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# Assimilating Green Skills in Building Construction Programme: Crucial to Realizing Environmental Sustainability

SAMAILA HAMZA<sup>1</sup>, AEDE HATIB BIN MUSTA'AMAL @ JAMAL<sup>2</sup>, YUSRI BIN KAMIN<sup>1,2</sup>, WALEED MUGAHEH AL-RAHMI<sup>2</sup>, AZLINA KOSNIN<sup>2</sup>, MUHAMMAD SUKRI SAUD<sup>2</sup>, NORNAZIRA SUHAIROM<sup>2</sup>, NORAFFANDY YAHYA<sup>2</sup>, AND MOHD SAFARIN NORDIN<sup>2</sup>

<sup>1</sup>Faculty of Technology Education, Abubakar Tafawa Balewa University, Bauchi 740272, Nigeria

<sup>2</sup>School of Education, Faculty of Social Sciences and Humanities, Universiti Teknologi Malaysia, Johor Bahru 81310, Malaysia

Corresponding author: Samaila Hamza (abdulhamidibrahim84@gmail.com)

**ABSTRACT** Greening of any curriculum through the infusion of green skills is needed in the construction sector. This study identified important green skill areas in relation to building energy efficiency that are suitable for inclusion in the Building Construction Programme (BCP) at universities for the attainment of environmental sustainability. A questionnaire was used with 308 respondents. Data analyses were carried out using Descriptive Statistics, Exploratory Factor Analysis (EFA), and Confirmatory Factor Analysis (CFA). The supremacy of the identified energy efficiency skills over the non-energy efficiency skills is confirmed as its integration into BCP helps in realising environmental sustainability. Findings include the important areas to be included into the building construction programme curriculum. Findings can be used by the government for the adoption and practical implementation of these findings.

**INDEX TERMS** Curriculum, building construction, energy efficiency, environmental sustainability, greening, green skills.

## I. INTRODUCTION

The (physical) environment is an important sustainability dimension. If the environmental problems are unresolved, the social and economic dimensions cannot be improved because they are dependent on the environment. Activities conducted particularly in the construction sector is one factor that can lead to environmental hazard. [11] described that the erection, maintenance, and life cycle of construction projects cause pollution and have unintended effects on the environment.

Environmental sustainability or sustainable development is the ability of the environment to support an indefinite natural resource extraction rate while maintaining environmental qualities. [4] notes that environmental sustainability activities focus on the potential impact of resource usage, hazardous substances, waste, and emissions on the physical environment. Reference [5] noted that this aspect of sustainability focuses on the effects of development activities on living and non-living natural systems and their effectiveness

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can be assessed in terms of the inputs (materials, energy, and water) and results (emissions, discharges, and waste) of development processes [6]. At the same time, environmental effects which have caused ecological problems due to climate change, require constant and immediate attention across the world to preserve the environment for the next generation.

Reference [3] suggests that it is possible to find a medium that generates sufficient economic growth and sufficient environmental protection as humanity has the capacity to implement sustainable development by meeting present needs without compromising the ability of future generations to meet their needs. The Australian Green Skills Agreement views green skills as the technical skills, knowledge, values, and attitudes needed by the workforce to develop and support sustainable social, economic and environmental outcomes in business, industry, and the community [2]. According to [1], green skills can decrease negative environmental impacts and support economic reformations that address climate change and create effective economies which can eventually achieve environmental sustainability and decent working conditions.

Following an agreement on green economies by world leaders during Rio+ in June 2012, [10] reported that the world was ready to adopt green economies to achieve sustainable development, eliminate poverty and inequality, and create jobs. Aware of the importance of green practices to combat the world economic and ecological problems, many countries have begun moving towards a greener economy by infusing green skills into various occupations.

Reference [8] suggests that environmental sustainability could be instilled among workers through education, particularly by inserting the element of green skills in engineering programmes' curriculum. Green skills have been taught in various educational institutions either as new courses or by being added into the existing courses. Reference [8] supported the feasibility of sustainability integration into existing courses while maintaining the original technical content. Such integration can be done by connecting tangible examples of environmental sustainability with the overall concepts. An awareness of environmental sustainability improves student environmental knowledge.

This study focuses on the assimilation of green skills into the Building Construction Programme (BCP) curriculum as part of the initiatives to achieve environmental sustainability in Nigeria. Specifically, the study aims to identify the energy efficiency skills to be integrated into the BCP curriculum. The findings could pave way for the preparation of the Nigerian workforce towards a more sustainable development.

## II. LITERATURE REVIEW

### A. ENERGY EFFICIENCY IN BUILDING CONSTRUCTION

In the climate change debate, according to [13], reduced building energy consumption has been identified as one of the main ways to tackle the problem on environmental sustainability. Energy consumption is an important source of CO<sub>2</sub> emissions from the consumption of fossil fuels. Energy consumption is regarded as the root cause of CO<sub>2</sub> emissions that create environmental problems. Reference [14] noted that energy consumption has been labeled as a major source of CO<sub>2</sub> emissions, particularly fossil fuel consumption. Reference [14] further pointed out the ability to use computer simulation software to predict building energy and carbon performance to minimize energy consumption and reduce CO<sub>2</sub> emissions, as well as the ability to calculate and measure carbon emissions and integrate passive and active energy designs to enhance building energy efficiency. Reference [15] showed that the residential and commercial energy usage of buildings is gradually increasing over time in the manufacturing and transportation sectors. Energy use in both residential and commercial buildings in the United States accounted for 40% of total energy consumption. To this end, [16] indicated that sustainable construction is being accepted in courses, as energy prices and health/safety issues as driven energy efficient and 'green' practices in the construction sector.

With regards to the above development [2] in Green Skills Australia (GSA) pointed out that to bridge important gaps

in energy efficiency, maintainable painting, and the execution of workplace projects, Sustainability Victoria focused on courses in green skills. To address the energy efficiency gap according to Adult and Experiential Learning (CAEL), [17] evaluated home energy efficiency and home design to communicate the value of their proposed work to homeowners/clients as well as to perform the recommended activities to measure their effectiveness. In encouraging energy efficiency in building construction, [18] demonstrated that green economy jobs require various skills, educations, and occupational profiles from engineering, architecture, and construction programs. Considering the importance of energy efficiency to achieving sustainability, [19] pointed out that energy availability, economic growth, and sustainable development goes hand in hand so that solutions to energy supply constraints should use prospective energy mixes that are environmentally friendly, sustainable, and efficient. Energy is important to every socio-economic endeavor, such as construction, that accumulates wealth and requires energy for its survival/development. Reference [20] posited that the impact of anthropogenic on the environment, increased climate change, allowing for unprecedented changes in the frequency of extreme events. Supporting the above assertion, [21] propound that "*energy-efficient high-performance buildings demand a synthesis of architectural design, construction methods, and energy systems*", which implies a need for green skills for energy efficiency in BCP. In line with the above, Manufacturing Skills Australia [4] demonstrated that energy is a significant cost for most businesses and energy efficiency skills are essential for all site workers as they provide a framework for the skills, knowledge, and performance required to achieve specific energy efficiency workplace outcomes. The auditing of energy usage for a work area includes: auditing the energy efficiency of a work or process area; assisting in a "gate to gate" site-wide or "door to door" audit in a department or process area; and identifying a range of sustainability issues and environmental sensitivities in a work or process area. Energy and waste use data were acquired by ranking waste in equipment and processes, comparing waste to external targets, identifying the root cause of waste, and proposing a range of solutions and strategies to improve energy efficiency. (Asia-Pacific Education Research Institutes Network (ERI-Net) [22].

