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Emerging Case Oriented Agents for Sustaining Educational Institutions Going Green towards Environmental Responsibility

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Abstract

Purpose

The aim of this research is to design a system deployment model that integrates case based-agent technique to develop an eco-responsibility decision support tool for Greening educational institutions towards environmental responsibility.

Design/methodology/approach

Data was collected by employing questionnaire from a statistical population that comprises of practitioners across educational institutions in Malaysia that implement Green practices to measure the feasibility of the developed tool based on factors derived from the literature. Accordingly, descriptive, exploratory, and factor analysis approach using Statistical Package for Social Sciences (SPSS) was employed to test the feasibility of the developed tool.

Findings

Results from descriptive analysis confirms the tool is feasible based on mean values which ranges from 4.1619 to 3.6508 on a 5 point scale indicating that the tool is effective in sustaining educational institutions going Green. Besides, results from exploratory analysis verifies the reliability of the tool based on the acceptable Cronbach's alpha reliability coefficient score higher than 0.7 and Kaiser-Meyer-Olkin (KMO) value being above 0.5. Finally, results from factor analysis reveal that the developed tool is usable, efficient, helpful, flexible, credible, and supports educational institutions in going Green at 88.44 percent of the total variance.

Research limitations/implications

The sample population in this study comprises only practitioners in educational institution in Malaysia. Theoretically, this research provides feasibility factors and associated items that can be employed in evaluating developed information systems.

Practical implications

Practically, this study develops an eco-responsibility decision support tool to facilitate Green implementation that provides information on how practitioners in educational institutions can adopt Green practices.

Social implications

Technically, this study shows how case oriented agents aid educational institutions in going Green for environmental responsibility. Socially, this research provides the dimension or process for Green practice implementation in educational institution towards environmental responsibility.

Originality/value

The eco-responsibility decision support tool provides a web based platform for promoting ecological protection by supporting the measuring of practitioners' current Green practices for environmental responsibility. Thus, research findings of this study are expected to help decision makers to generate useful insights into environmental friendly strategies to be implemented in educational institution. Lastly, the statistical tests employed in this paper can be employed in testing the feasibility of information system application in future.

Keywords**:** Sustainability; Green practice; Environmental responsibility; Feasibility study; Case oriented agents; Educational institutions.

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1. Introduction

Humanity is faced with several environmental issues ranging from natural environment damage, climate change and natural resources depiction (Nifa *et al*., 2015). Accordingly, the number of users in university campuses prompts for more sustainable methods in the usage of Information Technologies (IT) infrastructure deployed (Ramli *et al*., 2014). Presently, there exist pressures from governmental and non-governmental associations that motives universities to implement Green practices into their institutional process there by supporting environmental responsibility (Ulkhaq *et al*., 2016). Therefore, several approaches have been proposed such as ISO 14000 framework and UI Green Metric which currently assess and rates universities in achieving environmental sustainability (Sonetti *et al*., 2016). These approaches serve as guide to direct universities towards going Green, but actually do not provide comprehensive information needed to implement Green practices (Anthony, 2016). Although ISO 14000 framework and UI Green Metric do evaluates campus Green practices based on their in-house assessment procedures, they do not provide an autonomous approach to evaluate campus Green initiatives (ISO, 2004a; UI Green Metric, 2016) .

Therefore, this study proposed two Artificial Intelligence (AI) techniques that can be deployed to support university campus Green practice for environmental responsibility. Correspondingly, this research integrates software agent to assess university campuses current Green practice implementation and Case Based Reasoning (CBR) to provide best practices support to enhance campus environmental responsibility. Respectively, an agent is a software program that can perceive its environment via sensors and executing upon that environment over effectors (Olsson and Funk, 2009). Wooldridge and Jennings (1995) define software agents as a software or hardware system with reactive, autonomous, pro-active and social abilities characteristics. Agent technology offers a procedure that enables flexible communications with other agents, humans and systems (Jnr *et al*., 2017b). Likewise, Case based Reasoning (CBR) is one of the emerging techniques for deploying intelligent systems (Chang *et al*., 2016). CBR addresses new problems by using previously successful solutions to similar problems (Jahani *et al*., 2015).

Currently, university campuses are implementing Green practices to promote environmental responsibility towards attaining sustainability (Nifa *et al*., 2015). But at the moment there is need for tool to adequately provide up-to-date information on how Green practices can be implemented in university campuses (Anthony Jr *et al*., 2018). Furthermore, practitioners in universities utilize manual based evaluation of their current Green practices. Therefore, this article presents the Green dimension or process to be implemented and also develops a system deployment model that integrates software agent and CBR to implements an eco-responsibility decision support tool that provides information on how university campuses can adopt Green practices. In addition, the tool autonomously assesses benchmarks and rate the current Green practices implemented in university campus. The structure of this paper is organized as follows: Section 2 presents the theoretical background. Section 3 is the proposed system deployment model. Section 4 is results and discussion. Section 5 is the implications of study. The final section is the conclusion, limitation and future works.

2. Theoretical Background

2.1. Overview of Agent Technology

Agent is a software program that can be applied to support university campus Green practice. An agent makes decisions based on co-ordination of other individual agents in a collaborative environment (Shen *et al*., 2015), as seen in Figure 1.

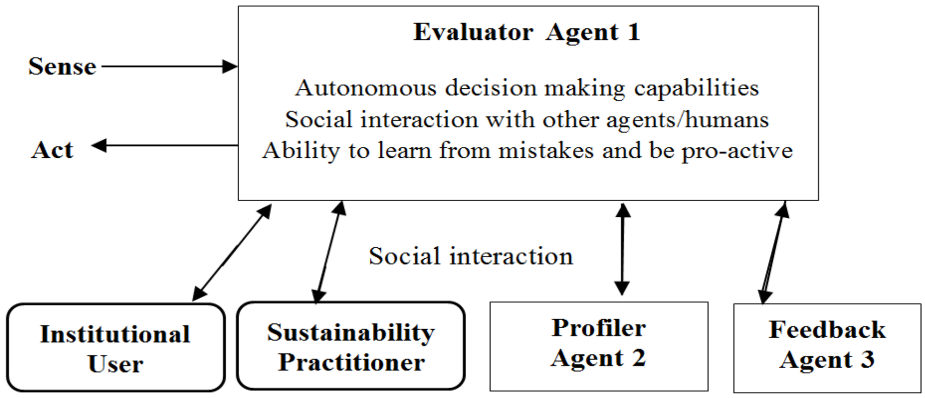

Figure 1 Agent in its environment

Accordingly, Figure 1 shows an example of an agent (evaluator agent) that can sense and act to its environment. It can also interact and communicates with other agents (profiler and feedback agent) and humans (institutional users and sustainability practitioner). Agents are influenced by several characteristics which include autonomy which is the capability of an agent to execute self-determining decisions (Sissa *et al*., 2012). Agents possess social ability features which are the capability of agents to communicate with other agents as well as end user (Jnr *et al*., 2017b). Agent is also reactive (Chang *et al*., 2016), hence they respond to changes in their surrounding environment, and lastly they are proactive and as such agents can initiative different functions (Farooq *et al*., 2009) such as Green practice measurement.

2.2. Background of Case Based Reasoning (CBR)

CBR is a technique based on utilizing past knowledge or experience for solving problem and making decision (Cheng and Ma, 2015). It involves the searching of solutions to new problems using previously addressed problems (Chang *et al*., 2015). CBR comprises reusing past solutions in new scenarios based on a similarity measure algorithm utilized for searching and retrieving similar cases which are defined in terms of case problem and solution parameters (Jnr *et al*., 2017b). The similarity measure aids the CBR method to detect the cases that are most related to the problem (Farooq *et al*., 2009).

Figure 2 shows the CBR cycle where a case is searched to provide solution for a new problem from a case base that contains best practices of cases that matches the already existing cases in the case base library (Wu and Zang, 2009). CBR is based on four steps which include retrieval, reuse, revise, and retaining of cases (Chang *et al*., 2015) as seen in Figure 2. The parameters can be attributed to a non-numeric or numeric value. The CBR similarity uses algorithm measure such as Nearest Neighbor (NN) algorithm which uses Structured Query

Language (SQL) to match a searched query against a set of cases in the case base by calculating the similarities that exist between new problem and saved solution case (Yang *et al.,* 2013).

