Investigating the Antecedents to Teaching Green Information Technology (Green IT): A Survey of Student Teachers in Swaziland

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ABSTRACT

There is abundant scientific evidence that the natural environment, on which we are completely dependent for life, is degrading and depleting to the extent that our medium- to long-term well-being and existence is under threat. It is also clear that IT is contributing to this degradation and depletion, which requires that Green IT practices be an imperative. Since Green IT practices are often not common sense, it is vital that these Green IT practices are taught to others, and teachers typically have the skills and opportunities to teach many people. This demonstrates the relevance and significance of the study. The research problem is the lack of research addressing the theoretical antecedents to teaching Green IT, which are considered vital for understanding how to improve student teachers' intention to teach Green IT and their resultant teaching of Green IT. The study addressed this research problem by surveying student teachers using a quantitative questionnaire at three teacher training institutions in Swaziland, Africa. The resultant data was analysed using structural equation modeling (SEM) based on an a priori set of antecedents and their hypothesized relationships from the literature. The findings indicate that the most beneficial allocation of time and resources would be to enhance the student teachers' level of awareness, perceived behavioural control and person-related beliefs to positively influence their intention to teach Green IT, and consequently, their actual behaviour of teaching Green IT.

CCS CONCEPTS

• **Social and professional topics** → **Sustainability;** Adult education[1]

SAICSIT '18, September 26–28, 2018, Port Elizabeth, South Africa

ACM ISBN 978-1-4503-6647-2/18/09…$15.00
https://doi.org/10.1145/3278681.3278695

KEYWORDS

Green Computing, Green Information Technology (Green IT), Green Information Systems (Green IS), education and teaching, environmental sustainability, structural equation modeling (SEM), student teachers, theory of reasoned action (TRA), theory of planned behaviour (TPB)

ACM Reference format:

Ricky Nhlanhla Dlamini and Grant Royd Howard. 2018. Investigating the antecedents to teaching Green Information Technology (Green IT): A survey of student teachers in Swaziland. In Proceedings of the South African Institute of Computer Scientists and Information Technologists (SAICSIT '18). ACM, New York, NY, USA, 10 pages. DOI: https://doi.org/10.1145/3278681.3278695

1 INTRODUCTION

The natural environment is important because human life relies on it for existence [48]. However, the natural environment is rapidly degrading and depleting, which is considered life-threatening to all people in all parts of the world [23]. In response to the degradation, environmental sustainability has become a priority to protect the environment [16]. In relation, the term "Green" refers to many endeavours that aim to protect the environment [33].

The literature discloses that Information Technology (IT) also contributes to environmental degradation [70]. This occurs throughout the IT lifecycle, comprising production, usage and disposal, which produce harmful carbon emissions and e-waste [54]. Consequently, the concept of Green IT emerged to addresses these negative effects on the environment [17]. Notably, the concepts of Green ICT, Green computing and sustainable IT are regarded as conceptually equivalent to the concept of Green IT. Thus, the term Green IT is used in this study, but it appropriately refers to all of these concepts. The main goals of Green IT are the reduction of carbon dioxide emissions, which contribute to climate change and global warming and the reduction of electronic waste (e-waste) [22, 54], which contain hazardous substances including selenium and cadmium [5].

Nevertheless, Green IT practices are often not common sense and so it is vital that Green IT practices are taught to others. Teachers, typically, have the skills and opportunities to influence the behaviour of the many pupils they teach throughout their

teaching careers [39] and student teachers, in particular, are viewed as essential agents for imparting Green IT knowledge and instilling Green IT behaviour into future generations since they have their entire teaching careers ahead of them and should understand contemporary IT and related issues. However, the literature demonstrates that student teachers have limited knowledge and competencies relating to the many aspects of environmental sustainability [10, 11, 24, 25]. In addition, the teaching of environmental education in schools is considered inconsistent due to a lack of knowledge and a poor commitment to teach about environmental matters [42]. Thus, research focusing on Green IT and student teachers is important for environmental sustainability and minimising IT-related environmental depletion and degradation.

Subsequently, a literature search was done in August 2016 for relevant, contemporary Green IT articles published since 2010, which was regarded as a reasonable start date for obtaining contemporary IT research. The search resulted in just over fifty articles. Of those, only eighteen involved various types of students. Out of those eighteen, only one involved education faculty students, however, this article also involved other students and it did not address teaching Green IT. Importantly, none of the articles addressed the theoretical antecedents to teaching Green IT, which are considered vital for understanding how to improve student teachers' intention to teach Green IT and their actual behaviour of teaching Green IT. This is the research problem and addressing it presents an original contribution to the academic body of knowledge. In addition, this research problem and addressing it has value for teaching practice by informing teaching and curriculum design in teacher-training institutions, specifically, it provides curriculum guidance for promoting environmental sustainability in general and Green IT in particular. Furthermore, out of the articles reviewed, only four involved participants from African countries. This necessitates further sustainability research in Africa because Africa is a continent that is especially vulnerable to global warming and environmental degradation [45].