The above requires a detailed understanding of renewable and conventional (fossil and nuclear) energy resources, the infrastructure and networks that transform and transport energy resources to consumers, as well as the technical, economic, social, and institutional factors needed to manage and transition current energy systems toward energy efficiency and sustainability [23] Batterman *et al.* [23] stressed that, as presently understood, most green energy efficiency jobs need high levels of expertise and therefore, colleges have the challenge of preparing low-income individuals with technical skill for higher level positions. Green building skills are needed in all construction operations and services, ranging from site meetings to the completion of a building.

With reference to services and operations in building construction, [24] noted that some occupations are more challenging to organize for low-skilled workforces as the gap between basic green jobs, such as manual work for solar installation, to more technical work such as the installation of lighting systems is wide. For example, energy efficiency technicians must possess strong conceptual and analytical thinking skills to comprehend the functioning of complex energy and air systems in homes and buildings. To identify green energy efficiency construction skills, Manufacturing Skills Australia [4] recommended that all construction companies include the ability to acquire and analyze data as well as the ability to apply mass balancing, energy balancing, and combined mass and energy balancing to calculate resource/energy loss. Other skills are needed to determine calculation boundaries, such as as the selection mass or energy balancing on a per process basis; the identification of processes that are not energy efficient, and the provision of recommendations on how to improve energy efficiency over the short and long-term [4].

To explain the rationale for energy efficiency skills in the construction industry, [25] pointed out that frequently, greenhouse gas emissions are produced during processing and waste removal which generates pollution. As energy and the environment remain the main concerns of producers and consumers despite the economic recession, energy efficiency and ecologically friendly practices are of great importance. For example, [11] noted that for sustainable construction practices, the Malaysian government via the Tenth Malaysian Plan (2011e2015) stresses the simplification of the affordable housing delivery system, the delivery of high quality and environmentally sustainable buildings, and the cultivation of healthy and sustainable building practices. In essence, there is a need to infuse green skills that involve energy efficiency skills in the BCP curriculum.

### B. RESEARCH QUESTION AND HYPOTHESIS

This study answers the following questions and tested the following research hypothesis.

#### 1) RESEARCH QUESTION

RQ1: What are important green energy efficiency skills in construction that are appropriate for inclusion into Building Construction Programme for the attainment of environmental sustainability in Nigeria?

RQ2: What is the relationship between data samples and important green energy efficiency skills for construction that are considered suitable for integration in Building Construction Programme?

#### 2) HYPOTHESIS

H: There is a significant relationship between the research data samples and important green energy efficiency skills in construction that are considered appropriate for integration in BCP.

### III. RESEARCH METHODOLOGY

This section discusses the following sub-headings.

#### A. PARTICIPANTS (POPULATION) FOR THIS STUDY

This study had two groups of respondents, professionals in the construction industry and university teachers in Nigeria. The target population of this study was 308, of which 214 were BCP teachers and 94 were building construction professionals. Since the population was manageable no sampling was carried out in this study.

#### B. DATA COLLECTION

Data collection is a vital feature of any educational study. The reason data gathering was conducted was its usefulness in allowing for a full range of data collection possibilities, its organization of methods by their predetermined nature, and its focus on numeric versus non-numeric data analysis [26]. In this study, a structured questionnaire was used to seek respondent opinions. Quantitative data collection methods aid researchers in collecting data about diverse research phenomenon aspects from numerous respondents. The structured questionnaire was developed after an intensive literature review in line with the specific objectives of this study. Subsequently, the 12-item structured questionnaire was the same for both respondent groups. It consisted of two main sections, "A" and "B". Section A solicited information on demographic characteristics while section B consisted of 12 items on important green energy efficiency construction skills for infusion into BCP in universities for the attainment of environmental sustainability.

### IV. DATA ANALYSIS AND FINDINGS

In determining the research results, suitable techniques and statistical tools were used for data analysis. Data acquired by this study was analyzed using descriptive statistics such as mean and standard deviation, Exploratory Factor Analysis (EFA), inferential statistics, Confirmatory Factor Analysis (CFA), and Structural Equation Modelling (SEM) with the help of IBM-SPSS version 21 and IBM-SPSS-AMOS (Analysis of Moment of Structures) version 18 statistical software packages (SPSS, 2011). EFA was applied (using 136 respondents out of 308) to identify important green skills involving energy efficiency by exploring and summarizing the underlying correlational structures of collected data using 12 questionnaire items [27]. CFA was carried out (using the remaining 172 respondents) to test the correlational structure of the data sets against the hypothesized structures and to rate the goodness of fit of the analyzed data.

Additionally, quantitative validity checks instrument accuracy using certain procedures [28]. The instrument (12-item questionnaire) was validated by three experts in the department of Industrial and Technology Education, Abubakar Tafawa Balewa University Bauchi, Nigeria. Each expert was given a copy of the questionnaire to determine if it evaluated what it intended to evaluate. The objectives and research

questions of this study were also provided and experts were asked to suggest changes in question structure and suitability. Validator suggestions were further included in the final draft of the questionnaire. When testing Cronbach’s alpha during reliability analysis, SPSS version 23 was used to analyze responses to the 12-item questionnaire. According to Nunnally and Bernstein [29], in research of this nature, Cronbach’s Alpha coefficient scores greater than 0.70 are sufficiently reliable for questionnaires [30], [31]. To make the questionnaire sufficiently reliable, under each of the 11 constructs, three items were deleted from each construct due to low Cronbach’s Alpha coefficient values. Table 3.3 and 3.4 presents the analyzed data, with overall Cronbach’s Alpha coefficient scores of 0.785, which is greater than 0.7.