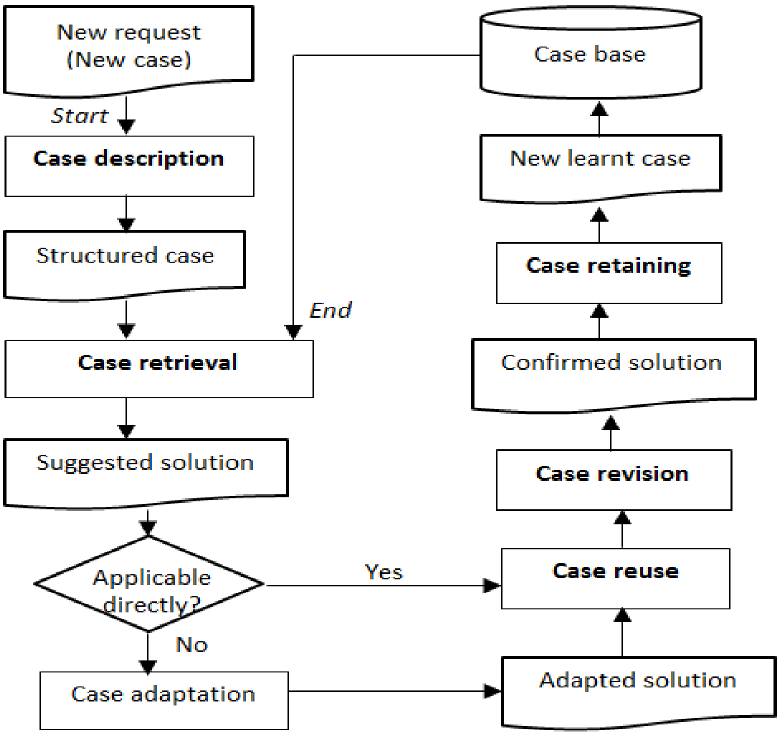

Figure 2 CBR Cycle

Thus, CBR uses case similarity procedures to identify and measure cases that are similar in terms of the case parameter weights. Case parameter similarities measures in CBR involve the use of non-numeric values in calculating the parameter similarity between two strings (searched keyword and data in the case base).

2.3. Review of Techniques Applied for Green Practice

Presently several techniques has been utilized by researcher in implementing Green practice. These techniques have been previously utilized by a few researchers to assist organizations go Green by reducing water consumption, energy utilization, cost reduction and at the same time caring for the environment. Table 1 presents existing research that addresses the feasibility of related techniques applied for Green practice

Table 1 Review of existing techniques applied for Green practice

#	Authors, Year and Research	Technique (s) Applied	Contributions
1	Romli *et al.* (2015) developed an Eco-CBR method for aiding Green product design.	CBR	This approach is intended to be used to help industrial decision makers propose Green production solutions by reusing Green solutions from similar cases.
2	Chen and Ma (2015) developed a non-linear CBR approach for retrieving cases and selection of target credits in projects.	CBR	Provide project designers with references of previous cases for new Green building projects, so that they can learn and utilize good best practices from the past.
3	Huang and Lin (2013) designed an agent-based Green web service selection and dynamic speed scaling.	Software agent	Reduce cost and energy consumption associated with IT systems and services, since energy efficiency is becoming a critical concern.

4	Silva *et al.* (2013) developed group decision approach to adopt Green IT Practices	Strength, Weakness, Opportunity, Threat (S.W.O.T) analysis	Support decision process of adopting Green practices by group decision since SWOT analysis is an essential tool for strategic decision-making.
5	Jeong *et al.* (2013) propose an approximate life cycle assessment (LCA) method	Analytical Hierarchy Process (AHP) and CBR	Presented the approximate method for a rapid and convenient environmental evaluation in product development.
6	Rogers *et al.* (2013) developed a garbage can model of decision making.	Software agent	Investigated how Green may also impact decision making when constructing IT projects.
7	Bai and Sarkis (2013) designed a fuzzy approach to achieve Green data center.	Fuzzy logic	The fuzzy based approach for decision system using fuzzy numbers to help rank sustainability strategies.
8	Sissa (2012) integrated agent for sustainable ICT services toward ecological sustainability	Software agent	The agent approach aid to investigate socio environmental operation in understanding IT usage and their effects on the environment.
9	Ghazalli and Murata (2011) implemented an assessment model for remanufacturing end of life choice strategy.	AHP and CBR	The authors incorporated AHP with CBR and used the NN algorithm to retrieve past cases that are closest to the current case under consideration.
10	Wang *et al.* (2011) proposed a CBR model to aid retailing operations for going Green.	CBR	Provide methods in facilitating and improving their Green activities in the relevant process.
11	Kuo (2010) provided an intelligent decision support method for product recycling schemes.	AHP and CBR	Practitioners can retrieve and use experiences from past cases to carryout recycling activities and end of life strategies.
12	Pawlish and Varde (2010) worked on a decision support system for Green data centers.	CBR and Decision trees	Enabled better decision-making to create energy efficient data centers heading towards a Greener and more sustainable environment.
13	Deng *et al.* (2009) suggested a fuzzy logic based decision model	Fuzzy logic	To help practitioners better pursuit Green practices.
14	Ciocoiu and Ciolac (2009) developed an automated framework for Green IT classification	Software agents	Assist in Green IT investment decisions.

Table 1 reviews existing techniques applied to aid Green practice aimed at attaining sustainability. It can be deduced from the review that the existing studies only developed or suggested the technique to address issues related to Green practice. However, none of the authors applied the technique(s) to assess current Green practice. It is imperative that there is need for a technique(s) that will assess benchmark and rate the current Green practice.

2.4. Eco-Friendly Practice Implementation in Higher Educational Institutions

Eco-friendly practice implementation comprises of Green creation, Green distribution, Green sourcing, Green usage, end of life and water management. Accordingly, Green creation in university campuses involves synthesizing, analyzing and designing ecological friendly services as well as products with less energy (Saha, 2014). Besides, Green creation aims to decrease use of non-renewable resources, manage non-renewable resources utilization to reduce toxic emissions to the environment (Rahim and Rahman, 2013). Likewise, Green distribution refers to procedures which use systems with limited low environmental effects, which are highly proficient, towards little or no waste generated (Raza *et al*., 2012). Moreover, Green distribution encompasses non-pollutant delivery procedures to encourage negligible waste formation, which enhances energy efficiency thereby lowering electricity utilization (Jnr *et al*., 2017a).

In addition, Green sourcing encompasses buying only electronic products having labels such as Environmental Protection Agency (EPA) energy star, Tjänstemannens Central-Organization (TCO 95) (Sweden), Blue Angel (Germany) label, etc. (Anthony *et al*., 2018). Similarly, Green usage mainly aims to save power, which in turn leads to decreased pollutants for a healthy society (Saha, 2014). Hence, Green usage initiatives helps to reduce energy utilization of computers and other IT infrastructures as well as utilizing them in an ecologically sound and proficient manner (Chen *et al*., 2008). Furthermore, end of life relates to policies that reduce e-waste by repairing, re-deploying, or disposing, refurbishing, retaining, reusing of outdated IT hardware in an environmentally friendly manner (Anthony *et al*., 2018).

Lastly, water management aims to ensure ethical use of water within university operations by implementing efficient water consumption (Jnr *et al*., 2018). Water management practice also aims to prevent water pollution and contamination from campus daily operations by saving water and installing rainwater harvesting catchment to collect rainwater (Ayog *et al*., 2015). Correspondingly, the implemented eco-responsibility decision support tool (see Figure 6) measures institutions Green practice based on Green creation, Green distribution, Green sourcing, Green usage, end of life and water management. In addition, the tool provides best practice support in relation to these eco-friendly processes described in this Section.

