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# Experts' Opinion Matters! Green Technology Elements for Construction Technology in Vocational Colleges

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**Abstract:** Green Technology refers to clean energy production, the use of alternative fuels, and technologies that are less harmful to the environment than fossil fuels. It has garnered a significant amount of interest due to increasing awareness about the impacts of climate change and the depletion of natural resources. While the buildings emit more carbon dioxide and other greenhouse gases than other industries, the use of Green Technology will be able to reduce human impacts on the natural environment and prevent climate change. Therefore, the purpose of this study is to investigate the Green Technology Elements for Construction Technology in Vocational College that is seen fundamental as these students will be in the construction workforce in the future. The study was conducted using the Fuzzy Delphi Method (FDM) involving a combination of 20 experts with various expertise from a heterogeneous group. A set of questionnaires using a 7-point Likert Scale was formed based on expert interviews in the first phase of this study and the data obtained were then analysed using triangular fuzzy numbers and ranking for each variable was determined using the defuzzification process. The findings showed that all elements listed reached the experts' consensus. Expert consensus also found that the Carbon Initiatives element ranked first meanwhile the Introduction to Green Technology element ranked last in the list of elements. These elements are agreed upon in preparing academically exemplary individuals while ensuring every graduate from Vocational College, especially from the Construction Technology course is equipped with job-ready skills to tackle real-life problems.

**Keywords:** Green technology, construction technology, TVET, vocational college, Fuzzy Delphi Method

## 1. Introduction

In the last decades, the growing pattern of global and local climate change identified with the rise of average temperature, sea level rise including warmer oceans and damaged corals, changes in rain and snow patterns, increased flood disasters, depleting natural resources, damages from deforestation, excessive carbon emission, more droughts and wildfires, changes in animal migration and life cycles, deforestation toxic and non-biodegradable waste due to human activities has become a common subject of discussion in global society of the planet more than desirably (Yaacob et al., 2022). It is now clear that environmental impact reduction is essential to achieve sustainable development for the planet as a whole and that resource waste and ecosystem degradation are accelerating the process of temperature rise. A substantial and expanding body of research has examined how these issues will harm not only the environment but also the socioeconomic growth (Yapin et al., 2017). Recent studies have focused on the financial burdens placed on the government, the residents of the affected regions, and the environment, infrastructure, and welfare (12th Malaysia Plan, 2021).

The country's ability to cover all costs alone raises serious concerns because there are superior ways to use the money. Numerous industries have been found to add to greenhouse emissions (GHG) by sector in 2020, including residential and commercial at 31%, industry at 30%, transportation at 20%, and agriculture at 11%. (IPCC, 2020). Top of the list is the

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residential and commercial sector, which adds up to 31% of greenhouse gas emissions (GHG), a worrying trend if respected governing bodies concerned do nothing. It also reveals fresh information about how 40% of the energy used to produce greenhouse gases (GHG) is consumed by buildings (Khan et al., 2021). According to recent data, buildings will emit 42.4 billion tonnes of carbon globally by 2035, up 43% from 2007. This raises concerns for the entire globe (Darko & Chan, 2016). Buildings will therefore significantly and practically contribute to lowering carbon pollution and lowering the negative effects of global warming. Additionally, buildings and construction materials are virtually indestructible and have long-lasting effects on society and the ecosystem (wangstudies & Shirowzhan, 2021; Bulut et al., 2020; Vidorni et al., 2019).

Although the environmental damage caused by buildings and the materials, they are made of has been the subject of extensive research recently because they use about one-third of the energy produced globally, there have been significant steps taken by the governing bodies to regulate policies for housing boards and developers in the nation. According to the OECD's report titled "Towards Green Growth," policymakers should adhere to the idea of green development. Therefore, prior research has provided strong support for the use of building assessment tools as an all-encompassing strategy and complete coverage to address environmental, social, and economic aspects using the most cutting-edge green technologies in a developed nation like Malaysia (Kamal et al., 2019). There are seven (7) rating tools that have been developed in Malaysia for the purpose of evaluating green building assessment tools: The Green Building Index (GBI), GreenRE (REHDA), Melaka Green Seal (Melaka), CIS20-GreenPASS (CIDB), Penarafan Hijau (PH-JKR), MyCREST (CIDB-JKR), and CASBEE Iskandar (IRDA-Japan) (Ong et al., 2019; CIDB, 2016). All of these tools, according to a summary, are intended to revolutionise greener building practises and are beginning to emerge in response to growing environmental awareness and concern, declining natural resource availability, rising energy prices, and rising demand for sustainability in building design and construction (Aliagha, 2013).