Accordingly, the study's research question was what aspects should be focused on to improve the teaching of Green IT? To answer this question, the study's research objective was to investigate the antecedents to teaching Green IT in an African country context, in order to understand how to improve student teachers' intention to teach Green IT, and consequently, their actual behaviour of teaching Green IT.

The paper consists of five sections. This section provides the introduction and background to the study. In Section Two, research that relates to the research problem is analysed and synthesised, including applicable theories, frameworks and models. In addition, the study's research model and hypotheses are presented at the end of Section Two. Section Three describes and justifies the methodology of the study. Chapter Four is the results and discussion of the data. Section Five presents the study's conclusions, including answers to the research question, the study's limitations and future research avenues.

2 LITERATURE REVIEW

2.1 Student teachers, teachers and sustainability

Research has shown that student teachers often have superficial knowledge and comprehension of concepts related to environmental sustainability [38, 73] and it has been found that educators and student teachers misunderstand numerous environmental issues [10] such as greenhouse gas (GHG) emissions and ozone layer depletion [13].

It seems that student teacher training relating to education for sustainability is ad-hoc globally [9]. Few teacher-training institutions have incorporated sustainability education into teacher training courses [7]. Moreover, it appears that a shortage of sustainability courses in tertiary education has caused a shortage of teachers with an adequate knowledge of environmental and sustainability education [25]. This may be due to education for sustainability being a relatively new concept [9]. Nonetheless, teacher-training institutions should offer courses to help student teachers boost their environmental sustainability insight and knowledge [9]. It has also been suggested that extra training for environmental sustainability knowledge and awareness be mandatory for student teachers in developing countries [59].

Notably, education for sustainability has faced many challenges in schools. It has been found that teachers do not have time to teach sustainability because they have to concentrate on their major subjects, which have time tables that do not allow time for sustainability education [62, 71]. Similarly, it has been discovered that teachers typically have a high workload, and, as a result, sustainability teaching is not incorporated into teaching curriculums [73]. Some teachers have even felt threatened by the prospect of teaching the subject and integrating sustainability education into schools can be very difficult because teachers do not receive the needed support from their schools' administration [62].

2.2 Applicable theories, frameworks and models

Corresponding to the study's research problem and objective, the relevant literature presented six prominent and potentially applicable theories, frameworks and models, namely the Green IT adoption model (GITAM) [50], the Green–readiness framework (G-readiness) [51], the belief-action-outcome framework [48], the theory of reasoned action (TRA) [26], the theory of planned behaviour (TPB) [2] and the decomposed theory of planned behaviour (DTPB) [46, 67, 68].

The Green IT adoption model (GITAM) relates directly to Green IT, but its suitability for this study is limited because it applies to organisational Green IT adoption and does not focus on an individual's Green IT behaviour. Similarly, the G-readiness framework is useful for determining an organisation's readiness to implement Green IT and it does not focus on an individual's Green IT behaviour. Thus, its suitability for this study is also

limited. Also, the belief-action-outcome (BAO) framework is more appropriate for an organisational environment. Thus, its suitability for this study is limited.

However, the theory of reasoned action (TRA) is useful for identifying where and how to target strategies for changing behaviour. Nevertheless, TRA has been criticised and then expanded into and augmented to form the theory of planned behaviour (TPB) for wider theoretical application. Several authors point out that TPB is an important theoretical framework for recognizing the variables that predict behavioural intention for a particular behaviour [41]. TPB has helped scholars to understand the variables that influence people's intentions to behave in certain ways [43].

Notably, TPB has also received criticism and was extended to form the decomposed theory of planned behaviour (DTPB). However, DTPB has been shown to be mostly applicable to the adoption and utilization of new technology [32] with constructs referring to aspects of using technology, which may not transfer well into this study's teaching context where there is no specific technology use. Thus, its suitability for this study is also limited.

2.3 Research model for the study

Following the preceding analysis, only two out of the six theories, frameworks and models provide a useful fit for the study's research problem, question and objective. The two are TRA and TPB. These fit because they explain the antecedents to an individual's behaviour, which can appropriately be set to teaching behaviour. Thus, the research model for this study is based on TRA and TPB. Furthermore, TRA and TPB have explained behaviour resulting in insightful research, which includes research in the Green IT and IT domain [3, 14, 15, 17, 21, 28, 44, 47, 49].