2.5. Comparison of Green Assessment Tools

One of the main challenges confronting university campuses today is defining and achieving sustainability goals which includes identifying and developing Green operational standards and best practices, and most significantly, measuring and assessing the current Green practices against those best practices. Accordingly, Hankel *et al.* (2017) also developed a self-assessment model that supports enterprise to assess their readiness to implement Green ICT by considering attitude, policy, practice, technology and governance as independent variables that influences Green ICT adoption. However the authors did not considered the Green process to be implemented. Likewise, Hankel and Lago (2016) designed a maturity model to aid enhance the use of Green ICT within the organization by assessing the level of maturity of Green ICT promotes awareness and motivation.

Likewise, Foogooa and Dookhitram (2014) proposed a self-Green ICT maturity assessment tool for small and medium based enterprise which is simple, easily accessible and also efficient, besides the assessment questions were simply understood and the answers could be easily categorized. Moreover, for the self-assessment tool to be functional there is need for a minimal ICT knowledge from the practitioners. Muladi and Surendo (2014) also designed a self-assessment questionnaire for rating Green IT Implementation in organizations based on ISO/IEC 15504 rating scale which consisted of strategy, technology, process and man as variables to be measured. Odeh and Meszaros (2012) developed a model that incorporates a rating approach for recognizing, informing and guiding IT based enterprise toward sustainability attainment. Their rating model is comprised of innovative recognition, economic security, environmental preservation and social responsibility.

Lastly, Jain *et al.* (2011) proposed utilizing Balanced Score Card (BSC) to analyze the current Green IT initiatives implemented in enterprise aimed at achieving sustainability. The BSC aimed at translating enterprise's managerial goal into a set of sustainability performance procedures for Green IT evaluation success. Respectively, Table 2 shows a comparison and evaluation of existing Green assessment tools, based on the assessment method, capability of the tool in carrying out Green assessment, evaluation, benchmark and rating. In addition, the comparison of the tool comprises of the ability of the tool to provide sustainability reporting, providing certification and lastly providing best practice suggestion. Accordingly, it can be seen that only the proposed tool is automated whereas the other tool are mainly manual based. In addition, our proposed tool performs all the functionalities as compared to the other existing tools as presented in Table 2.

Table 2 Evaluation of Green assessment tools

Green Assessment Approaches	Assessment Method	Performs Evaluation	Implements Benchmark	Implements Rating	Sustainability Reporting	Provides Certification	Best Practice Suggestion
Hankel *et al.* (2017) developed a Green ICT self-assessment model.	Manual Questionnaire	✓	✓	✓	✓	✕	✕
Hankel and Lago (2016) designed a Green ICT maturity model.	Manual Questionnaire	✓	✓	✓	✓	✕	✓
Foogooa and Dookhitram (2014) proposed a self-Green ICT maturity assessment tool.	Manual Check List	✓	✓	✓	✓	✕	✓
Muladi and Surendo (2014) also designed a self-assessment questionnaire.	Manual Questionnaire	✓	✓	✕	✕	✕	✕
Odeh and Meszaros (2012) Green IT Rating Model.	Manual Questionnaire	✕	✓	✓	✓	✕	✓
Jain *et al.* (2011) proposed balanced scorecard for assessing Green IT initiatives.	Manual using Balance scorecard	✕	✕	✕	✓	✕	✓
Eco-responsibility decision support tool (2018)	Autonomous Web Based	✓	✓	✓	✓	✓	✓

Based on the review of prior studies in Table 2, it can be seen that the current methods adopts a monotonous assessment method, as assessors need to design question papers and carryout the assessment at a particular venue, which may or may not be suitable to practitioners. Hence an automated Green assessment model or tool is needed to replace the self-assessment manual approach as suggested by (Park *et al*., 2012). Accordingly, this study implements the eco-responsibility decision support tool to provide an autonomous web based assessment method. Our tool performs evaluation, implements benchmark based on ISO/IEC 15504 rating scale similar to Muladi and Surendo (2014) as well as implements rating, provides reporting, certification and lastly provides best practice suggestions on how practitioners in university campuses can improve Green practice initiatives.

3. Proposed System Deployment Model

This study proposes a case oriented agent model by deploying software agent and CBR to facilitate educational institutions going Green towards environmental responsibility. Accordingly, Figure 3 depicts the system deployment model based on case oriented agents. The agents collaborate and interact to support eco-friendly practices in educational institutions by sharing knowledge for eco-friendly practices to be implemented. The case oriented agent model employs CBR to support institutional users gain access to knowledge by retrieving past solved cases, adapting these cases to solve current problem thus assisting decision making of users. The application of CBR provides solution by searching the Green case base and comparing the parameters of each case to the present problem to be resolved. It then synthesizes related cases and derives the final solution by modifying the differences between the current problem and the solution described in the Green case base as seen in Figure 3.

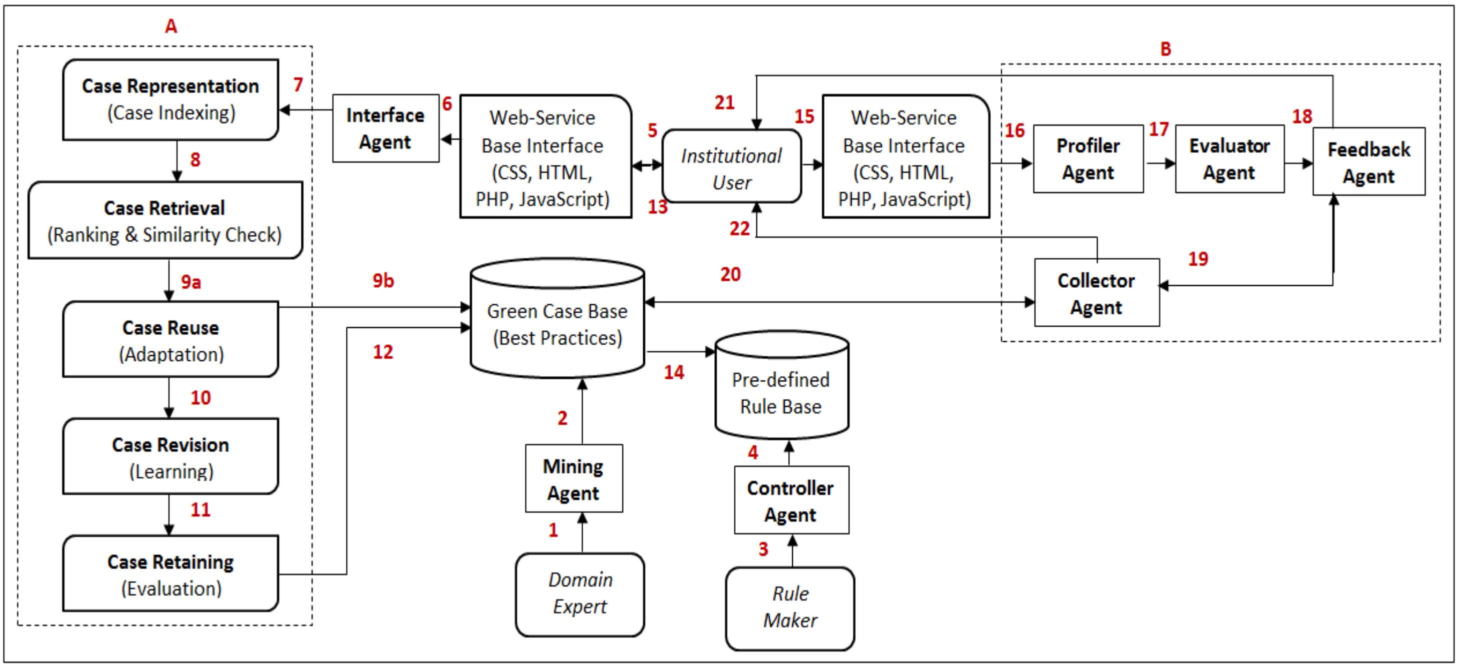

Figure 3 System deployment model

Figure 3 shows the system deployment model that integrates CBR and agents to facilitate decision support to institutional users towards adopting eco-friendly practices. The system deployment model is further described below;

3.1. System Deployment Model Description

Accordingly, Figure 3 depicts the application of software agents and CBR to develop the system deployment model to aid university campus go Green. The "**A**" portion shows how CBR technique is applied to facilitate practitioners in university campuses implement Green practices by providing best practice information. Whereas the "**B**" portion shows the software agents that communicates to assess, benchmark and rate the current Green practice implemented by practitioners in university campuses for environmental responsibility.