According to Azyyati's comparative study from 2017, although there are clear regulations for housing boards and developers to follow, such as green building assessment tools, it is far more important for contractors, employees, and especially site supervisors to be knowledgeable about greener technology practises because they are in charge of all the groundwork on construction sites. The knowledge includes the mindset, information, skills, and attitudes that a person needs to live in, work in, create, and support a sustainable and resource-efficient environment. Examples of such knowledge include how to use less energy and water, improve the quality of the indoor environment, choose smart materials, and consider how a building will affect its surroundings (Rajput et al., 2021; Azzyyati 2017). Green technology knowledge will benefit from improved energy efficiency practices, decreased building waste materials and effects on human health and the environment, and will be put into practice through better designs, operations, maintenance, and removals.

Although foreign employees perform 3D (Dirty, Dangerous, and Difficult) jobs on construction sites, site supervisors are in charge of supervising and assigning the tasks and responsibilities of a construction team, which is normally made up of construction workers and subcontractors. Furthermore, they also monitor projects' progress while ensuring that workers know and follow onsite health and safety regulations, ordering building supplies, scheduling equipment maintenance as needed and training new construction employees. Hirschmann (2022) estimates that 1,385,000 employees will be employed on construction sites in Malaysia in 2022, which is a sizeable number that demands attention. Additionally, the value of the building work completed in the fourth quarter of 2021 decreased by 12.9%, totalling RM27.6 billion (DOSM, 2022). This underlines once more how crucial the building sector is to a nation like Malaysia. Vocational College, a renowned TVET school and a gold mine for talent, has a big responsibility in creating skilled and semi-skilled workers for the country as the need for a large number of building site workers in this country will keep increasing year after year (Kaliappan & Hamid, 2021).

According to Kaliappan and Hamid (2022), vocational colleges are crucial because they produce 13.2% of the TVET grads in this nation. The readiness of vocational colleges to redesign their curricula to meet industry demands, such as the addition of green technology, has, however, raised some doubts (Kaliappan & Hamid, 2022). Green technology is viewed as an emerging idea with the primary objective of promoting sustainable development, which entails identifying environmentally friendly sources of growth, developing new environmentally friendly industries, and creating jobs and technologies by lowering environmental risks and ecological scarcities, pollution, and carbon emissions, improving energy and resource efficiency, and preventing the loss of biodiversity (Guo et al., 2020; Siti Ramlee Mustapha & Siti Shuhada, 2014). In a similar vein, Majumdar (2011) noted that people should be prepared for the workforce by having the knowledge, competencies, skills, values, and attitudes necessary to become productive, responsible citizens who respect the dignity of work and support sustainable communities. It is crucial for vocational colleges to instill green technology, particularly when it comes to construction technology, as their primary goal is for 70% of their graduates to work in the industry.

Therefore, it is essential that vocational colleges create their own Green Technology curricula that fully satisfies both the demands of the business and their Standard Curriculum for Vocational College (KSKV). On the other hand, green technology components for construction technology in vocational colleges should promote building responsiveness to sustainable growth and aid in decision-making (Nilashi et al., 2015). The students enrolled in construction technology will be able to get a better understanding of the current tendency in construction and be environmentally responsible with the help of pertinent and accurate elements. According to the United States Environmental Protection Agency (2016), a green building is one that is designed, constructed, operated, maintained, renovated, deconstructed, generates structures, and employs processes that are resource- and environmentally-conscious for the duration of the building's life. Overall, it appears that there is some evidence to suggest that the elements are chosen centre around the process in order for the construction workers to be able to connect it to their job scope and to minimise and eradicate the side effects of buildings on the environment.