In addition, relevant previous research has combined TRA and TPB for specific research purposes [17]. Accordingly, combining the two theories has provided valuable insights into the antecedents of behaviour in Green IT research. So, combining TRA and TPB in this study's research model would be justified and could be appropriate for addressing the research problem, answering the research problem and achieving the research objective.

Furthermore, in addition to combining TRA and TPB, two more constructs are added to the study's research model, in a similar manner to another relevant study [49]. Notably, the practice of augmenting TRA, which is an earlier version of TPB, with additional variables, is an accepted research practice for addressing specific research contexts [6, 12, 20, 74]. These two constructs are person-related beliefs and level of awareness. Including these additional constructs is important because both these constructs are indicated as influencers of Green IT behaviour [49]. Specifically, it was discovered that person-related beliefs and level of awareness have a direct influence on attitude toward behaviour, intention and actual behaviour. The study's research model is presented below in Fig. 1.

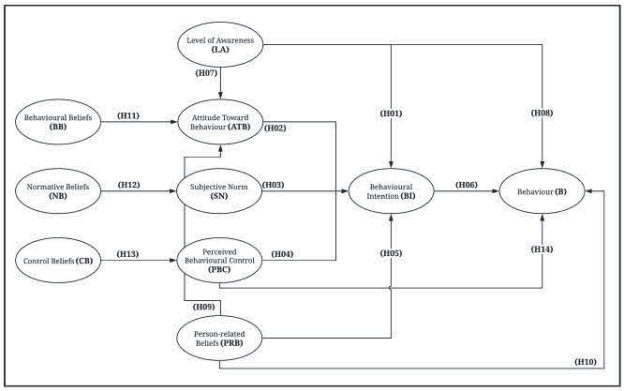

Figure 1: Research model for the study.

Based on the research model in Fig. 1, the research hypotheses for the study follow. All are specified as alternative hypotheses (H_A1-14), where the null hypotheses ($H_0$1-14) corresponding to the alternative hypotheses, indicate that there is no influence among each set of constructs:

1. Level of awareness (LA) positively influences behavioural intention (BI).
2. Attitude toward behaviour (ATB) positively influences behavioural intention (BI).
3. Subjective norm (SN) positively influences behavioural intention (BI).
4. Perceived behavioural control (PBC) positively influences behavioural intention (BI).
5. Person-related beliefs (PRB) positively influences behavioural intention (BI).
6. Behavioural intention (BI) positively influences behaviour (B).
7. Level of awareness (LA) positively influences attitude toward behaviour (ATB).
8. Level of awareness (LA) positively influences behaviour (B).
9. Person-related beliefs (PRB) positively influences attitude toward behaviour (ATB).
10. Person-related beliefs (PRB) positively influences behaviour (B).
11. Behavioural beliefs (BB) positively influences attitude toward behaviour (ATB).
12. Normative beliefs (NB) positively influences subjective norm (SN).
13. Control beliefs (CB) positively influences perceived behavioural control (PBC).
14. Perceived behavioural control (PBC) positively influences behaviour (B).

3 RESEARCH METHODOLOGY

3.1 Philosophy, Methodological Choice and Research Strategy

This study adopts a positivistic research philosophy, quantitative methodology and survey research strategy to address the research problem, answer the research question and achieve the

research objective, and involves quantitative data and hypothesis testing [53, 56].

3.2 Sampling

It could be argued that the population for this study is every student teacher across the entire African continent and even across the globe. However, this is not practically possible in one study or even in many extensively resourced studies. It is also not practically possible to obtain a complete list of every student teacher across the entire African continent and even across the globe in order to draw a perfectly random sample from which to generalise the sample results.

Therefore, this study follows advice provided in the literature, which recommends proceeding with a purposive sample [61, 69] that is representative of the main categories of student teachers to which the research problem relates and enables the research problem to be addressed [29]. Importantly, purposive sampling can be used with quantitative surveys [18, 30], but it is an inherently biased technique and requires caution when used in quantitative studies [61, 69]. In order to mitigate the bias, in this study clear criteria are used for selecting respondents [34].

The criteria used for selecting respondents are student teachers from teacher-training institutions in the African country of Swaziland, covering all education teaching grade ranges and qualification types and exhibiting a wide range of demographic characteristics. Specifically, the sample consists of student teachers from three teacher training institutions in Swaziland, the teaching grade ranges of early childhood, primary and secondary education and the qualification types of diplomas and bachelor's degree. Thus, the sample is representative of the main categories of student teachers to which the research problem relates. Table 1 shows the sample for the study.