**A. EXPLORATORY FACTOR ANALYSIS OF GREEN SKILLS INVOLVING ENERGY EFFICIENCY SKILLS**

RQ1: What are important green energy efficiency skills in construction that are appropriate for inclusion into BCP for the attainment of environmental sustainability in Nigeria?

Table 1 shows the EFA results for green energy efficiency skills, including estimates for ENF1 to ENF12. The value for KMO was .774, which exceeded the factor analysis validity threshold value of 0.500 recommended by [32], [33]. This cut-off value was supported by Bartlett’s Sphericity test, which is significant at 0.000, establishing that the results were significant (see Table 1). Additionally, the inter-item correlation of all the 12 energy efficiency skill items were greater than 0.3 except for ENF4 and ENF6, which shows a relationship between the remaining 10 variables.

**TABLE 1. Sampling adequacy for green energy efficiency skills (KMO).**

KMO and Bartlett's Test		
KMO (MSA)		0.774
Bartlett's Test of Sphericity	ACS	1021.404
	df	66
	Sig.	0.000

More so, Table 2 indicated that Measures of Sampling Adequacy (MSA) justified the KMO value of as all AIs anti-image correlation diagonal values were greater than 0.5.

Upon re-examination, the contents of ENF4 (“Identify ways to improve energy efficiency in the short and long-term in a building”) and ENF6 (“Apply the techniques of energy balancing to calculate energy loss in a building.”) were not included in EFA. The results of this test signified that the sample was adequate for EFA as its assumptions were considerably met [34]. Table 3 indicates that there were two components with initial eigenvalues greater than 1. These components collectively accounted for 70.088% of variable variation, which is greater than the minimum accepted variance of 60% recommended by [35]. This suggests that only two extracted factors had associative relationships. Similarly, the Extraction and Rotation Sums of Squared Loadings was

**TABLE 2. Sampling adequacy for green energy efficiency skills (Anti-image).**

Item	Anti-image	
	Als	Corr. Diagonal
ENF1		0.848 <sup>a</sup>
ENF2		0.715 <sup>a</sup>
ENF3		0.793 <sup>a</sup>
ENF4		0.570 <sup>a</sup>
ENF5		0.711 <sup>a</sup>
ENF6		0.609 <sup>a</sup>
ENF7		0.783 <sup>a</sup>
ENF8		0.751 <sup>a</sup>
ENF9		0.810 <sup>a</sup>
ENF10		0.867 <sup>a</sup>
ENF11		0.838 <sup>a</sup>
ENF12		0.762 <sup>a</sup>

also equal to 70.088%. Hence, the variation explained by the initial solution was because of latent factors, which implied the suitability of the extraction method.

Table 4 presents the variance observed for every item against other green skill items. All values were above 0.4, excluding ENF9 and ENF10, which signifies that the extraction communalities obtained through principal component analysis were satisfactory. Upon re-examination the content of ENF9 (“Quantify the carbon footprint in each process step in CO2 equivalent tonnes.”); and ENF10 (“Identify and shortlist the sustainability issues in the work site”) were excluded from EFA. For factor analysis, all 8 remaining items for energy efficiency skills (ENEFSKILL) were loaded into two factors.

From Table 5, Factor 1 consisted of five items, which were ENF5 (“Identify ways to improve energy efficiency in the short and long-term in a building.”), ENF7 (“Evaluate the sustainability impact of a worksite to identify the sustainability issues for the steps within a selected process.”), ENF11 (“apply the principles of sustainability and issues such as climate change.”), ENF3 (“eliminate or reduce resource loss to improve energy efficiency.”), and ENF8 (“Determine energy usage by defining boundaries for an energy audit for all or part of a building.”). Factor 2 consisted of three items, \ which were ENF1 (“use mathematics and process data to identify the energy-intensive steps of a construction process.”), ENF12 (“analyse and evaluate sustainability risks using root cause analysis.”), and ENF2 (“select of energy balancing for the building being examined.”).

**B. MEASUREMENT MODEL OF GREEN SKILLS FOR ENERGY EFFICIENCY IN BUILDINGS**

RQ2: What is the relationship between data samples and important green energy efficiency skills for construction that are considered suitable for integration in BCP?

TABLE 3. Total variance for green energy efficiency skills.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.228	52.850	52.850	4.228	52.850	52.850	3.670	45.875	45.875
2	1.379	17.238	70.088	1.379	17.238	70.088	1.937	24.213	70.008
3	.783	9.788	79.876						
4	.589	7.363	87.239						
5	.543	6.788	94.027						
6	.256	3.200	97.227						
7	.129	1.613	98.840						
8	.093	1.160	100.000						

TABLE 4. Total communalities and rotated component matrixes for green energy efficiency skills in construction.

Communalities		
Item	Initial	Extr.
ENF1	1.000	.471
ENF2	1.000	.699
ENF3	1.000	.661
ENF4	1.000	.886
ENF5	1.000	.562
ENF6	1.000	.823
ENF7	1.000	.431
ENF8	1.000	.784
ENF9	1.000	.396
ENF10	1.000	.380
ENF11	1.000	.640
ENF12	1.000	.457

H: There is a significant relationship between the research data samples and important green energy efficiency skills in construction that are considered appropriate for integration in BCP.

This data analysis section tested the measurement model for green energy efficiency skills, which addressed research question 2 and tested the hypothesis at >0.05 based on the EFA.

Results for Green Skills for Energy Efficiency in Buildings (GSEEB). GSEEB was observed as a second-order latent construct identified using two first-order latent constructs. Additionally, among the initial 12 measurement items GSEEB, ENF9, ENF10, ENF6, and ENF4 were deleted after

the EFA, and the remaining 8 items were extracted into two factors (1 and 2). Building on the above, in CFA factor 2 of GSEEB in EFA was a first-order latent construct named ENEF1 that consisted of four items: ENF1, ENF12, and ENF2. Factor 1 of ENEF SKILL in EFA was a first-order latent construct of GSEEB called ENEF2 that consisted of four items: ENF7, ENF11, ENF3, ENF8, and ENF5.

In the CFA of ENEF SKILL via Amos 23, the computed values for model fit indices from the measurement model (initial model) for GSEEB did not satisfy goodness of fit indices with 3.071 for (x2)/DF (normed CMIN), GFI (0.962), TLI (0.920), CFI (0.945), AGFI (0.927), RMSEA (0.076), and P<0.000. This resulted in the modification of the initial model by removing variables that decreased the model goodness of fit [36]. Figure 4.15 shows the structure of the measurement model.