The objective of this study is to investigate the Green Technology Elements for Construction Technology in Vocational College that is seen fundamental as these students will be responsible for environmental protection and conservation in the future. Moreover, the information obtained from this study will be insightful for policy-makers, environmental learning program designers and lecturers of Vocational Colleges and Vocational Technical Education and Training Division, Ministry of Education to be prepared for the future. The aim of this research project has therefore been to answer the following research questions:

i) What are the Green Technology Elements for Construction Technology in Vocational Colleges according to the panel of experts?
ii) How did the Green Technology Elements rank for Construction Technology in Vocational College by a panel of experts?

## 2. Methodology

The Fuzzy Delphi Method (FDM) applied in this study has followed the guidelines initiated by Murray, Pipino & Gigch (1985) and reviewed later by (Guttorp, Kaufman & Gupta, 1990). FDM is a combination of a fuzzy set theory, which is applied in traditional Delphi techniques. Overall, there are two main components in FDM, namely Triangular Fuzzy Number and Defuzzification Process. Triangular Fuzzy Number is classified into three values (m1, m2, m3): minimum value, most reasonable value, and maximum value. Meanwhile, defuzzification is a process of elements being ranked based on a priority based on the expert's agreement. Fuzzy Delphi Method has been used in this study to obtain expert consensus regarding a problem (Ridhuan & Nurulrabihah, 2020; Ridhuan, Saedah, Zaharah, Nurulrabihah, & Ariffin, 2017). Furthermore, it is also seen as a group communication process that is effective in allowing a group of individuals, as a whole, to deal with a complex problem (Linestone & Turoff, 1975). In addition, FDM has been selected as it has a rigorous process for an element to be accepted. In this situation, an element must meet three conditions to be accepted; (i) threshold value, $d \leq 0.2$, (ii) percentage of expert panels group consensus $\geq 75\%$ and; (iii) α-cut value $\geq 0.5$ (Ridhuan & Nurulrabihah, 2020). Hence, it is proven that, for an element to be selected it is requisite to meet all three conditions or will be rejected. Therefore, the researchers decided that the Fuzzy Delphi method is the best method to validate interview findings by using a panel of 20 experts in this study as it has high reliability as suggested by (Saedah, 2013). A qualitative interview was conducted in a much earlier phase of this study, and subsequently, the Fuzzy Delphi method is used to validate its findings. This section has attempted to provide a summary of the Fuzzy Delphi Method which is a technique frequently used for eliciting consensus from within a group of experts that has application in reliability and has many advantages over other methods of using panel decision-making (Yousuf, 2007; Helmer 1983).

## 2.1 Instrument

Traditionally, instruments have been formed based on the literature review, pilot studies, or experiences using FDM techniques Skulmoski, Hartman & Krahn, (2007), expert interviews, or nominal group techniques (Siraj, Abdullah, & Rozkee, 2020; Ridhuan & Nurulrabihah, 2020; Ridhuan, Saedah, Zaharah, Nurulrabihah, & Ariffin, 2017). Therefore, based on these suggestions, a set of questionnaires was formed based on expert interviews in the first phase of this study and has been published (Kaliappan & Hamid, 2021). Hence, a seven-point Likert questionnaire was prepared to answer the research questions stated at the beginning of this paper. A broader perspective has been adopted by Ridhuan & Nurulrabihah, (2020) and Finstad (2010), who agreed that seven-point Likert items have been shown to reduce fuzziness value that occurs at each agreement scale (3.3% of fuzziness in a seven-point Likert Scale compared to 20% of fuzziness in a five-point Likert Scale), to be more accurate, easier to use, and a better reflection of an expert’s true evaluation. To conclude this section, a panel of experts were asked to specify their level of agreement on Green Technology Elements for Construction Technology in Vocational College based on the 7-point Likert Scale ranging from completely agree to completely disagree. Henceforth, the data was translated to a Fuzzy scale and analysed using a fuzzy Delphi linguistic scale. All the elements of Green Technology for Construction Technology in Vocational Colleges are listed in Table 1.