Table 1: Study sample

Institution	Respondents	Teaching grade range	Qualification type
Teacher training institution A	81	Early childhood grades	Early childhood education diploma
Teacher training institution B	42	Primary and secondary school grades	Bachelor of special and inclusive education
	5	Primary and secondary school grades	Bachelor of education in leadership and management
	60	Primary school grades	Primary teacher's diploma
Teacher training institution C	42	Secondary school grades	Secondary teacher's diploma
	70	Primary school grades	Primary teacher's diploma
Total	300		

3.3 Development of the Data Collection Instrument

In order to operationalise and measure the research model, items were adapted from relevant, validated and reliable prior studies that measured the same constructs, especially studies relating to Green IT [1, 3, 4, 14, 15, 17, 31, 49, 52, 60]. After careful consideration and selection the final items were further subjected to two pilot tests and minor changes made until the reliability measures were acceptable, as indicated in Table 3.

The measurement scale selected for the questionnaire items is the Likert scale, which was developed by Rensis Likert in 1932 in order to measure attitudes scientifically [36]. Several scholars who have studied attitude toward behaviour, subjective norm, behavioural intention and behaviour have used Likert scales in their studies [14, 15, 17, 28, 49]. Specifically, this scale provided for a range of five possible responses to each item, namely "strongly disagree", "disagree", "neither agree nor disagree", "agree" and "strongly agree".

The questionnaire consisted of two sections. The first section was Section A, which gathered a student teacher's demographic information because they define the characteristics of the sample [55] as shown in Table 4. The next section of the questionnaire was section B, which measured each of the constructs in the study's research model. The items used to measure the constructs in the questionnaire are shown in Table 2 below.

Table 2: Final questionnaire/measurement items for each construct in the study's research model

	Construct: Attitude toward behaviour (ATB)
1.	Teaching Green IT is good.
2.	Teaching Green IT is valuable.
3.	Teaching Green IT is useful.
4.	Teaching Green IT is worthwhile.
	Construct: Subjective Norm (SN)
5.	Most people who are important to me would approve of me teaching Green IT.
6.	Most people who are important to me would appreciate me teaching Green IT.
7.	Most people whose opinions I value would approve of me teaching Green IT.
8.	Most people whose opinions I value would appreciate me teaching Green IT.
	Construct: Perceived behavioural control (PBC)
9.	I am confident that I can teach Green IT.
10.	I am sure that I can teach Green IT.
11.	I am certain that I can teach Green IT.
12.	I am positive that I can teach Green IT.
	Construct: Behavioural beliefs (BB)
13.	I believe that teaching Green IT would help others to decrease energy consumption.
14.	I believe that teaching Green IT would help others to decrease carbon emissions.
15.	I believe that teaching Green IT would help others to decrease pollution.
16.	I believe that teaching Green IT would help others to decrease electronic waste.
	Construct: Normative beliefs (NB)

17. I believe that school management would expect me to teach Green IT.
18. I believe that educators would require me to teach Green IT.
19. I believe that education professionals would want me to teach Green IT.
20. I believe that schools would expect me to teach Green IT.

Construct: Control beliefs (CB)

21. I believe that I am in control of whether I teach Green IT.
22. I believe that I decide whether I teach Green IT.
23. I believe that I choose whether I teach Green IT.
24. I believe that I determine whether I teach Green IT.

Construct: Behavioural intention (BI)

25. I intend to teach Green IT.
26. I aim to teach Green IT.
27. I plan to teach Green IT.
28. I strive to teach Green IT.

Construct: Level of awareness (LA)

29. I know about Green IT.
30. I am informed about Green IT.
31. I am aware of Green IT.
32. I have learnt about Green IT.

Construct: Person-related beliefs (PRB)

33. I believe that student teachers have a role to play in promoting Green IT practices.
34. I believe that student teachers have a role to play in advancing Green IT practices.
35. I believe that student teachers have a role to play in progressing Green IT practices.
36. I believe that student teachers have a role to play in furthering Green IT practices.

Construct: Behaviour (B)

37. I teach Green IT.
38. I instruct Green IT.
39. I lecture Green IT.
40. I coach Green IT.

3.4 Ethics

Ethical clearance was required from the University of South Africa (Unisa) in order to carry out the research. The ethical clearance required permission firstly from each teacher-training institution participating in the study. Once these permissions were obtained, ethical clearance was obtained from the Unisa School of Computing. Thereafter, each individual respondent was required to provide informed consent as part of the questionnaire. To ensure confidentiality and anonymity, the names of the respondents and institutions are not revealed in any part of this paper. In addition, respondents' participation was voluntary and respondents were allowed to withdraw from the study.