Figure 1 shows a total of eight important GSEEB areas: ENF1 (“use mathematics and process data to identify the energy-intensive steps of a construction process.”), ENF12 (“analyze and evaluate sustainability risks using root cause analysis.”), ENF2 (“select of energy balancing for the building being examined.”), ENF5 (“identify ways to improve energy efficiency in the short and long-term in a building.”), ENF7 (“evaluate sustainability impact of a worksite to identify the sustainability issues for the steps within a selected process.”), ENF11 (“apply the principles of sustainability and issues such as climate change”), ENF3 (“eliminate or reduce resource loss to improve energy efficiency.”), and ENF8 (“determine energy usage by defining boundaries for an energy audit for all or part of a building.”). These factors were used to determine relationships in respondent responses for integration in BCP. The model revealed that ENF11 and ENF7 had high standardized residual covariance values of 2.647 and 2.757, which were >.4, that contributed to model unfit. Therefore, to further model analysis, the contents of these items were covered in CFA.

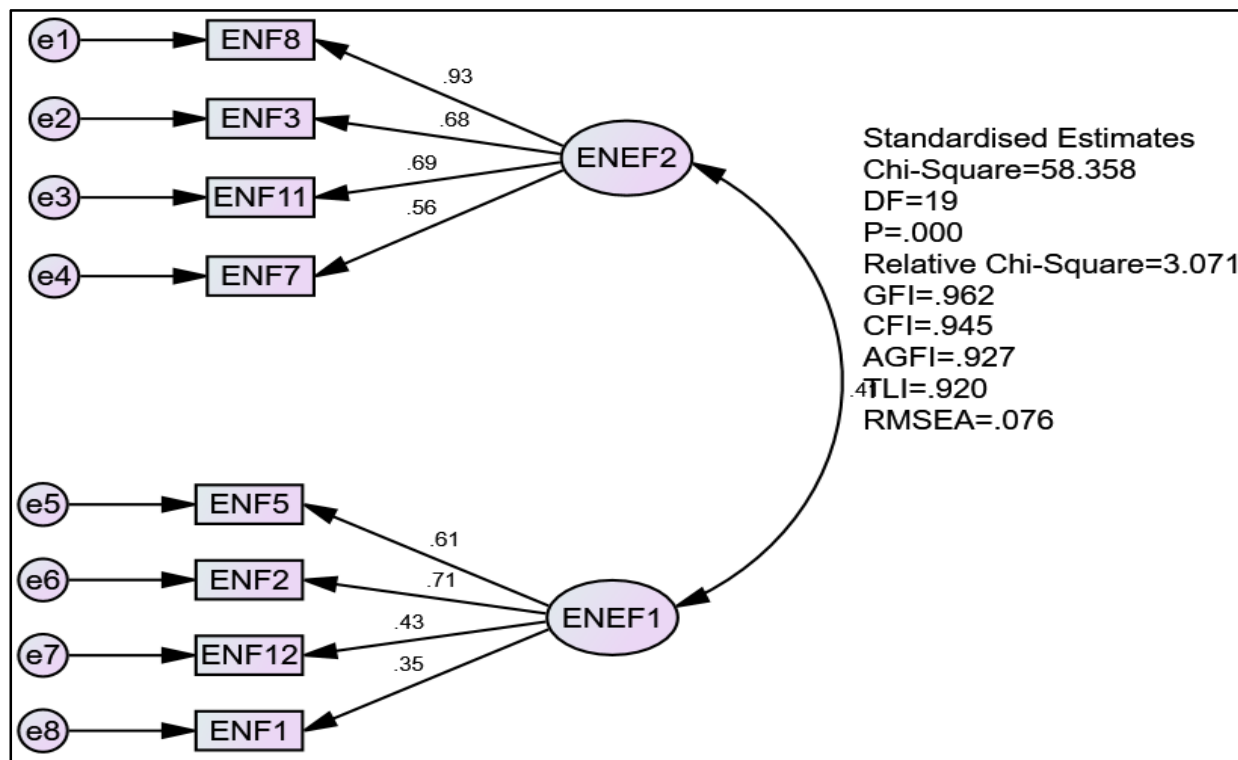


FIGURE 1. GSEEB Measurement Model.

After the second CFA run via Amos 23, the validity inspection of the ENF measurement model indicated that the model fit standardized estimates were satisfactory (Figure 2.0), indicating that CMIN was 51.802 with 18 DF. as the p-value associated with this result was significant at  $p < .005$  and the sample size for CFA was quite large ( $N = 172$ ), a significant p-value was expected [37]. In addition, the normed CMIN (2.878) was accepted (between 1 and 3). A good value for normal CMIN (less than 3) is enough to indicate a good model fit [38]. GFI (0.967), CFI (0.953), TLI (0.927) and AGFI (0.933) were greater than 0.9. RMSEA was 0.072, which is less than 0.08. These results suggest that the modified model for energy efficiency skills revealed a satisfactorily fitness as recommended by [36]. Therefore, the hypothesis of a significant relationship between research respondent responses and GSEEB was upheld at  $<0.05$  as shown in Figure 2.

Figure 2 shows a structural model for the significant relationship between respondent responses and the eight energy efficiency skills areas for integration in BCP curriculum for universities in Nigeria. From the modified model (Figure 2) it can be concluded that for the suitable integration of green skills into BCP curriculums these important GSEEB areas need to be given priority.

**C. COMPUTATION OF VALIDITY AND RELIABILITY OF GSEEB**

Convergent validity was achieved as all items in the measurement model were statistically significant and the calculated

Average Variance Extracted (AVE) for every construct was equal to or greater than 0.5 according to [36]. Similarly, construct validity in this study was achieved as the Fitness Indexes for every construct achieved the desired level [35]. Additionally, discriminant validity in this study was achieved as the modified model was free from redundant items and all correlations between the exogenous constructs (second-order latent construct) were less than 0.9 [36]. The evaluation of modified model reliability in this study was carried out using Internal Reliability, which was achieved as the Cronbach's Alpha value for the construct exceeded 0.7. Composite Reliability (CR) was achieved all CR values for the second-order latent construct modified model was greater than 0.6. This was computed using  $CR = \frac{\sum K^2}{\sum K^2 + \sum (1 - K^2)}$ ; where  $K$  = factor loading for every item,  $n$  = number of items in a model, and  $D$  (Delta) was equal to  $\sum (1 - K^2)$  as transmitted in columns E-J in Table 6 below. For Average Variance Extracted (AVE) all calculated value were greater than 0.5 as computed using  $AVE = \frac{\sum K^2}{n}$ ; where  $K$  and  $n$  were the same as in CR above according to [36] as shown in columns A-D in Table 4.0 below.