1-The domain experts who have experience on Green practice add new information which comprises of Green creation, Green distribution, Green sourcing, Green usage, end of life and

water management initiatives on how university campuses can go Green (see Section 2.4). They also add Green assessment questions and respective answers.
2-Mining agent saves all data into the Green case base as best practices.
3-Rule maker usually the system administrators set pre-defines rules to provide Green solution to practitioners when the Green case base do not provide any usable answer or when it is empty.
4-Controller agent adds all set rules to the pre-defined rule base.
5-Practitioners search for information on Green practice through the web-service base interface developed by programming languages such as CSS, HTML, PHP MySQL and JavaScript.
6-Interface agent executes the search query using Structured Query Language (SQL).
7-The case representation is called using case indexing to search for similar case
8-This leads to case retrieval where the cases in the Green case base are checked based weighting of case parameters after which the cases are ranked based on which case is more similar.
9ab-The case can be reused by practitioners in implementing Green practices or the solution can also be adapted to suits its situation after which the case is saved to the Green case base.
10- The adaptation of an existing case then lead to the revision of the existing case in the Green case base. This will assist the tool learn of the new or adapted solution.
11- The adapted case is retained, but before retaining the case. The tool evaluates the prior case with the new case to ascertain which case should be saved to the Green case base.
12- Next after the case retaining and evaluation, the case is saved.
13- The retrieved case is display to practitioners through the web-service base interface.
14- If not similar case is retrieved from the Green case base, the system retrieves a suitable case from the "Pre-defined Rule Base" based on the procedures set by the rule maker.
15- Practitioner request to evaluate current Green practices through the web-service base.
16- The web-service base calls the profiler agent who prompts the practitioner to login to create a session before commencing the Green practice assessment.
17- After practitioner is logged in and takes the Green practice assessment. The evaluator agent assesses benchmarks and scores the user based on the Green questions asked and valid answers provided using a pre-defined benchmark adopted from ISO (2004b) (Not sustainable (0-15%); partially sustainable (>15%-50%); largely sustainable (>50%-85%); fully sustainable (>85%-100%)).
18- Feedback agent collects the assessment sessions information and sends the data to the collector agent.
19-Collector agent saves the assessment session into the Green case base.
20- The practitioner assessment sessions data are saved into the Green case base, so that the information can be retrieved by the user to view his/her university Green practice assessment rating or score.
21- The feedback agent retrieves and displays the evaluation score of the user.
22- The collector agent retrieves and displays Green implementation recommendations to practitioner based on failed Green assessment questions.

3.2. Applicability of CBR in the Deployment System Model

This section describes the feasibility of the CBR in the deployed system model as shown in Figure 3.

3.2.1. Case Representation and Indexing

Accordingly new and past Green practice knowledge are stored in the case base library as shown in equation 1.

$$C(C = \{cncp = 1, 2, 3, \ldots, total\_c\}) \quad (1)$$

Where cn is the n-th previous case, cp is the case parameters and total_c is the total sum of past cases. Each Green implementation case consists of case parameters as seen in Table 3 which shows the case structure. The case number is numerical value assigned to all cases and can range from 1 to nth value. The indexing of n parameters as ith case of the case base is given in equation 2

$$Ci = \sum j\ Pij = (Pi1, Pi2, Pi3, \ldots\ldots Pin)\ldots \quad (2)$$

Where C represents a case and each parameter Pij represents each case index parameter.

Table 3 Case structure and Content

Parameter No	Case parameter	Parameter Value
1	Case number	Integer, from 1 to n.
2	Case index	Vector, {keyword1, keyword n}.
3	Case category	Binary value, private or public.
4	Problem description	Text, including problem domain and problem definition.
5	Successful solution	Text, including possible solution and recommendation steps.

3.2.2. Case Retrieval, Similarity Check and Ranking

The phase aims to discover the best corresponding case by comparing similarity between the new searched case and existing case using NN algorithm for measuring the similarity of the problem case and solution cases as shown in equation 3.

$$similarity\ (NC, RC) = i{=}1\sum nwi * sim\ (NCi, RCi) / i{=}1\sum nwi \quad (3)$$

Where NC is new Green case, RC is retrieved Green case, NCi and RCi are the parameter i of the new Green case NC and RC correspondingly, wi is the weight of case parameter i, and sim (NCi, RCi) is the similarity value of case parameter i. The value of sim (NCi, RCi) is computed as shown in equation 4.

$$sim\ (NCi, RCi) = 1\ |\ NCi-RCi| / |NCi| + |RCi|\ | \quad (4)$$

The similarity check and ranking of the case is based on the weight value assigned to each case parameter as shown in equation 5.

$$dps = \sum kWk\ |\ Xpk - GCsk| \quad (5)$$

Where dps means distance between the problem pth that is searched by the campus user and sth solution cases with reference to the case parameters. W represents the weight assigned to the case parameters. X is the selected case chosen by the user, while GC is the Green case base.

3.2.3. Case Reuse and Adaptation

Once the most similar case is chosen by the practitioner, it will be directly reused as a recommended solution. The similarity between a new problem and an existing Green case retrieved to be reused by the user is calculated as follows:

similarity (sq, gcb) = $\sum$Wi * sim (pi, si).. (6)

Where sq is the search query executed by the campus user, gcb is Green case base and w indicates the weight assigned to case parameters respectively. pi is the problem case and si. Conversely, in most circumstances, the retrieved case is not directly applicable. In this situation the solution presented are not usually applied by the practitioner and are needed to be adapted before they can be applied to solve the current problem. Hence, equation 7 is utilized for case adaptation with an initial value AC(a):

AC(a) = n$\sum$Wac =1 [Sim (a, ac) * AC(ac)] / n (7)

Where AC(ci) is the value of the adapted case ac, n is the number of selected cases adapted and Sim(a,ac) is the solution similarity between the initial case c and adapted case ac.

3.2.4. Case Revision and Learning

This phase involves modifying existing case solution based on the adapted case and also verifies the adapted solution for the new problem by learning about the revised case. Equation 8 describes how a selected solution si is revised based on the survival value PV(si) of the case.

PV (new) (si) = PV (old) (si) + ΔPV (si) (8)

Where

ΔPV (si) = (Sat (si) – 0.45) * L (9)

Where Sat(si) is the representative value of the approval degree of solution selected by the practitioner si, and ‘‘L’’ represents the CBR learning rate, set to 0.1 as suggested by Yang (2013) for gradually modifying SR(si). Accordingly, equation 8 is used to identify the survival value of a selected case solution as such ΔPV (si) in equation 9 is redefined as:

Table 4 Satisfaction degrees and their representation modified from (Yang, 2013)

Satisfaction degree	Representative value
Highly satisfied	0.80
Satisfied	0.65
Moderate	0.45
Unsatisfied	0.25
Highly unsatisfied	0.10

ΔPV (si) = (Sat (l) – 0.45) * Sim (c, a) * l (10)

As seen in Table 4, 0.45 is the moderate satisfaction value for any solution case selected by the user.

3.2.5. Case Retaining and Evaluation

This phase involves storing resulting new cases for future reference in the Green case base as best practice. Although, since the selected case solution si was adapted as AC(a) in equation 7. Thus, equation 3 is not used to retain previous retrieved case instead equation 11 is used for case retaining. Where sinew is the assign a survival value to the adapted case solution and PVave is the averaged survival value of the case in Green case base.

$$PV\ (sinew) = PVave * Sat\ (sinew) \quad (11)$$

$$PVave = n\sum i = 1\ PV\ (si) / n \quad (12)$$

To evaluate which case saves to the Green case base equation 13 is used for case details comparison of old and adapted case.

$$Sim\ (si, ac) = |Ssi \cup Sac| / |Ssi \cap Sac| \quad (13)$$

Where ‘‘ac’’ is the case adapted by the user, ‘‘si’’ is the selected case solution, Sa is the solution part of the adapted case ‘‘ac’’ and Ssi is the solution part of the select case solution‘‘si’’. Sim(si,ac) measures the extent to which the selected case is useful.