4 RESULTS AND DISCUSSION

4.1 Reliability

The reliability of the questionnaire items was tested using Cronbach's alpha. The Cronbach alpha was used to assess the internal consistency between the different items that measure each construct in the research model. To improve the reliability of the questionnaire, two pilot studies were done. The first used a sample of twenty-five and the second a sample of fifteen student teachers that were representative of the respondents for the main study. After each pilot study, minor improvements were made to the questionnaire items. Table 3 shows the Cronbach alpha coefficients for all the constructs defined and measured in the questionnaire and based on the data from the main study. The Cronbach values are above 0.7 which means that they are considered reliable for measuring the constructs of the study [57].

Table 3: Reliability analysis of the questionnaire items measuring each construct

Construct	Cronbach Alpha
Attitude toward behaviour (ATB)	0.741
Subjective norm(SN)	0.833
Perceived behavioural control (PBC)	0.880
Behavioural beliefs (BB)	0.773
Normative beliefs (NB)	0.896
Control beliefs (CB)	0.856
Behavioural intention (BI)	0.904
Level of awareness (LA)	0.903
Person-related beliefs (PRB)	0.886
Behaviour (B)	0.939

4.2 Data Collection and Handling

Data collection for the main study started on the 4th of April 2018 and ended on the 20th April 2018. Data were collected from three teacher training institutions in Swaziland as explained and justified in section 3.2. Importantly, respondents who took part in any of the two pilot studies were excluded from the main study. In total, three hundred student teachers completed the online survey for the main study, which was administered by the researcher using Google Forms.

After data collection, data cleaning was performed. The purpose of data cleaning is to identify and remove errors and inconsistences which are caused by inaccurate entry [58]. Incomplete data or irrelevant data is identified and then either replaced or modified or deleted, as appropriate. The only changes that were made to the data were to demographic data items from Section A in the questionnaire. For example, one respondent entered "lesbian" for gender and since "lesbian" is a sexual orientation and not a gender it was changed to "I do not want to answer this question".

Data cleaning was done in a Microsoft Excel file before it was imported into SPSS. SPSS, actually IBM SPSS Statistics, is a statistical package for the social sciences and a widely-used

commercial software package used for statistical analysis. SPSS was used for all the statistical analyses in the study except the structural equation modeling (SEM) processing.

4.3 Respondent Demographics

A total of three hundred online survey questionnaires were completed by student teachers. A summary of the demographic information of the respondents is shown in Table 4. The researcher met each respondent in person and had them complete the questionnaire at the same time, which resulted in all the responses being complete and suitable for analysis, following the aforementioned data cleaning.

Table 4: Demographic profile of sample

Item	Variable description	Freq.	%
Gender	Male	124	41.3 %
	Female	174	58.0 %
	I do not want to answer	2	0.7 %
	Total	300	100%
Home language	Swazi	293	97.7%
	English	6	2.0%
	Zulu	1	0.3%
	Total	300	100%
Age	16-20	18	6.0%
	21-25	105	35.0%
	26-30	67	22.3%
	31-35	30	10.0%
	36-40	17	5.7%
	Above 40	6	2.0%
	I do not want to answer this question	57	19.0%
	Total	300	100%
Year level of subjects/modules/courses	First year subject/modules/courses	57	19.0%
	Second year subject/modules/courses	84	28.0%
	Third year subject/modules/courses	156	52.0%
	I do not want to answer this question	3	1.0%
	Total	300	100%
Teaching grade range	Early childhood grades	65	21.7%
	Primary school grades	184	61.3%
	Secondary school grades	48	16%
	I do not want to answer This question	5	1.7%
	Total	300	100%
Subject category	Languages	64	21.3%
	Mathematics	87	29.0%
	Physical Education	7	2.3%
	Arts	14	4.7%
	Special Education	10	3.3%
	Computers	20	6.7%
	Social Science	42	14.0%
	Natural Science	27	9.0%
	Other	24	8.0%
	I do not want to answer this question	5	1.7%
	Total	300	100%
Qualification registered	Early childhood education diploma	81	27.0%
	Primary teacher's diploma	130	43.3%
	Secondary teacher's diploma	42	14.0%
	Bachelor of special and inclusive education	42	14.0%
	Other	5	1.7%
	Total	300	100%
Practical teaching experience (in months)	0 - 48	222	74.0%
	49 - 96	13	43.3%
	97 -144	2	0.7%
	145 - 192	2	0.7%
	193 - 240	2	1.0%
	Above 240	1	0.3%
	I do not want to answer this question	58	19.3%
	Total	300	100%

4.4 Exploratory Factor Analysis

Factor analysis can be categorised into two types, namely exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) [72]. EFA is appropriate when it is believed that one or more latent factors exist and they exert a directional influence on the observed variables [65]. EFA was performed to find out if the questionnaire items load onto the constructs identified [19]. Thus, EFA helps to evaluate construct validity [72], convergent, discriminant and face validity.