**1) SUMMARY OF VALIDITY AND RELIABILITY RESULTS OF GSEEB**

The summary of the output estimate for GSEEB in CFA via Amos 23 (Table 7) shows that factor loadings were acceptable (all items over 0.7). In addition, Table 5.0 indicates that the AVE for ENEF1 was 0.67 and the CR for ENEF1 was 0.89.

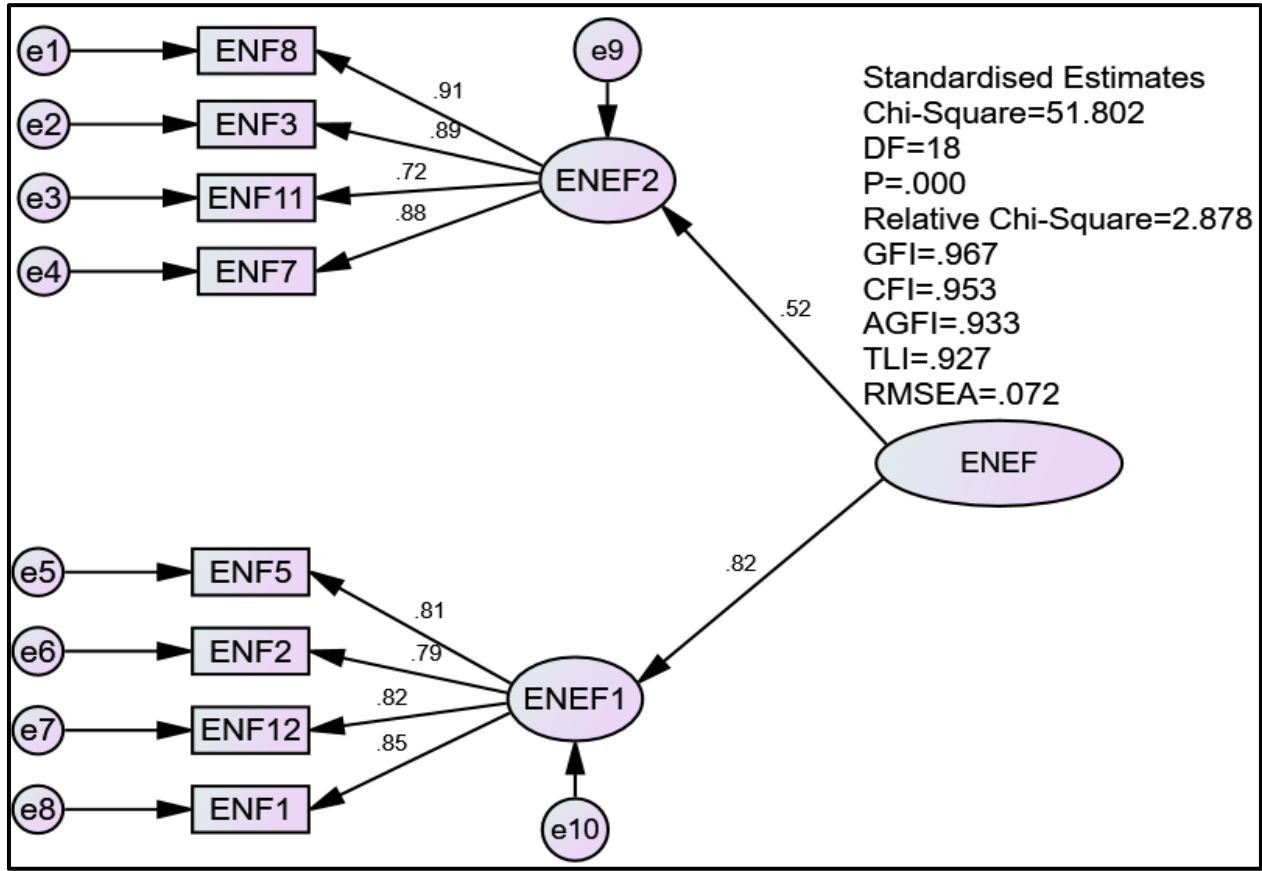


FIGURE 2. Modified Measurement Model for Energy Efficiency Skills.

The AVE for ENEF2 was 0.73 and the CR for ENEF2 was 0.91. These results show that all AVE values were greater than 0.5 and all CR values were greater than 0.7, which signifies that ENEF1 and ENEF2 had acceptable convergent validity as recommended by [36].

The first-order construct of GSEEB also had good internal reliability (0.87) and an examination of inter-correlations between the two dimensions (ENE1 and ENE2) of GSEEB showed an estimate of 0.52, which is significantly above the threshold value of 3.0 and below the cut-off value of 0.90 (Table 5) as recommended by [36], implying distinctness in construct content or discriminant validity. The congeneric measurement model with all uni-dimensional constructs did not contain any cross-loadings among measured variables or among error terms. Taken together, these results support the modified measurement model’s validity and, as such, the proposition that GSEEB was a second-order latent construct composed of ENE1 and ENE2 was confirmed.

**D. IMPORTANT AREAS OF ENERGY EFFICIENCY SKILLS CONSIDERED APPROPRIATE FOR INFUSION IN BCP CURRICULUM**

Table 8 presents important energy efficiency skills appropriate for infusion in BCP curriculums.

TABLE 5. Rotated component matrixes for green energy efficiency skills in construction.

Rotated Component Matrix		
Item	1	2
ENF8	.846	
ENF3	.732	
ENF11	.619	
ENF7	.587	
ENF5	.529	
ENF2		.876
ENF12		.851
ENF1		.648

**V. DISCUSSION**

This study found that computational skills such as the ability to use mathematics to process data to identify the energy-intensive steps of a construction process and the selection of an energy balancing method for a building under examined need to be incorporated into BCP to achieve

**TABLE 6. Computation of AVE and CR for GSEEB modified model.**

FACTOR	ITEM	A	B	C	D	E	F	G	H	I	J
		Estimate	Squared Loadings (Estimate Square) A2	Sum of squared loadings (sum of A2 per factor)	AVE = C/number of items per factor)	Delta D= 1-estimate squared (1-B)	Sum of loadings/est. (sum of A)	Sum of loadings squared (sum of F2)	Sum of Delta (sum of E)	CR denominator=(G+H)	CR = G/I
ENE F2	ENF8	0.91	0.83	2.91	<b>0.73</b>	0.17	3.40	11.56	1.19	12.75	<b>0.91</b>
	ENF3	0.89	0.79			0.21					
	ENF11	0.72	0.52			0.58					
	ENF7	0.88	0.77			0.23					
ENE F1	ENF5	0.81	0.66	2.67	<b>0.67</b>	0.34	3.27	10.69	1.33	12.02	<b>0.89</b>
	ENF2	0.79	0.62			0.38					
	ENF12	0.82	0.67			0.33					
	ENF1	0.85	0.72			0.28					