3.2.6. Green Case Base and Pre-Define Rule Base

This comprises all the Green cases that have been successfully implemented previously. The Green case base also contains Green assessment questions and answers used to assess practitioners’ current Green practice. Thus, a case Green case base GCB containing n number of cases may be expressed as given in equation 14.

$$GCB=\sum n\ Cn = (C1, C2, C3, \ldots\ldots..Cn)\ldots \quad (14)$$

Furthermore, if there is no direct solution for new problems; solutions can be recommended to be used by existing pre-defined rules added in the rule base by rule experts.

3.3. Eco-Responsibility Decision Support Tool Development

Software agents are deployed in implementing the eco-responsibility decision support tool for Green practice assessment as shown in Figure 3. Thus, each agent implementation algorithm is presented below;

3.3.1. Interface Agent

This agent initiates an algorithm that authenticates the practitioner that intends to take the Green practice assessment as a participant. The interface agent implementation algorithm is shown below;

Input:
Uname, username of participant
Pword, password of participant
Output:
Authentication of participant
Selection of assessment category

Function participant_authentication ( )
Start
1. Get uname and pword of participant
2. Profiler agent sends inputted uname, pword to Green case base for authentication
msg.setArg ("uname",uname);
msg.setArg ("pword",pword);
3. Profiler agent retrieves uname, pword from Green case base using the statement
String query = Select * from practitioners where uname = "username" and pword="password";
4. **if**
(uname, pword received from participant == uname, pword in Green case base);
Then
Participant is valid user;
Else
Participant is not a valid user and interface agent display error message “login is failed”;
5. **If**
(login access is granted and Green practice category selected = Green practice category from options provided);
Start Green practice assessment session ()
Go to Green practice assessment ()
Else
Select assessment category from Green assessment option provided;
Return to participants profile ()
End

3.3.2. Profiler Agent

This agent initiates the Green assessment session algorithm that presents how the assessment session is deployed and executed by the profiler agent. The implementation algorithm for profiler agent is as follows;

Input:
Assessment category, assessment category chosen by participant
Assessment questions, Green assessment questions for assessment category selected
Answers alternatives, assessment alternatives to be selected as preferred answer
Session timer, to keep track of time elapsed during each assessment session
Assessment_question_count, counter to compute Green assessment questions
Participant, user taking the assessment
d∈GP= {Green creation, Green distribution, Green sourcing, Green usage, end of life, water management}
Output:
Assessment alternatives_selected as answer by participant
Begin
Function assessment_session ( )
1. **If** (participant choses to start the Green practice assessment)
Then
Invokes the profiler agents and create a connection with the Green case base
2. **If** (Green case base connectivity is successful)
Then

Profiler agent retrieves Green practice questions randomly from Green case base in relation to the assessment category selected by participant
Using the command below
String query = Select * from assessment_questions where cat_id= "sel_category";
andand -int rnd = rand.next_int{no_of_records in Green case base);
rand_ d∈GP.add_Items{""+rnd);
Else
No retrieval of Green assessment questions and answers
3. **If** (all required ransom Green assessment questions are retrieved)
Then
Set session_timer = zero; Set Green_assessment_question_count = one
Else
Retrieve remaining Green assessment questions
4. Initiate
Start incrementing session_timer (session_timer = session_timer + 1)
Profiler agent retrieves and displays Green assessment questions and answers available to participant systematically
While (Green _assessment_question_count <= total Green_ assessment_questions or timer <= pre-defined allocated time)
5. Stop practitioners from providing answers to Green assessment questions
6. Call evaluator agent to initiate calculate_session_result ( )
Return ()
End

3.3.3. Evaluator Agent

This algorithm is responsible to evaluate, score and rate the practitioner based on the Green practice assessment session that has been taken by the practitioner. The evaluator agents communicates with the profiler agents and also performs procedures such as selecting assessment category, retrieving assessment questions for selected assessment category with its alternatives/answer and valid pre-defined answer. The implementation algorithm for evaluator agent is shown below;

Input:
Assessment_question_count, counter to count Green assessment questions
Answers, alternative answers selected by participants
Correct answer, correct pre-defined answer of a particular Green assessment question
Green_score, marks allocated to a participant for valid answers provided during the Green practice assessment session
Output:
Displays uname of participant
Total number of Green assessment questions attempted
Final assessment score of the participant
Function calculated_assessment_result ( )
Start
1. While (session_timer <= pre-defined allocated time);
Set answered_value = false;
Set Green_score = zero;
2. **For**
(Green assessment question “q” = 1,

q <= Green_assessment_question_count, next Green assessment question);
3. **If**
(Answer selected = valid answer);
Then
Set answered_value = true;
Else
No change in answered_value status;
4. If (answered_value is set to true);
Then
Increment Green_score by 1 (Green_score = Green_score + 1);
Else
No change in Green_score;
Call and sends evaluation data to feedback agent;
Return Green_score ()
End

3.3.4. Feedback Agent

This agent is responsible for retrieving assessment results from the evaluator agent and Green case base by displaying the assessment result to the practitioner. The algorithm is shown below;

Begin
Function final_assessment_result ( )
Select Participant.PID, Participant.Name,
Participant.Evaluation, Participant.Score, Evaluation.EID,
Evidence.Detail
From
Participant INNER JOIN Evaluation ON Participant.PID = Evaluation.PID;
Display Participant.Evaluation
Return ()
End

The feedback agent retrieves and displays the session result using deployed SQL statement which is embedded inside the feedback agent.

3.3.5. Collector Agent

Collects assessment data from feedback agent and retrieves Green practice recommendations to practitioners.

Input: Green assessment evaluation data from feedback agent
Output: retrieves and maps Green practice recommendations to practitioner
Function recommendation_report ( )
1. **Begin**
2. **For** every user [assessment participant]
3. {
4. Collects users' assessment evaluation session;
5. Computes number of success and failed Green practice;
6. }
7. **If** the Green assessment question is focus on objective computation [a, b, c, d, e, f]

8. **Then**
9. Retrieves and display recommendations from Green practice library in objective format;
10. **Else**
11. **If**
12. Green assessment question focus on subjective computation then;
13. Sort recommendation with the same subjective instance
14. Implement pair wise comparison;
15. Retrieves and display recommendations from Green case base in subjective format;
16. **Return** Green recommendation;

    End

3.3.6. Mining Agent

This agent collects Green practice data from domain expert. The mining agent mines Green practice data from the domain expert and saves all mined data in the Green case base. The implementation algorithm is presented below;

d∈GP= {Green creation, Green distribution, Green sourcing, Green usage, end of life, water management}
i= {Items} = Each Green process items or metrics
Begin
Function Green_practice_mining ( )

1. **Initiates** mining agents and communicates with GA;
2. Collects Green practice based on GA and i;
3. **Start** with each GA to dispatch and collect all the Green practice items/metrics from the domain expert host machine;
4. Validate Green practice content;
5. After validation mining agent proceeds with execution;
6. **If** (execution is paused)
   Mining agent displays error message;
   If (errors have been resolved)
7. Saves to Green case base;
   Else Re-directs to Step 4

Return ("display success message to domain expert")
End

3.3.7. Controller Agent

This agent add rule base that comprises of Green creation, Green distribution, Green sourcing, Green usage, end of life and water management. The implementation algorithm is shown below;

Start
Function Green_practice_implementation ( )
Rule maker is responsible to provide data on the index and content of Green practice.
Let

1. RM = {d | d is the rule maker data}
2. GP = {gp | gp is the Green practice that is been added by d's and is given as, d ∈GP}
3. d∈GP= {Green creation, Green distribution, Green sourcing, Green usage, end of life and water management}

4. Indexing the added Green process to the pre-define rule base' is the enabler for assessment as show in Figure 3. One element in the set GP is a set of individual process (P1, P2, P3, P4, P5, P6) that are saved in the pre-define rule base.
5. The controller agent collects data on Green process (d∈GP) to avoid double inputs.