Before the EFA proceeded, a Kaiser-Meyer-Olkin (KMO) Test was done to measure how suited the data was for factor analysis [27]. The KMO value ranges from 0 to 1 [37]. A KMO value greater than 0.5 shows a strong correlation structure between items and provides good justification to do EFA. The KMO value obtained was 0.847, which implies a strong support for conducting EFA. Within SPSS, the factors were extracted using principal components analysis [19, 40, 63].

Fig. 2 shows the resultant EFA scree plot and plots the eigenvalue for each factor. The first ten factors have eigenvalues greater than one and there is an inflection point at factor eleven, which suggests that the first ten factors account for most of the total variance within the data [63].

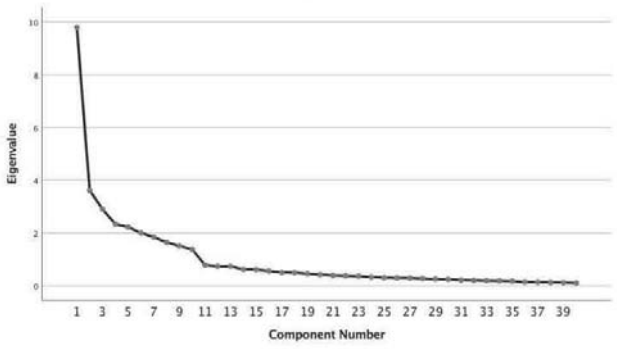

Figure 2: Scree Plot.

Furthermore, Table 5 shows the rotated matrix with factor loadings. The purpose of factor loadings is to ascertain how the items of the questionnaire load onto the factors [27]. A factor that that has no items that load onto it is usually discarded [63]. Furthermore, a loading of 0.40 on a factor can be considered meaningful [27]. Importantly, the table corresponds to the groupings of the items on the questionnaire providing support for the study's research model and the items used to measure each construct.

Table 5: Rotated matrix with factor loadings

Rotated Component Matrix[a]										
Construct & Item	Component									
	1	2	3	4	5	6	7	8	9	10
B39	.91									
B38	.89									
B40	.88									
B37	.87									
LA31		.86								
LA30		.84								
LA29		.81								
LA32		.80								
NB20			.79							
NB17			.78							
NB18			.78							
NB19			.78							
PRB33				.87						
PRB35				.85						
PRB34				.82						
PRB36				.75						
BI27					.81					
BI25					.78					
BI26					.78					
BI28					.78					
PBC10						.84				
PBC11						.81				
PBC9						.79				
PBC12						.74				
CB23							.88			
CB24							.87			
CB22							.85			
CB21							.71			
SN7								.82		
SN8								.81		
SN5								.75		
SN6								.74		
BB15									.83	
BB14									.83	
BB16									.67	
BB13									.67	
ATB2										.77
ATB4										.72
ATB3										.71
ATB1										.69

Extraction method: Principal components analysis
a.10 components extracted.

4.5 Structural Equation Modeling (SEM)

4.5.1 SEM software and version used to fit the model. While SPSS was used for all the preceding statistical analyses, it was not used for the SEM analysis because the researcher did not have access to the AMOS statistical software, which is an added SPSS module that has SEM processing features. AMOS is an acronym for analysis of moment structures.

The SEM analysis was run on the lavaan version 0.6-1 software package [64], which is free, well-tested and commercial-quality software for latent variable modelling. lavaan is an acronym for latent variable analysis. lavaan is implemented as an R package and R is a well-established language and environment for statistical computing and graphics.

4.5.2 SEM model fit measures and criteria. Model fit addresses how well the SEM model fits the sampled data to ensure that there is not a large discrepancy between the observed and theoretical relations [8]. lavaan, using the maximum likelihood (ML) method, provided a number of model fit indices that point to an acceptable fit when considered together with the study's extensive theoretical evidence from the literature that supports the research model. Nevertheless, there were a few indices indicating that there may be other models, statistically, which could provide better fits. This provides opportunities for future research, but would still require ample complementary theoretical justification to support any alternative model.