**TABLE 7. Summarized results for AVE, CR, and internal reliability for the GSEEB modified model.**

First-Order Latent Construct	Second-order Latent Variable	Estimate	AVE	CR	Internal Reliability of GSEEB	Correlation Between Second-Order Latent Constructs
ENE F2	ENF8	0.91	0.73	0.91	0.87	0.52
	ENF3	0.89				
	ENF11	0.72				
	ENF7	0.88				
ENE F1	ENF5	0.81	0.67	0.89	0.87	0.52
	ENF2	0.79				
	ENF12	0.82				
	ENF1	0.85				

**TABLE 8. Important energy efficiency skills.**

S/N	Important Areas
1.	Use of mathematics to process data to identify the energy-intensive steps of a construction process
2.	Selection of an energy balancing method for a building under examination
3.	Elimination or reduction of resource loss to improve energy efficiency
4.	Identification of ways to improve energy efficiency over the short and long-term for a building
5.	Evaluation of the sustainability impact of a worksite to identify sustainability issues
6.	Determination of energy usage to define energy audit boundaries for all building components
7.	Application of the principles of sustainability to address issues such as climate change
8.	Analyzation and evaluation of sustainability risks using root cause analysis

environmental sustainability. This finding corresponds with the recommendation of [14] that the ability to calculate and measure carbon emissions and integrate energy designs is an important skill for enhancing building energy efficiency. Computational skills will prepare BCP students for construction work where sustainability issues need to be addressed.

NBTE should look into the possibility of embedding these important areas into the BCP curriculum of Nigeria universities. Respondents agreed that energy efficiency knowledge, which includes the ability to eliminate/reduce resource loss as well as the ability to determine energy usage by defining boundaries need to be integrated.



More so, considering that global warming is negatively affecting the ozone layer, students must adequately trained on energy efficiency to ensure environmental sustainability in Nigerian states. The finding supports the report of Strietska-Ilina et al. [38], who found that the UN Decade on Education for Sustainable Development (ESD) had spurred further initiatives in this field and developed a wide range of good practices by integrating the principles, values, and practices of sustainable development into all aspects of education and learning. The finding is also supported by [39], who found that green buildings are an outcome of designs that focus on increasing sustainable resource use. Yu et al. [40] demonstrated that green buildings minimize pollution, reduce natural resource consumption, and create an environmentally friendly energy-saving environment. Dasmani, [41] recommended that the embedment of green skills in course curriculums produces students that can combat problems facing energy and resource efficiency. Having students that take part in combating environmental problems is highly needed in Nigeria. This study also identified ways to improve building energy efficiency over the short and long-term. This finding is in line with the recommendation made by [21] that “*energy-efficient high-performance buildings demand a synthesis of architectural design, construction methods, and energy systems*”, which implies the need for energy efficiency skills. In line with the above, Manufacturing Skills Australia [4] demonstrated that energy is a significant cost for most businesses and energy efficiency skills are essential for all workers on a site as they provide a framework for the skills, knowledge, and performance required to achieve specific workplace outcomes for energy efficiency.

The above also supported by the Asia-Pacific Education Research Institutes Network (ERI-Net) [22] report that there is a need for a range of solutions and strategies to improve energy efficiency. Respondents in this study also agreed that education should integrate the ability to evaluate the sustainability impact of a worksite as well as the ability to identify sustainability issues for the steps of a selected process. This finding in line with the report of the European Centre for the Development of Vocational Training CEDEFOP [42], which found that the impact and energy costs of business activity influences behavior and affects demand for green skills. Additionally, Dayue [43] recommended that in education, teachers and students should be aware of greening by recognizing the impact of green education on students overall development, including interpersonal and intrapersonal competence, employability, environmental protection skills, life-long learning, and low-carbon transition abilities. This prompted some teachers to vigorously study greening concepts and create an international movement to embed greening content in their instructions. Reference [44] recommended that sustainable accounting be used to ensure that development is based on a scientific approach that takes into account social, environmental, and economic impacts. Reference [45] supported the assumption that the main impacts

of climate change regulation on labour markets are primarily related to skills rather than actual levels of employment. This study’s findings also includes the ability to analyze and evaluate sustainability risks using root cause analysis. this supports the recommendation of [21] that auditing energy usage for a work area includes identifying sustainability issues and impacts and environmental sensitivities that apply to the work or process area.

Accordingly, [21] also stated that energy use and waste data includes the ranking of waste in equipment and processes, comparing waste to external targets, and identifying the root cause of waste. Reference [46] found that the working definition of UNEP describes a “*green economy as one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities*.” UNESCO [47] reported that building techniques should be adapted to natural disasters such as earthquakes. According to [48] green technology is an emerging concept with the ultimate goal of achieving sustainable development by reducing environmental risks, ecological scarcities, carbon emissions, and pollution as well as enhancing energy and resource efficiency to prevent the loss of biodiversity. Reference [49] found that Asian countries are pressured to prepare themselves for the risks of climate change as well as develop strategies for more resilient economic and social systems by redefining and reworking their educational systems. This study also found that familiarity with sustainability issues (which involves the ability to apply the principles of sustainability) needs to be embedded into educational systems to enable the attainment of environmental sustainability. The ability to put the principles of sustainability into practice is needed for the attainment of environmental sustainability, which if embedded properly will encourage environmentally sustainable development. Roufechaei et al. [50] reported that, with the Brundtland Commission report published in 1987 (Brundtland, 1987), the structures for sustainable development had been laid across the globe, nationally and locally, for all organizations. This finding supports [51] recommendation that to achieve change in environmental sustainability, emphasis should be placed on the role of Technical Education and Vocational Training (TVET) in developing generic green skills. This clearly implies that if sustainability issues could be incorporated into TVET by greening the construction sector, the attainment of sustainability would be guaranteed.

Additionally, the Asia-Pacific Education Research Institutes Network (ERI-Net) [22] maintained that auditing energy usage for a work area includes identifying a range of sustainability issues. This finding signifies the impact and environmental sensitivities that apply to the work or process area, which allows for the proposal of a range of solutions and strategies to improve energy efficiency. Conscientiously, looking at the aforementioned energy efficiency skills, it is convincing that when this framework is fully put into practice environmental sustainability could be achieved.