3.3.8. Unified Modeling Language (UML) Use Case and Class Diagram

UML use case diagram illustrates the functions that a system provides to its users and the interaction between the users and the system (Dennis *et al*., 2008).

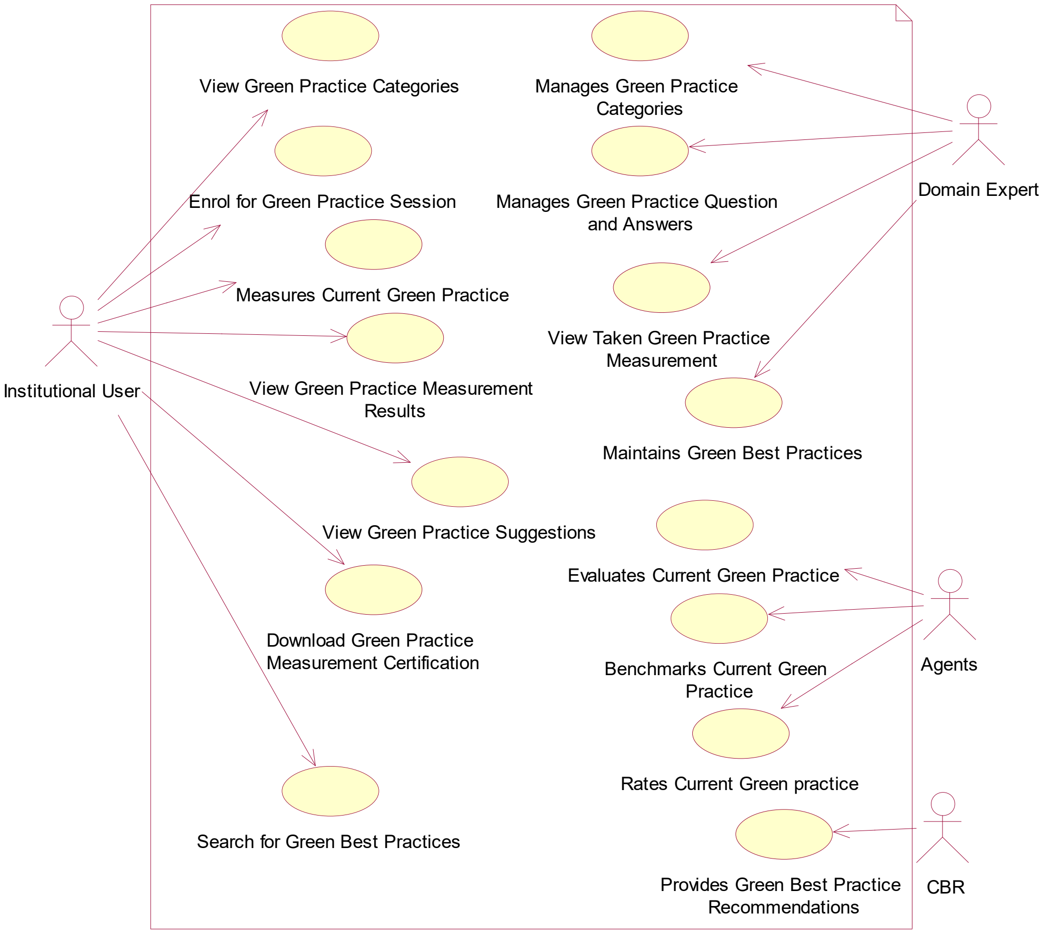

Figure 4 Use case diagram of the eco-responsibility decision support tool

Figure 4 shows the use case diagram for implemented tool, displaying the functionalities provided by implemented eco-responsibility decision support tool. Similarly, Figure 5 illustrates the class diagram which shows the relationship between classes thereby displaying the structure of the whole environment. Respectively, the eco-responsibility decision support tool is implemented in PHP (software agents) and MySQL (CBR) similar to prior studies (Yang, 2013, Zouhair *et al*., 2014) that utilized PHP to implement web based agent-CBR systems in their research. The tool was deployed in Xampp application software at local server port 80 for software agents and 3306 for CBR to test the feasibility of the tool.