The first model fit index is the chi-square test statistic, which is an absolute or predictive fit index. The chi-square test values were $\chi2(716) = 1382.615$, $p < 0.001$. Subsequently, the ratio of the chi-square test statistic divided by the degrees of freedom (CMIN/df) = 1382.615 / 716 = 1.931 was below the maximum recommended value of 3 to suggest a good fit [66]. Furthermore, the root mean squared error of approximation (RMSEA) = 0.056 (90% confidence interval = 0.051-0.060), which was below the maximum recommended value of 0.06 [35, 66] to suggest an acceptable fit. These two indices suggest an acceptable fit. In addition, the comparative fit index (CFI) = 0.907 was above the minimum recommended value of 0.90 and close to the cut-off value of 0.95 [35] to suggest an acceptable fit.

However, the Tucker-Lewis index (TLI) or non-normed fit index (NNFI) = 0.899 was just below the minimum recommended value of 0.90 required for an acceptable fit and away from the cut-off value of 0.95 [35] and the standardized root mean squared residual (SRMR) = 0.110 was above the maximum recommended value of 0.08 required for an acceptable fit and above the cut-off value of 0.09 [35]. These two indices indicate that there may be other models, statistically, that could provide better fits.

Nevertheless, since the ratio CMIN/df, RMSEA and CFI suggest an acceptable fit and the study has provided extensive theoretical evidence from the literature to support the research model, investigating alternative models with optimal index values is left for future research and would still require ample complementary theoretical justification to support any

alternative model. Importantly, there was enough statistical support to proceed with the SEM model for the purposes of the study.

4.5.3 SEM model parameter estimates. Fig. 3 depicts the research model following the SEM processing, comprising the model's latent variables or constructs represented by circles and solid and dashed lines with arrows that represent the hypothesized relationships among the latent variables. A solid line indicates that there is a statistically significant influence where p < 0.05 and a dashed line indicates the influence is not statistically significant where p >= 0.05. The direction of an influence of one latent variable on another is represented by the direction of the corresponding single-headed arrow.

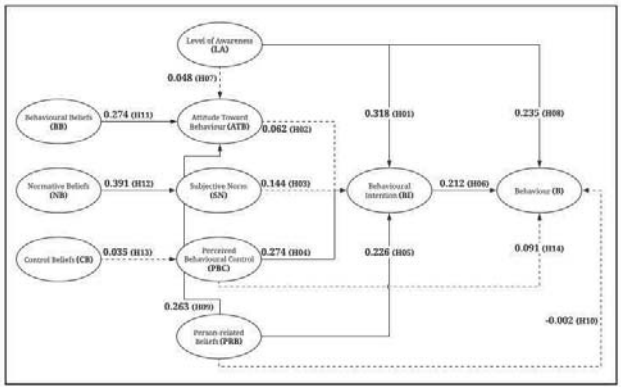

Figure 3: SEM results for the study's research model.

Table 6 below is the lavaan output showing the parameter estimates of the SEM model. The column labelled "Estimate" contains the unstandardized linear regression coefficients for each set of independent and dependent variables. The column labelled "Std.Err" contains the standard error values of the estimates and is a measure of the accuracy of the estimates where lower values indicate better accuracy. The column labelled "z-value" contains values equal to the "Estimate" values divided by the "Std.Err" values. In lavaan, the "z-values" are based on the Wald test and provide a measure of how many standard deviations away, negative or positive, from the mean of zero an estimate is.

The column labelled "P(>|z|)" contains the probability value between zero and one inclusive of obtaining the corresponding estimate when its null hypothesis is true. This is also known as the p-value and if it is below the specified significance level of 5% or alpha of 0.05, then the probability is very low that the estimate could be observed if the null hypothesis is true, so, the null hypothesis is rejected when p < 0.05. Similarly, the null hypothesis is not rejected when p >= 0.05. In Fig. 3, where a p-value >= 0.05 for a relationship between two constructs as hypothesized by the research model, then the relationship is not statistically significant and represented by a dashed line. Where the p-value < 0.05 for a relationship, then the relationship is statistically significant and represented by a solid line. Only statistically significant relationships are regarded as having an influence in the model.

The column labelled "Std.lv" contains the standardized estimate values with a mean of zero and a standard deviation of one. These standardized estimate values are shown in Fig. 3 for each relationship between two constructs as hypothesized by the research model. The applicable hypothesis number is also shown in brackets next to each standardized estimate value in Fig. 3.