**Table 1 - Elements of green technology for construction technology in vocational college**

| Elements of Green Technology for Construction Technology in Vocational College | | | |
|---|---|---|---|
| 1. | Introduction to Green Technology | 5. | Material and Resources |
| 2. | Energy Efficiency | 6. | Water Efficiency |
| 3. | Indoor Environmental Quality | 7. | Carbon Initiatives |
| 4. | Sustainable Site Planning and Management | 8. | Innovation |

## 2.2 Panel of Experts

The main strength of this study is the inclusion of 20 experts who have good and in-depth knowledge as well as are directly involved in the areas studied. Thus, sampling in Delphi-based techniques cannot be obtained statistically as it requires the experts' preliminary identification made by the researchers (Adler & Ziglio, 1996). Once the experts have been acknowledged, ethical approval was obtained from all 20 experts before they were to be involved in the study. Although the current study is based on a small sample of experts, the findings are in line with recommendations made by Jones and Twiss (1978) who suggested the use of 10 to 50 experts, Sekaran (2003) recommended 7 to 100 experts, Ludwig (1997) and Delbecq, Van de Ven, & Gustafson (1975) proposed 10 to 20 experts. Hence, the researcher chose a 20-person expert panel as it not small enough and not be able to provide feedback on an issue that has been identified as demanded by Ludwig (1997) and Delbecq, Van de Ven, & Gustafson (1975) meanwhile not involving a large number of expert panels as it will make it more difficult and often reflect negative implications while performing fieldwork (Linstone & Turoff, 1975).

Notwithstanding these limitations, the researchers do not involve more experts as inexperienced experts can weaken the accuracy of the results (Saaty & Özdemir, 2014). Therefore, the researchers have set criteria to select experts for this study. The study has gone some way towards partaking with experts to have background or experience in the field related to the study being conducted to reach a consensus among experts (Pill, 1971). Thus, primary inclusion criteria for the experts were based on; (i) knowledge of the field studied (Swanson & Holton, 2009; Delbecq, Van de Ven, & Gustafson, 1975) ie at least to have a Bachelor's Degree; (ii) experience in the field studied for at least five years (Hsu & Sandford, 2007; Berliner, 2004a); (iii) involving a combination of experts with various expertise from a heterogeneous group (Somerville, 2007); (iv) 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 (Nurulrabihah et al., 2020). The panel of experts selected is stated in table 2 below.

**Table 2 - Panel of experts**

| | Expert's Position | Institution |
|---|---|---|
| 1. | Head of Department | Department of Civil Engineering Technology<br>Vocational College |
| 2. | Head of Program for Construction Technology | Department of Civil Engineering Technology<br>Vocational College |
| 3. | Vocational Training Officer (Ts) | Vocational Engineering Technology (Green Building)<br>Kolej Kemahiran Tinggi Mara |
| 4. | Head of Department (Ts) | Department of Civil Engineering Technology<br>Vocational College |
| 5. | Vocational Training Officer (Ts) | Vocational Engineering Technology (Green Building)<br>Kolej Kemahiran Tinggi Mara |
| 6. | Trainer for Construction Technology | Department of Civil Engineering Technology<br>Vocational College |
| 7. | Senior Engineer (PhD) | Environment and Energy Efficiency Branch (CASKT)<br>Public Works Department |
| 8. | Assistant Director (Ts) | Malaysian Vocational Diploma Assessment and Evaluation Unit<br>Technical Vocational Education and Training Division, Ministry of Education |
| 9. | Manager | Centre for Advance Construction Technology and Innovation (CACTI-I)<br>Construction Research Institute of Malaysia (CREAM) |
| 10. | Senior Manager | Construction Technology & Innovation Division<br>Monitoring & Coordination of Operations Unit<br>Construction Industry Development Board (CIDB) |
| 11. | Assistant Director (Ts) | Vocational Curriculum Development Unit<br>Technical Vocational Education and Training Division, Ministry of Education |
| 12. | Senior Lecturer (Ir, PhD) | Department of Architecture<br>Faculty of Civil Engineering and Built Environment<br>Universiti Tun Hussein Onn Malaysia |
| 13. | Senior Assistant Director | Curriculum Management Unit<br>Department of Skills Development |
| 14. | Lecturer (Ts, PhD) | Faculty of Civil Engineering Technology |