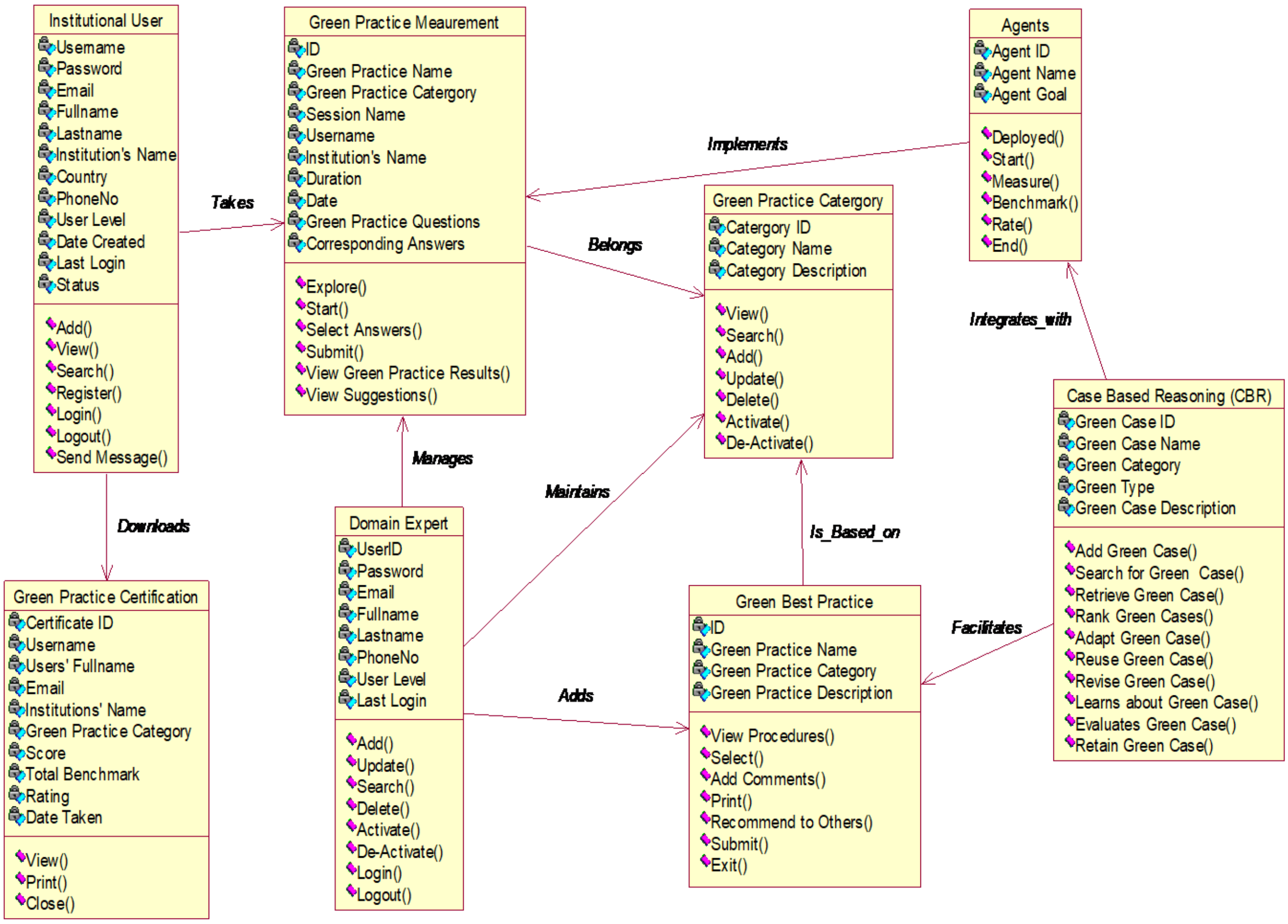

Figure 5 Class diagram design of the eco-responsibility decision support tool

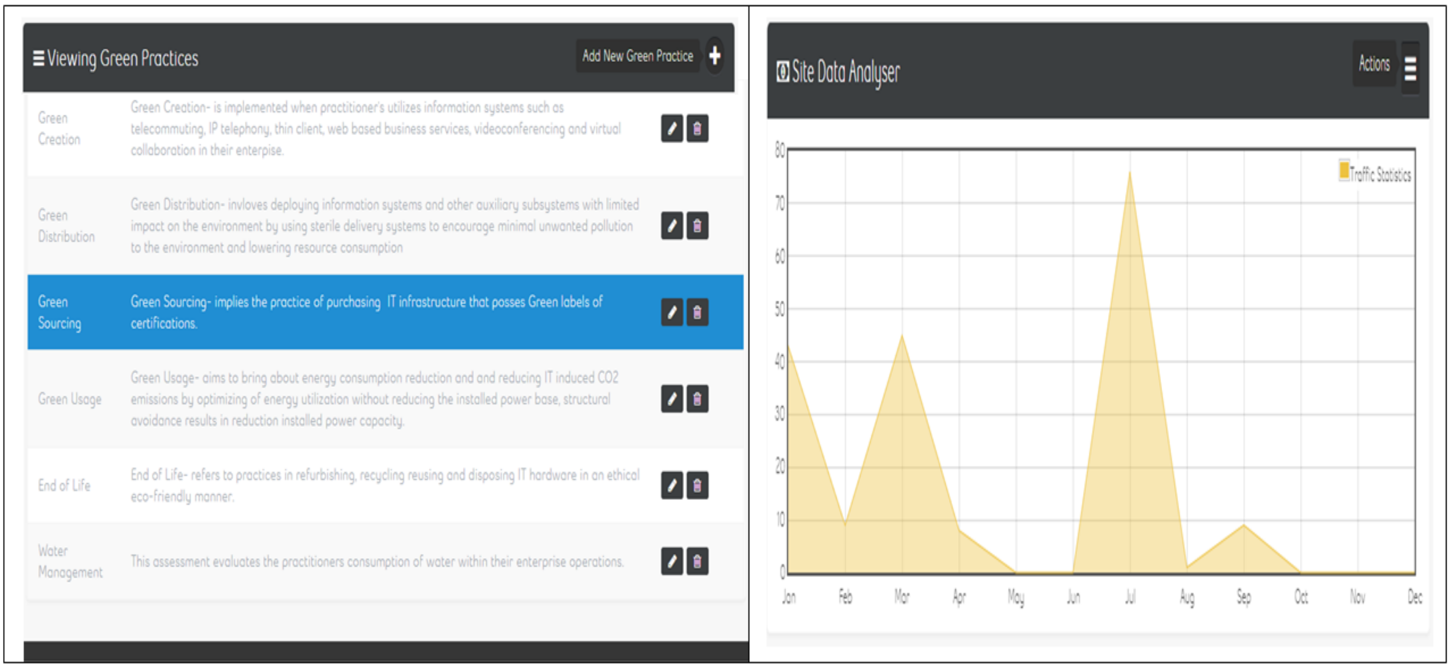

Figure 6 Developed eco-responsibility decision support tool interface

Furthermore, our work is similar to Kwon *et al.* (2005); Gawali and Meshram (2009); Yang (2013); Chang *et al.* (2015); Cheng and Ma (2015); Shen *et al*. (2015) where the authors implemented their agent and CBR systems based on an online platform. Hence, the interface of the eco-responsibility decision support tool is shown in Figure 6 which depicts the available Green practice as controlled by the profiler agent. Likewise, Figure 6 shows operational usage chart of the tool by institutional users to measure, search, and retrieve Green practices on how to attain environmental responsibility in educational institutions.

4. Results and Discussion

4.1. Questionnaire Design

To validate the developed eco-responsibility decision support tool, we designed questionnaire items derived from prior studies as seen in Table 5.

Table 5 Questionnaire design

#	Factors	Items	References
1	Usability	UBY1-Easy of navigation and use. UBY 2-Speed of system and interactivity. UBY 3-Interactivity and friendliness.	(Wang and Senecal, 2007; Tojib *et al.,* 2008; Poelmans *et al*., 2008; Madan and Dubey, 2012)
2	Efficiency	ECY 1-Appropriateness and ease of learning. ECY 2-Functionality adequacy. ECY 3-Easy to control and good readability.	(De Marsico and Levialdi, 2004; Lewis, 2006; Lee and Kozar, 2012; Madan and Dubey, 2012)
3	Helpfulness	HFS1-System usefulness. HFS2-Information quality. HFS3-Interface quality.	(Lewis, 2006; Tojib *et al*., 2008; Poelmans *et al*., 2008; Madan and Dubey, 2012)
4	Flexibility	FBY1-Memorability. FBY2-Understandability and completeness. FBY3-Operability and simplicity.	(De Marsico and Levialdi, 2004; Elling *et al.,* 2012; Lee and Kozar, 2012; Madan and Dubey, 2012)
5	Supportability	STY1-Good layout and error prevention. STY2-Confidentiality and security. STY3-Easy to maintain system content.	(De Marsico and Levialdi, 2004; Tojib *et al.,* 2008; Lee and Kozar, 2012)
6	Credibility	CBY1-Provides consistency data. CBY2-Usefulness and trustfulness. CBY3-Comprehensiveness and self-descriptiveness.	(Palmer, 2002; Abran *et al*., 2003; Seffah *et al*., 2006; Jr *et al*., 2018)
7	Satisfaction	SFN1-Portability and adaptability. SFN2-Provide Feedback and user guidance. SFN3-Responsiveness in processing request.	(Seffah *et al*., 2006; Downing and Liu, 2011; Anthony *et al*., 2018)

Table 5 presents the derived questionnaire factors associated elements, and references where the items were derived from in formulating the questionnaire instrument. After which data was collected from a few practitioners in educational institution in Malaysia that implements Green practices. The participants were mainly sustainability practitioners and IT practitioners as respondents since they possess detailed knowledge towards Green practice implementation. Hence, the respondents are selected using purposively sampling. At the end of the data collection from Sept 2017 till Nov 2017, 105 valid responses which is low but still appropriate to proceed with testing of the tool based on the number of responses used in prior studies, where Ghazalli and Murata (2011) collected data from 15 respondents, whereas Chang *et al.* (2015) utilized data from 32 respondents in their study on testing agent-CBR system.

4.2. Demographic Characteristics

To analyze the collect questionnaire data we employed Statistical package for Social Sciences (SPSS) for descriptive, explorative, and factor analysis to determine the feasibility of the developed eco-responsibility decision support tool as used in previous studies (Chan *et al.*, 2012; Amerioun *et al*., 2018). The questionnaire items were similarly measured with a 5 point Likert scale ranging from not important as "1" and very important as "5", completely dissatisfied as "1" and completely satisfied as "5", similar to prior study (Chong and Mohamad Zin, 2012), whereas the demographic items gender, age, education, experience and job title all measured using ordinal measurement. Table 6 shows the demographic characteristic of the respondents.

Table 6 Characteristic of the questionnaire respondents

Profile	Options	Frequency	Percentage
Gender	Male	66	62.9 %
	Female	39	37.1 %
Age	< 25	12	11.4%
	25-34	45	42.9%
	35-44	42	40.0%
	45-55	6	5.7%
	>55	12	11.4%
Education	Diploma	6	5.7%
	Bachelor's Degree	42	40.0%
	Master's Degree	39	37.1%
	PhD	18	17.1%
Working Experience	0-5	24	22.9%
	6-10	54	51.4%
	11-15	18	17.1%
	16-20	9	8.6%
	>20	24	22.9%
Job Title	IT Practitioner	54	51.4%
	IT Administrator	12	11.4%
	Environmental Practitioners	21	20.0%
	IT Manager	12	11.4%
	IT Staff	3	2.9%
	Others	3	2.9%

4.3. Descriptive Analysis

Descriptive analysis is used to describe the data collected to accurately characterize the factors under observation within a specific sample. Descriptive analysis is frequently employed to summarize a study sample prior to analyzing the study's primary data (Anthony *et al*., 2018). Results from descriptive analysis provide information about the overall representativeness of the sample, as well as the information necessary for other researchers to replicate the study. In this study the minimum, maximum, mean and standard deviation values are used to present the results from descriptive analysis. Therefore, mean rank was used to establish the arithmetic average of the distribution of the 7 factors based on the scale (1 – least effective; 2 – fairly effective; 3 – effective; 4 – very effective; and 5 – most effective) (Chan *et al*., 2012) as presented in Table 7. Descriptive analysis was employed to provide an overview of the participants' perception of the feasibility of the eco-responsibility decision support tool in relation to the questionnaire.