Table 6: lavaan output showing the parameter estimates of the SEM model

Dependent Variable	Independent Variable	Estimate	Std.Err	z-value	P(>|z|)	Std.lv
ATB	BB	0.304	0.096	3.160	0.002	0.274
ATB	PRB	0.293	0.106	2.749	0.006	0.263
ATB	LA	0.054	0.075	0.713	0.476	0.048
SN	NB	0.424	0.109	3.899	0.000	0.391
PBC	CB	0.035	0.071	0.489	0.625	0.035
BI	PRB	0.276	0.082	3.370	0.001	0.226
BI	PBC	0.335	0.107	3.128	0.002	0.274
BI	SN	0.163	0.084	1.934	0.053	0.144
BI	ATB	0.068	0.072	0.946	0.344	0.062
BI	LA	0.389	0.107	3.648	0.000	0.318
B	LA	0.256	0.083	3.083	0.002	0.235
B	BI	0.189	0.069	2.742	0.006	0.212
B	PBC	0.099	0.076	1.305	0.192	0.091
B	PRB	-0.002	0.073	-0.024	0.981	-0.002

From the SEM results in Fig. 3, for the study's research model, the following null hypotheses are rejected indicating statistically significant relationships H01 (LA->BI), H04 (PBC->BI), H05 (PRB->BI), H06 (BI->B), H08 (LA->B), H09 (PRB->ATB), H11 (BB->ATB) and H12 (NB->SN). However, the following null hypotheses are not rejected indicating relationships that are not statistically significant H02 (ATB->BI), H03 (SN->BI), H07 (LA->ATB), H10 (PRB->B), H13 (CB->PBC) and H14 (PBC->B).

Among the statistically significant relationships, Table 7 below shows that the standardized estimates range in value from 0.212 to 0.391 with the highest influence being NB on SN and the lowest influence being BI on B.

Table 7: Ranking of the standardized estimates for the statistically significant relationships

Dependent Variable	Independent Variable	Std.lv (in descending order)
SN	NB	0.391
BI	LA	0.318
ATB	BB	0.274
BI	PBC	0.274
ATB	PRB	0.263
B	LA	0.235
BI	PRB	0.226
B	BI	0.212

The preceding SEM is important for the study and academics as it presents a method to specify and analyse the structural

relationships hypothesized between theoretical constructs. This enabled the study's objective to be met and provided the required insights about which relationships among the constructs have significant influence to improve the outcome behaviour of teaching Green IT.

The SEM model is also important for education management because it emphasizes where focus and resources would be best allocated for improving the teaching of Green IT. According to Fig. 3, allocating time and resources to improve the student teachers' level of awareness (LA), perceived behavioural control (PBC) and person-related beliefs (PRB) would positively influence the student teachers' intention to teach Green IT, which would, in turn, positively influence their actual behaviour of teaching Green IT.

5 CONCLUSIONS

There is abundant scientific evidence that the natural environment, on which we completely depend for life, is degrading and depleting to the extent that our medium- to long-term well-being and existence is under threat. It is also clear that IT is contributing to this degradation and depletion, which requires that Green IT practices be an imperative. Since Green IT practices are often not common sense, it is vital that these Green IT practices are taught to others, and teachers typically have the skills and opportunities to teach many people. This demonstrates the relevance and significance of the study.

The study's research question was what aspects should be focused on to improve the teaching of Green IT? Thus, the study's research objective was to investigate the antecedents to teaching Green IT in an African country context, in order to understand how to improve student teachers' intention to teach Green IT, and consequently, their actual behaviour of teaching Green IT.

The literature provided extensive theoretical support for an a priori set of antecedents and their hypothesized relationships for the behaviour of teaching Green IT, as specified in Fig. 1. SEM provided the method to specify and analyse these hypothesized relationships and to provide the required insight about which relationships have a significant influence relating to the outcome behaviour of teaching Green IT.

Therefore, according to Fig. 3 and to answer the study's research question, the aspects that should be focused on to improve the teaching of Green IT are the student teachers' level of awareness, perceived behavioural control and person-related beliefs to improve their intention to teach Green IT, and, in turn, improve their teaching of Green IT.

Nonetheless, the study has limitations, which include its African country context, its purposive sampling method and the SEM model fit indices that were outside of guideline levels. While the study's African country context is important since there was very little relevant research evident in African countries and Africa is a continent that is especially vulnerable to global warming and environmental degradation, it would be useful to test the model in other countries for further refinement. In addition, future research could include implementing random sampling where practically possible to promote generalisations and modifying the SEM model for better fit indices where appropriate theoretical justification can be found.

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