| | | |
|---|---|---|
| 15. | Head of Researcher (PhD) | Universiti Malaysia Pahang<br>Centre for Education and Training in Renewable Energy, Energy Efficiency & Green Technology (CETREE) |
| 16. | Deputy Director (Ts, PhD) | Technology and Technical Accreditation Secretariat (TTAS)<br>Malaysia Board of Technologists (MBOT) |
| 17. | Senior Lecturer (PhD) | Department of Civil Engineering Technology<br>Universiti Malaysia Perlis |
| 18. | Director (Associate Professor, PhD) | Centre for Education and Training in Renewable Energy, Energy Efficiency & Green Technology (CETREE) |
| 19. | Senior Executive Assistant | Building and Facilities<br>Talent Development and Administration<br>Malaysian Green Technology and Climate Change Centre (MGTC) |
| 20. | Lecturer (PhD) | Civil Engineering Department<br>Politeknik Port Dickson |

*Qualification(s): (i) Ts: Technologists; (ii) PhD: Doctor of Philosophy; (iii) Ir: Professional Engineer

## 2.3 Data Analysis

In most recent studies, Fuzzy Delphi findings has been analysed using Excel according to the steps suggested by (Chang, Huang, & Lin, 2000; Ridhuan et al., 2017). The steps are as follows:

Step 1: Assume that an expert 'K' is invited to determine the importance of the evaluation criteria for the variables to be measured using linguistic variables as in Table 3.

**Table 3 - Level of agreement scale**

| Linguistic Variable | Triangular Fuzzy Numbers | | | Likert Scale |
|---|---|---|---|---|
| | m1 | m2 | m3 | |
| Completely Agree | 0.9 | 1.0 | 1.0 | 7 |
| Mostly Agree | 0.7 | 0.9 | 1.0 | 6 |
| Agree | 0.5 | 0.7 | 0.9 | 5 |
| Somewhat Agree | 0.3 | 0.5 | 0.7 | 4 |
| Disagree | 0.1 | 0.3 | 0.5 | 3 |
| Mostly Disagree | 0.0 | 0.1 | 0.3 | 2 |
| Completely Disagree | 0.0 | 0.0 | 0.1 | 1 |

Step 2: As recommended in Table 2, transform each linguistic variable into a triangular fuzzy number. Based on the values of m1 (0.9 = probable 90% fully agree), m2 (1.0 = likely 100% completely agree), and m3 (1.0 = likely 100% absolutely agree), the selected value in the instrument scale was converted to the fuzzy scale as shown in Table 3. (Hassan, Ibrahim & Yaakob, 2018). In other words, the level of agreement and accuracy of the data obtained increases with increasing Fuzzy scale selection. Next, assume that the fuzzy number is a variable for each criterion for an expert to

$i = 1, \ldots, m, j = 1, \ldots, n, k = 1, \ldots, K.$ and $\tilde{r}_{ij} = \frac{1}{K}[\tilde{r}_{ij}^{1} \oplus \tilde{r}_{ij}^{2} \oplus \cdots \oplus \tilde{r}_{ij}^{K}]$

Step 3: To determine the separation between $\tilde{r}_{ij}$ and $\tilde{r}_{ij}^{k}$, each expert employs the vertex approach (Chen, 2000). The requirement is that the threshold value obtained, d (m, n), must be less than or equal to the value of 0.2. (Cheng & Lin, 2002). The formula below is used to determine the distance between two fuzzy numbers, also known as the threshold value. The d value is the threshold value according to the formula. The threshold value, expert consensus %, defuzzification, and item ranking are then determined by tabulating the data to determine the fuzzy value (n1, n2, n3) as well as the average fuzzy value represented by (m1 - the minimum value, m2 - reasonable value, and m3 - maximum value).