## VI. CONCLUSION AND RECOMMENDATIONS

The findings of this study were used to develop a conceptual model for infusing green skills into the curriculum of BCP students to realize environmental sustainability in Nigeria. Significant green energy efficiency construction skills were identified using respondents/participants made up of teachers and industry professionals. A model was developed in adherence to the analyzed data that indicated important areas based on their appropriateness towards green skills. This conceptual model has some implications for the supervisory agency National Board for Technical Education (NBTE) to consider to ensure that identified areas are infused into curriculums and properly imparted to students. The conceptual model could be used as a guide for the effective infusion of green skills to BCP students.

Environmental problems are a global issue caused by unsustainable development in many developing countries like Nigeria. This study provides a detailed understanding on the roles of green energy efficiency skills in construction towards achieving environmental sustainability by developing a conceptual model comprised of important energy efficiency skills elements. The findings if fully utilised could pave way for the preparation of workforce towards sustainable development and curriculum development. Also the methodology used in this paper an instrument was developed and In-depth analysis of the reliability and validity of the developed instrument. For the effective implementation of this model, the following recommendations are provided:

- There is a need for Federal and state Governments via NBTE to adopt and implement this model for BCP in universities in Nigeria.
- It is recommended that policy makers plan, organize, and implement this study's model into the BCP curriculum of universities in Nigeria.
- The model should be implementation by university BCP units under the supervision of school administrators to ensure that students acquire green skills to promote environmental sustainability.

## REFERENCES

- [1] M. Pavlova, "Fostering inclusive, sustainable economic growth and 'Green' skills development in learning cities through partnerships," *Int. Rev. Educ.*, vol. 64, no. 3, pp. 339–354, 2018.
- [2] G. McDonald, L. Condon, and M. Riordan, "The Australian Green skills agreement policy and industry context," *Institutional Response and Green Skills Delivery TAFE Directors Australia (TDA)*. Broadway, India: TDA, 2012.
- [3] S. McGrath and L. Powell, "Skills for sustainable development: Transforming vocational education and training beyond 2015," *Int. J. Educ. Develop.*, vol. 50, no. 15, pp. 12–19, 2016.
- [4] Yusri, "Manufacturing Skills for sustainability," Ph.D. dissertation, Dept. Educ. Training, North Sydney, NSW, Australia, 2012.
- [5] H. Said and L. Berger, "Future trends of sustainability design and analysis in construction industry and academia," *Pract. Periodical Struct. Des. Construct.*, vol. 19, no. 1, pp. 77–88, 2016.
- [6] Global Reporting Initiative (GRI). (Dec. 7, 2016). *Sustainability Reporting Guide-Lines, Version 3.1*. Accessed: 2011. [Online]. Available: <https://www.globalreporting.org>
- [7] M. Siriwardana and D. Nong, "Economic implications for Australia and other major emitters of trading greenhouse gas emissions internationally," *Int. J. Global Warming*, vol. 16, no. 3, pp. 261–280, 2018.
- [8] M. Lu, "Integrating sustainability into the introduction of environmental engineering," *J. Prof. Issues Eng. Educ. Pract.*, vol. 141, no. 2, p. C5014004, 2014.
- [9] N. H. M. Adzmi, M. Z. A. Hamid, Z. Awang, Y. Kamin, and N. A. Atan, "Generic green skills development: Initiatives of green manufacturing industries in Johor, Malaysia," *Adv. Sci. Lett.*, vol. 24, no. 4, pp. 2931–2935, 2018.
- [10] G. Nhamo, "Reviewing some implications of the green economy for higher and further education institutions," *Southern Afr. J. Environ. Educ.*, vol. 30, no. 1, pp. 79–95, 2014.
- [11] A. A. Tabassi, K. M. Roufehaei, M. Ramli, A. H. A. Bakar, R. Ismail, and A. H. K. Pakir, "Leadership competences of sustainable construction project managers," *J. Cleaner Prod.*, vol. 124, pp. 339–349, Jun. 2016.
- [12] B. Ozorhon and K. Oral, "Drivers of innovation in construction projects," *J. Construct. Eng. Manage.*, pp. 1–9, 2016. doi: [10.1061/\(ASCE\)CO.1943-7862.0001234](https://doi.org/10.1061/(ASCE)CO.1943-7862.0001234).
- [13] G. U. Aligha, N. B. Adnan, M. Baba, H. M. Ali, and S. E. Eluwa, "Low carbon green building skills requirements for existing buildings," *Adv. Mater. Res.*, vols. 1073–1076, pp. 1288–1292, Jan. 2015.
- [14] G. U. Aligha, M. N. Abdullah, N. M. Jaafar, and S. E. Eluwa, "Investigating skill gaps in green building skills for energy efficiency," *Adv. Mater. Res.*, vols. 1073–1076, pp. 1282–1287, Dec. 2014.
- [15] L. Pérez-Lombard, J. Ortiz, and C. Pout, "A review on buildings energy consumption information," *Energy Buildings*, vol. 40, no. 3, pp. 394–398, 2007.
- [16] A. P. McCoy, P. O'Brien, V. Novak, and M. Cavell, "Toward understanding roles for education and training in improving green jobs skills development," *Int. J. Construct. Edu. Res.*, vol. 8, no. 3, pp. 186–203, 2012.
- [17] Adult and Experiential Learning (CAEL). (Nov. 22, 2017). *Building Green Skills: A Green Jobs Program for San Antonio*, pp. 1–78. [Online]. Available: <https://www.voced.edu.au/content/ngv:64979>
- [18] C. Bradshaw, Mail & Guardian. (Dec. 21, 2017). *Partnerships Key to Green Skills*. Accessed: 2014. [Online]. Available: <https://mg.co.za/article/2014-03-31-partnerships-key-to-green-skills>
- [19] C. Uzoma, C. Nnaji, and M. Nnaji, "The role of energy mix in sustainable development of Nigeria," *Continental J. Social Sci.*, vol. 5, no. 1, pp. 21–29, 2012.
- [20] Z. Şen, "Noah and Joseph effects: Floods and droughts under global warming," *Int. J. Global Warming*, vol. 16, no. 3, pp. 347–364, 2018.
- [21] A. Passer, J. Wall, H. Kreiner, P. Maydl, and K. Höfler, "Sustainable buildings, construction products and technologies: Linking research and construction practice," *Int. J. Life Cycle Assessment*, vol. 20, no. 1, pp. 1–8, 2015.
- [22] Asia Pacific Education Research Institutes Network (ERI-Net), "Transversal competencies in education policy & practice (phase I): Regional synthesis report," UNESCO, Paris, France, Tech. Rep. TH/EPR/14/027, 2013, pp. 1–81. [Online]. Available: <https://unesdoc.unesco.org/ark:/48223/pf0000231907>
- [23] S. A. Batterman, A. G. Martins, C. H. Antunes, F. Freire, and M. G. da Silva, "Development and application of competencies for graduate programs in energy and sustainability," *J. Prof. Issues Eng. Educ. Pract.*, vol. 137, no. 4, pp. 198–207, 2011.
- [24] M. R. Bozell and C. D. Liston, "Building effective green energy programs in community colleges," *Workforce Strategy Center*, vol. 74, no. 120, pp. 1–28, 2010.
- [25] R. Y. Chiou, R. Belu, and T.-L. B. Tseng, "Infusion of green energy manufacturing into engineering and technology curricula," in *Proc. ASME Int. Mech. Eng. Congr. Expo.*, San Diego, CA, USA, Mar. 2013.
- [26] J. W. Creswell, *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. 4th ed. Thousand Oaks, CA, USA: Sage, 2014.
- [27] B. Williams, A. Onsmann, and T. Brown, "Exploratory factor analysis: A five-step guide for novices," *Australas. J. Paramed.*, vol. 8, no. 3, pp. 1–13, 2010.
- [28] U. Flick and G. Gibbs, "Analyzing qualitative data," in *Designing Qualitative Research*, vol. 104, A. Bryman and B. Burgess, Eds. Evanston, IL, USA: Routledge, 2016, p. 246.
- [29] J. C. Nunnally and I. H. Bernstein, *Psychometric Theory*, 3rd ed. New York, NY, USA: McGraw-Hill, 1978.
- [30] J. F. Hair, W. C. Black, B. J. Babin, R. E. Anderson, and R. L. Tatham, *Multivariate Data Analysis*, 5th ed. Upper Saddle River, NJ, USA: Prentice-Hall, 1998.
- [31] G. C. Moore and I. Benbasat, "Development of an instrument to measure the perceptions of adopting an information technology innovation," *Inf. Syst. Res.*, vol. 2, no. 3, pp. 192–222, 1991.

