that all of these elements are suitable to be added to the Construction Technology program for vocational colleges in Malaysia. The details of the NGT analysis result are shown in Table 3.

The items “Introduction to Green Technology in Construction,” “Green Technology for Energy Efficiency in Building,” “Green Technology for Indoor Environmental Quality,” “Sustainable Site Planning,” and “Sustainable Materials and Water Resources in Construction” all received the maximum score of 15, with a percentage of 100%, ranked as number 1. This suggests a consensus on their importance or agreement on their evaluation among all experts. Both

"Sustainable Components in Green Building Constructions" and "Green Building Index (GBI) have a score of 14 (93.33%) and are ranked 2, indicating they are viewed as very important but slightly less unanimous than the top-ranked items. The item with the lowest rank, "Case study of Green Technology Implementation in residential in UK, USA and China," has a score of 11 (73.33%) and is ranked 4, which may suggest it is of lesser importance, has less agreement among the experts, or is less relevant compared to other topics. In summary, the table shows a strong agreement among the experts on the importance of introductory and foundational aspects of Green Technology in construction. At the same time, more specific applications, such as case studies, have a relatively lower score and rank.

Table 3. Result of NGT analysis

No.	Items	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Score	Rank
1	Introduction to Green Technology in Construction	3	3	3	3	3	15 (100%)	1
2	Green Technology for energy efficiency in building constructions	3	3	3	3	3	15 (100%)	1
3	Green Technology for Indoor Environmental Quality	3	3	3	3	3	15 (100%)	1
4	Sustainable Site Planning and Management	3	3	3	3	3	15 (100%)	1
5	Sustainable Materials and Water Resources in Construction	3	3	3	3	3	15 (100%)	1
6	Sustainable Components in Green Building Constructions	2	3	3	3	3	14 (93.33%)	2
7	Green Building Index (GBI)	2	3	3	3	3	14 (93.33%)	2
8	Issues and Problems in Green Technology in Buildings Construction	3	3	1	3	3	13 (86.67%)	3
9	Introduction to Green Building Measurement and Assessment	2	3	3	2	3	13 (86.67%)	3
10	Green Building Assessments Criteria	2	3	2	3	3	13 (86.67%)	3
11	The Current Needs and Applications of Green Technology in Construction	2	3	1	3	3	12 (80%)	4
12	Environmental, Social and Economic Benefits of Implementing Green Technology in Constructions	2	3	1	3	3	12 (80%)	4
13	GBI Measurement Tools and Guidelines	2	3	2	3	2	12 (80%)	4
14	Filed Measurement of GBI for Residential New Construction	2	3	2	3	2	12 (80%)	4
15	Case Study of Green Technology Implementation in Construction in UK, USA and Asia	2	3	1	3	2	11 (73.33%)	5

4. DISCUSSION

In recent years, the integration of Green Technology within the construction industry has become critical in promoting sustainability and environmental stewardship. The data presented provides an insightful evaluation of different facets of Green Technology, as assessed by five experts. Their collective evaluations are crucial in identifying the areas of consensus and understanding the pivotal components of sustainable construction practices to reduce the environmental impact, especially the effects of global warming. In addition, the need for high-performance buildings is rising due to global warming and other environmental issues. High-performance buildings require a thorough consideration of location, climate, materials, cost, and other considerations, making it a complicated multidisciplinary research problem [34]. Experts suggest that integrating the GBT element into the Construction Technology Programme in vocational colleges as a core course is essential.

A key takeaway from the data is the unanimous scores given by all experts to introductory topics such as 'Introduction to Green Technology in Construction,' 'Green Technology for Energy Efficiency in Building,' 'Green Technology for Indoor Environmental Quality', 'Sustainable Site Planning and Management', and 'Sustainable Materials and Water Resources in Constructions'. These topics received the maximum score, reflecting a consensus on their fundamental importance in sustainable construction. This uniformity suggests that professionals and stakeholders in this industry need a strong grasp of the basics. In addition, adhering to strict guidelines on incorporating green building elements is crucial for achieving the suggested emissions reduction goals and mitigating the impact of global warming [35]. Hence, it was found that that elements 1-5 (Table 1) with the highest ranking are important for every construction technology student to acquire, since these will provide them with the requisite expertise to carry out duties associated with GBT after finishing their studies. Moreover, the perspectives provided by this panel of experts might be utilized by the ministry to identify and enhance the deficiencies in the current curriculum.

Conversely, the lower scores and ranks for items such as 'GBI Measurement Tools and Field Measurement of GBI for Residential New Construction' and 'Case Study of Green Technology Implementation in Residential in UK, USA and

China' indicate less agreement or possible variations in expert opinion regarding their application or importance. These disparities could arise from the specific nature of these topics, regional applicability, or the perceived maturity of these technologies and methodologies within the industry. The data implies a priority for the construction industry to solidify foundational knowledge and progressively delve into more complex and specific areas of green technology. For future research and practical application, the emphasis might be directed towards those areas where expert consensus is lower, thereby addressing knowledge gaps and advancing understanding in those domains. Overall, the expert evaluations serve as a guide for educational, research, and policy priorities in green technology within the construction sector.

5. CONCLUSION

The research analyses the criticality of embedding GBT elements into the Construction Technology Program at vocational colleges in Malaysia to address the escalating environmental issues, particularly global warming. The unanimous agreement among experts on foundational topics, such as the introduction to green technology in construction, energy efficiency, indoor environmental quality, sustainable site planning, and sustainable materials and water resources, highlights their essential role in fostering a sustainable construction industry. These components are deemed indispensable for equipping students with the knowledge and skills necessary for environmental conservation and sustainable practices within the construction sector. The emphasis on these areas reflects a consensus on the importance of establishing a solid understanding of green building principles from the outset. In contrast, the relatively lower scores and ranks assigned to more specialised topics, such as GBI measurement tools and case studies of green technology implementation in different regions, may indicate a variance in expert opinions on their immediate relevance or applicability in Malaysia. This disparity suggests that while foundational GBT knowledge is unanimously recognised as crucial, applying and exploring more advanced and specific GBT aspects may require further investigation and adaptation to local needs and conditions. On top of that, it is imperative for vocational colleges to prioritise these key GBT elements within their curriculum to not only address the immediate educational needs but also to contribute to the broader goal of mitigating global warming and advancing sustainable construction practices. This approach aligns with global efforts and best practices in green technology education, ensuring that graduates are well-prepared to meet the challenges and opportunities in the evolving construction industry landscape.

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DATA AVAILABILITY STATEMENT

The data used to support the findings of this study are included within the article.

AUTHOR CONTRIBUTIONS

Amminudin Ab Latif: Study conception and design, data collection, analysis and interpretation of results, draft manuscript preparation and reviewing.

Mohd Fakri Muda: Study conception and design, data collection, analysis and interpretation of results, draft manuscript preparation and reviewing.

Mohd Razmi Zainudin: Analysis and interpretation of results, draft manuscript preparation and reviewing.

Farah Wahida Mohd Latib: Analysis and interpretation of results, draft manuscript preparation, editing and reviewing.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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