$$d(m,n) = \sqrt{\frac{1}{3}[(m_1 - n_2)^2 + (m_2 - n_2)^2 + (m_3 - n_3)^2]}$$

Step 4: The percentage of expert panels group consensus should exceed 75% as stated by (Chu & Hwang, 2008; Murry & Hammons, 2017). This is because the Fuzzy Delphi technique involves the process of determining expert agreement whether it is greater than or equal to 75% for the entire construct or for each item. Each item is assumed to reach expert consensus if the percentage of expert agreement for the item is equal to or greater than 75%.

Step 5: Fuzzy evaluation aggregate is done with:

$$\tilde{A} = \begin{bmatrix}\tilde{A}_1 \\ \tilde{A}_2 \\ \vdots \\ \tilde{A}_m\end{bmatrix} \qquad \tilde{A}_i = \tilde{r}_{i1} \otimes \tilde{w}_1 \oplus \tilde{r}_{i2} \otimes \tilde{w}_2 \oplus \cdots \oplus \tilde{r}_{in} \otimes \tilde{w}_n,$$
$$i = 1, \cdots, m$$

Step 6: For each alternative option, the fuzzy evaluation is defuzzification with the formula shown below and as in Table 4. Alternative order of ranking options can be determined by value. The condition that must be followed for the acceptance of the expert agreement is that the α - cut value obtained must be equal to or exceed 0.5 (Bodjanova, 2006; Tang & Wu, 2010). If the resulting A value is less than the α-cut value (median value for '0' and '1') = 0.5, the item will be rejected because it shows expert agreement in rejecting the item, but if the resulting A value exceeds the α-cut value = 0.5, the item will be accepted because it shows expert consensus to accept the item.

**Table 4 - Expert detailed agreement based on defuzzification value**

| DEFUZZIFICATION VALUE | EXPERT CONSENSUS |
|---|---|
| 46.8 | Expert consensus strongly agrees |
| 42.0 | Expert consensus mostly agrees |
| 33.6 | Expert consensus agrees |
| 24 | Expert consensus somewhat agrees |
| 14.4 | Expert consensus slightly disagrees |
| 6 | Expert consensus disagrees |
| 1.2 | Expert consensus strongly disagrees |

## 3. Findings

The experts, overall, demonstrated all eight elements specifically Carbon Initiatives, Indoor Environmental Quality, Material and Resources, Innovation, Sustainable Site Planning and Management, Water Efficiency Energy Efficiency and Introduction to Green Technology reached a group consensus. The list of accepted elements based on the results of the analysis according to expert consensus can be referred to in Table 5. Therefore, the first research question has been answered. Together this result provides important insights into the defuzzification process which serves to determine the position of an element based on expert consensus. The translated defuzzification value in Table 5 also complies with the next condition where the α -cut value obtained must be equal to or exceed 0.5 (Bodjanova, 2006; Tang & Wu, 2010). The results of the analysis carried out show that all eight elements were accepted by experts.

It is also apparent from Table 4 that the researchers identified Carbon Initiatives as the element being ranked first with the defuzzification score value of 0.910. Next, Indoor Environmental Quality, Material & Resources and Innovation are the elements ranked second with a defuzzification score value of 0.890. The next element is Sustainable Site Planning and Management with a defuzzification score value of 0.873. Then, the next element is Water Efficiency with a defuzzification score value of 0.842. After that, the element of Energy Efficiency is ranked seventh with a defuzzification score value of 0.840. Finally, the element of Introduction to Green Technology is ranked last with a defuzzification score value of 0.837. Together these results provide important insights into the ranking of the Green Technology Elements for Construction Technology in Vocational Colleges and therefore the second research question. has been answered.