- [32] A. S. Beavers, J. W. Lounsbury, J. K. Richards, S. W. Huck, G. J. Skolits, and S. L. Esquivel, "Practical considerations for using exploratory factor analysis in educational research," *Practical Assessment, Res. Eval.*, vol. 18, no. 6, pp. 1–13, 2013.
- [33] J. F. Hair, M. Sarstedt, T. M. Pieper, and C. M. Ringle, "The use of partial least squares structural equation modeling in strategic management research: A review of past practices and recommendations for future applications," *Long Range Planning*, vol. 45, nos. 5–6, pp. 320–340, 2012.
- [34] A. L. Comrey and H. B. Lee, *A First Course in Factor Analysis*. New York, NY, USA: Psychology Press, 2017. doi: 10.4324/9781315827506.
- [35] J. F. Hair, M. Sarstedt, C. M. Ringle, and J. A. Mena, "An assessment of the use of partial least squares structural equation modeling in marketing research," *J. Acad. Marketing Sci.*, vol. 40, no. 3, pp. 414–433, 2012.
- [36] Z. Awang and SEM Made Simple, *A Gentle Approach to Learning Structural Equation Modeling Using AMOS Graphic*. Selangor, Malaysia: MPW5 Rich Publication, 2012.
- [37] J. F. Hair, W. C. Black, B. J. Babin, R. E. Anderson, and R. Tatham, *Multivariate Data Analysis*. Upper Saddle River, NJ, USA: Prentice-Hall, 2010.
- [38] O. Strietska-Iliina, C. Hofmann, M. D. Haro, and S. Jeon, *Skills for Green Jobs: A Global View: Synthesis Report Based on 21 Country Studies*. 2011.
- [39] C. Kamana and E. Escultura, "Building green to attain sustainability," *Int. J. Earth Sci. Eng.*, vol. 4, no. 4, pp. 725–729, 2010.
- [40] Z. Yu, C. Lu, and B. San, "Application of green construction technology in construction projects," in *Proc. Smart Construct. Manage. Context New Technol. (ICCREM ASCE)*, 2014.
- [41] A. Dasmani, "Challenges facing technical institute graduates in practical skills acquisition in the Upper East Region of Ghana," *Asia-Pacific J. Cooperat. Educ.*, vol. 12, no. 2, pp. 67–77, 2011.
- [42] *A Strategy for Green Skills?* CEDEFOP Briefing Note Thessaloniki, Australia, 2012.
- [43] F. Dayue. (Sep. 23, 2016). *A Survey Report on Greening in Higher TVET in China*, pp. 1–18. [Online]. Available: <https://www.tvet.online.asia/>
- [44] J. Gibberd, "Developing a sustainable development approach for buildings and construction processes," in *Smart and Sustainable Built Environments*. Carlton, VIC, Australia: Blackwell Publishing Asia Pty Ltd, 2008, pp. 300–310.
- [45] C. Martinez-Fernandez, C. Hinojosa, and G. Miranda, "Green jobs and skills: The local labour market implications of addressing climate change," OECD LEED Programme, OECD, Working Paper, 2010. [Online]. Available: <https://www.oecd.org/cfe/leed/44683169.pdf>
- [46] R. B. Mustapha, "Green and sustainable development for TVET in Asia," *Int. J. Tech. Vocational Educ.*, vol. 11, no. 2, pp. 133–142, 2016.
- [47] *Education for People and Planet: Creating Sustainable Futures for All*, Paper Commissioned Global Educ. Monit., UNESCO, Paris, France, 2016.
- [48] M. Ramlee and M. A. Siti Shuhada, "Perspective of technical students on green technology: A case study in a Malaysian public University," in *Proc. 10th Int. Conf. Asian Acad. Soc. Vocational Educ. Training (AASVET)*, Tokyo, Japan, 2014, pp. 194–205.
- [49] K. Baumgarten and S. Kunz. (Dec. 1, 2017). *Re-Thinking Greening TVET for Traditional Industries in Asia-the Integration of a Less-Skilled Labour Force Into Green Supply Chains*. [Online]. Available: [http://www.tvet-online.asia/issue6/baumgarten\\_kunz\\_tvvet6.pdf](http://www.tvet-online.asia/issue6/baumgarten_kunz_tvvet6.pdf)
- [50] K. M. Roufechai, A. H. A. Bakar, and A. A. Tabassi, "Energy-efficient design for sustainable housing development," *J. Cleaner Prod.*, vol. 65, pp. 380–388, Feb. 2014.
- [51] H. Zolkifli, Y. Kamin, A. B. A. Latib, Y. Buntat, and Z. Awang. (2016). *Generic Green Skills: Industry and Perspectives on Technical Education and Vocational Training (TVET)*. [Online]. Available: [www.tvet-online.asia](http://www.tvet-online.asia)

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