**Table 5 - Elements of green technology using Fuzzy Delphi Analysis (FDM)**

| | Elements | Triangular Fuzzy Numbers | | Defuzzification Process | | | | Expert Consensus | Ranking |
|---|---|---|---|---|---|---|---|---|---|
| | | Threshold Value, d | Percentage of Expert Group Agreement (≥75%) | m1 | m2 | m3 | Fuzzy Score (A) | | |
| 1. | Introduction to Green Technology | 0.187 | 85% | 0.700 | 0.865 | 0.945 | 0.837 | Accepted | 8 |
| 2. | Energy Efficiency | 0.198 | 85% | 0.710 | 0.865 | 0.945 | 0.840 | Accepted | 7 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 3. | Indoor Environmental Quality | 0.094 | 90% | 0.760 | 0.920 | 0.990 | 0.890 | Accepted | 2 |
| 4. | Sustainable Site Planning and Management | 0.146 | 80% | 0.750 | 0.900 | 0.970 | 0.873 | Accepted | 5 |
| 5. | Material and Resources | 0.118 | 90% | 0.770 | 0.920 | 0.980 | 0.890 | Accepted | 2 |
| 6. | Water Efficiency | 0.190 | 85% | 0.710 | 0.870 | 0.945 | 0.842 | Accepted | 6 |
| 7. | Carbon Initiatives | 0.103 | 90% | 0.800 | 0.940 | 0.990 | 0.910 | Accepted | 1 |
| 8. | Innovation | 0.118 | 90% | 0.770 | 0.920 | 0.980 | 0.890 | Accepted | 2 |

## 4. Discussion

The most obvious finding to emerge from the analysis is that all 8 elements of green technology for construction technology in vocational colleges were accepted by 20 panels of experts using the Fuzzy Delphi method. The elements include (i) Carbon Initiatives, (ii) Indoor Environmental Quality, (iii) Material and Resources, (iv) Innovation, (v) Sustainable Site Planning and Management, (vi) Water Efficiency, Energy Efficiency and; (viii) Introduction to Green Technology altogether reached expert consensus. This result is somewhat comparable to the findings of (Adam et al., 2018; Busono et al., 2021; Cole, 2019; Goldman et al., 2018; Zangori & Cole, 2019; Zelin & Support, 2016). Together these results provide important insights into the elements of Green Technology for Construction Technology in Vocational Colleges in Malaysia. Taken together, this result suggests that there is an association between Green Technology elements for Construction Technology for Vocational Colleges and Green Buildings as all the elements accepted were also listed in Green Building Assessment Tool elements in Malaysia such as Green Building Index (GBI), *Penarafan Hijau* (PH-JKR) and MyCREST (CIDB-JKR). A common concrete reason that emerged from this is such elements build upon a visionary perspective to contribute to personal and academic exemplary individuals while ensuring every graduate is equipped with job-ready skills to tackle real-life problems (Tasdemir & Gazo, 2020).

These initial results are suggestive of a link between knowledge and reality which is vital to enable students from Vocational College to infuse green technology in a way that enables them to gain the knowledge, skills and aptitudes to become sustainably minded citizens; to understand the complex sustainability issues and challenges facing the human society at local and global levels; and to enable to take actions to seek solutions to the numerous sustainability challenges they will face in their local communities and in their working lives (Besong, 2017). This was greatly discussed in The Green Curriculum Model by (Besong, 2017) that the degree of embedding green technology within the curriculum could then be measured using the green technology indicators or tools which are a reflection of how well the curriculum design encompasses the different elements of the green curriculum. These results furthermore have important implications to imbue students with the critical understanding of eight Green Technology elements education principles and processes that weave together the green technology-related content and principles to create more transformational learning experiences.

A further study with more focus on Green Technology has therefore been suggested by (Edling & Loring, 1996) through Integrated System for Workforce Education Curricula with Green Technology (ISWECGT) Model. This model made a point of including more information about the pedagogical benefits of integration, such as how students learn by making connections, how they can apply their knowledge and skills to novel and unfamiliar situations, how duplication of educational effort is reduced, and how commonalities between academic disciplines and labour market demands are identified. Green Technology is more clearly understood to be the comprehensive integrated framework in which three kinds of standards are located: academic, workforce, and employability. Further study confirmed that students in Vocational College must be inculcated with the context of learning content in Green Technology related to the real workforce in their secondary and moreover in their tertiary education as they are enrolled for Malaysia Vocational Certificate and Malaysia Vocational Diploma level (Saibani et al., 2012). In addition, this is also well supported by (Tasdemir & Gazo, 2020) to include the most influential elements and more real-life oriented elements across all disciplines by establishing connections with industry and other institutions to be able to satisfy the demand for a competent workforce.

The results of this study indicate that the elements agreed upon are vital for students from Vocational College as they would be able to make conscious decisions while constructing, operating, and dismantling buildings that will enormously benefit a move in the workforce and sustainable development (Khan et al., 2021). As mentioned from the results gained, it can be seen that by far the greatest demand is for Carbon Initiatives as it was ranked first by experts' consensus in the list of elements. It can thus be suggested that buildings have been widely recognized as one of the key sectors that contribute more than 40 per cent of total energy use and 20 to 40 percent of greenhouse gas (GHG) emissions and therefore this has prompted the establishment of Carbon Initiatives as a Green Technology element for Construction

Technology in Vocational Colleges (Fadhlin Abdullah & Abdullah, 2017). This observation may support the hypothesis that energy consumption and carbon emissions occur in all stages of a building life cycle hence there is a need to raise awareness and facilitate the global transition towards low-emission, energy-efficient buildings among the students of Vocational Colleges so that they will understand the impact towards nature while they are in the workforce. It can therefore be assumed that the lack of understanding regarding Carbon Initiatives will hamper the comprehensive basis of carbon reduction.

Therefore, if we do not address the urgent requirement of the economy and industry for a highly qualified skilled labour force, these findings add to a growing necessity on inculcating elements of green technology in Vocational Colleges. The gap between the competency profiles of graduates from vocational colleges and the competencies qualifications required by industry in various areas would expand if this scenario is not rectified immediately by taking effective action. Hence, vocational colleges now have the responsibility to implement the reforms deemed essential to integrate green technology into their curriculum and make it even more industry driven.

## 5. Conclusion

Together, these findings point to a significant relationship between TVET educational institutions and industry. The economy and technology are evolving quickly in the twenty-first century, which has an impact on how society functions and how people live. From this point forward, TVET must be able to anticipate and respond appropriately by providing pertinent courses, a suitable curriculum, and innovative approaches to teaching, learning, and evaluating students in relation to green technology, which is seen as an emerging concept with the primary goal of achieving sustainable development by lowering environmental risks, ecological scarcities, pollution, and carbon emissions, improving energy and resource efficiency, and preventing the loss of biodiversity. Given that vocational colleges offer courses in construction technology at both the certificate and diploma levels, it is crucial for the institution to seek revolution by incorporating elements of green technology because there is data to support the damage that buildings and constructions have done to the environment. As a result, it is anticipated that this study will make a significant contribution to the body of knowledge regarding TVET Institutions, particularly Vocational Colleges and Construction Technology. Together, these findings offer crucial information about how to aid vocational college students to develop the skills and self-assurance necessary for future employment, ensuring a beneficial influence on global sustainability issues after graduation. This study is anticipated to serve as a preliminary step for others intending to create similar curricula or courses for TVET institutions.

## 6. Implications

Education in TVET institutions should focus more of existing development and on the expansion of skills, knowledge, values, and sustainability-related perception. This entire process is to develop a bridge between TVET institutions and industries to assist students to create skills, knowledge, and attitudes in combating the growing pattern of global and local climate change. To develop a full picture, education has a larger impact on the mindset of our students as this is where we're teaching the next generation of consumers how to care for the planet we depend on for survival.

## 7. Future Recommendations

The findings from this study found Green Technology elements for Construction Technology in Vocational Colleges as suggested by a panel of experts. Further research is needed to confirm, establish and validate these findings for researchers to develop a relevant structured framework to fulfil the need of the industry regarding Green Technology. Therefore, the researchers will come up with a subsequent study, a curriculum framework that is intended to be the bridge between the Vocational Colleges and the industry to produce knowledgeable workers regarding Green Technology.

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