Table 7 Descriptive analysis

No.	Factors	Descriptive Analysis	Explorative Analysis	Interpretation of Mean

		Minimum	Maximum	Mean	Standard Deviation	Reliability	Validity	Mean Ranking	Mean Rating
1	Usability	3.00	5.00	3.8286	0.48286	0.779	0.222	5	Effective
2	Efficiency	3.00	5.00	4.0476	0.56695	0.775	0.199	4	Very Effective
3	Helpfulness	3.33	4.67	4.0667	0.36515	0.881	0.100	3	Very Effective
4	Flexibility	3.33	5.00	4.1016	0.37872	0.880	0.185	2	Very Effective
5	Supportability	3.00	5.00	4.1619	0.58491	0.896	0.284	1	Very Effective
6	Credibility	3.00	5.00	3.7333	0.69706	0.811	0.487	6	Effective
7	Satisfaction	3.00	5.00	3.6508	0.58540	0.824	0.414	7	Effective
Factors mean score were rated on a five-point Likert scale (1 – least effective; 2 – fairly effective; 3 – effective; 4 – very effective; and 5 – most effective)									

Results from Table 7 shows the minimum value selected by the respondents based on the 5 point Likert scale is 3 for all factors whereas the maximum value ranges from 4.67 for helpfulness of the tool to 5.00 for other factors. Next, the results also reveal that all factors mean score is between the ranges of 3.00 to 4.00. Thus, suggesting that the tool is feasible in sustaining educational institutions going Green. Moreover, the standard deviation score for all factors are lower than "1" indicating that the replies from the respondents are similar and not widely dispersed. In relation to the mean ranking and rating, the results shows that supportability is the most accepted factor with a mean and standard deviation score of 4.1619(0.58491), followed by the flexibility of the tool with a score of 4.1016(0.37872) and then it is the helpfulness of the tool towards environmental responsibility in educational institution with a mean sore of 4.0667(0.36515). Next, is efficiency with a score of 4.0476(0.36515), and then is the usability of the tool with a value of 3.8286(0.48286). The next factor is the credibility of the tool with a score of 3.7333(0.69706), and finally the last factor is the measure of how satisfied the respondents are with the decision support of the tool with a score of 3.6508(0.58540).

4.4. Explorative Analysis

Exploratory analysis aims to confirm the reliability and validity of the questionnaire factors. Where, validity refers to the degree in which a questionnaire measure what is intended to measure. Reliability is the extent in which the questionnaire factors give the same result consistently (Anthony Jr *et al.,* 2018). In this study validity is measured based on Pearson's correlation (*r*) value whereas reliability is measured Cronbach's alpha. Validity is measured by considering the correlation which is used to test the level of relationship between the seven factors. In this study the correlation levels of each factor is determined by conducting correlation analysis in SPSS on the data as shown in Table 7, where the correlation is significant at 0.01 levels (2 tailed) based on Cohen *et al*. (2013) the strength of relationship, correlation coefficient strengths ranges from 0.1 to 0.29 OR -0.1 to -0.29 as weak, 0.30 to 0.49 or -0.30 to -0.49 as moderate and 0.50 to 1.0 or -0.50 to -1.0 as strong.

Results from Table 7 suggest that the Pearson's correlation (*r*) value was from 0.1 for helpfulness of the tool to 0.487 for credibility of the tool representing a weak to moderate positive correlation, signifying that the factors are statistically significant at p = 0.000. In addition all Pearson's correlation are higher than "0" thus confirming the factors. Accordingly, the Pearson's correlation results fulfill the criteria for validity of the factors. In addition, the

Cronbach's alpha reliability coefficient was employed for checking internal consistency (reliability) between 0 and 1, based on the average inter-item correlation. The usual rule is that if the alpha value is larger than 0.70, according to Fields (2009), it can be established that the questionnaire factors are reliable. In this study, each factor alpha value was found to be greater than 0.70, as seen in Table 7 implying that there is good internal consistency (reliability).

Table 8 KMO and Bartlett's tests for each factor

No.	Factors	KMO	BT	DF	P-Value
1	Usability	0.500	9.885	3	0.020
2	Efficiency	0.508	17.949	3	0.000
3	Helpfulness	0.525	9.773	3	0.021
4	Flexibility	0.565	13.681	3	0.003
5	Supportability	0.500	58.311	3	0.000
6	Credibility	0.686	97.269	3	0.000
7	Satisfaction	0.567	72.352	3	0.000
Note KMO= Kaiser-Meyer-Olkin; BT =Bartlett's Test of Sphericity Chi-square value; DF= Degree of Freedom; *P*-Value is significant when P=<0.05 using two-tail test.					

Results from Table 8 presents the Kaiser-Meyer-Olkin (KMO) measure and Barlett's test of sphericity for the extraction factors was deployed on each factor. Respectively, KMO value ranges from 0 to 1, where 0 indicates the sum of partial correlations is large as comparative to the sum of correlation, and thus factor analysis would not be applicable (Chan *et al*., 2012). A value close to 1 specifies that the correlations are relatively compact and factor analysis would produce distinct and reliable discrete factors. As recommended by Chan *et al.* (2012); Amerioun *et al.* (2018), the KMO value for each factor should be greater than the acceptable threshold of 0.50. Accordingly, results from Table 8 reveal that the KMO value of the factors are much higher than the acceptable threshold of 0.50. The Barlett's test of sphericity is used to measure how the respondents' rates each factor (Chan *et al.,* 2012). The results further suggest that the value of the test statistic for Barlett's sphericity Chi-square value is large and the associated significance level is lower than the *P*-value< 0.05.

Owing to the fact that the recommendation of KMO value and the Barlett's test of sphericity Chi-square value are both achieved, it can therefore be concluded that factor analysis was appropriate for this research and can be preceded with confidence and reliability.

4.5. Factor Analysis

Factor analysis is considered as a statistical method employed to identify a relatively small number of specific factors which can be utilized to examine the correlation among sets of many interrelated items (Chan *et al*., 2012). Factor analysis is important, as it further clarifies the data analysis from the mean score and also helps to extract and confirm the factors (Chong and Mohamad Zin, 2012) that test the feasibility of the implemented tool. Thus factor analysis is employed in this study as carried out by Chan *et al.* (2012); Amerioun *et al.* (2018) in their research to analyze data from the questionnaire to measure the importance of the factors for validating the feasibility of the eco-responsibility decision support tool. The principal components analysis (PCA) (Yuang *et al*., 2017; Chan *et al*., 2012) is deployed in factor analysis of this study. PCA was used to examine the factors and to confirm the interdependence of each factor due to its simplicity and distinctive characteristic of data-reduction capacity for factor extraction. PCA can generate a linear combination of components which account for as much of the variance that exists in the data as possible. PCA also helps to explore the correlation among the perceived replies from the respondents and measure if there is an underlying structure of concern within the 7 factors.

Table 9 Factor analysis, eigenvalues and variance of factors after extracted sum

No.	Factors	Items	Factor Loading	Extracted Sums of Squared Loadings		
				Total Eigenvalue	Percentage of Variance	Cumulative Percentage
1	Usability	UBY1	0.951	1.302	33.404	76.814
		UBY 2	0.700			
		UBY 3	0.653			
2	Efficiency	ECY1	0.685	1.413	32.746	79.862
		ECY 2	0.665			
		ECY 3	0.664			
3	Helpfulness	HFS1	0.538	1.330	31.751	76.093
		HFS 2	0.590			
		HFS 3	0.603			
4	Flexibility	FBY1	0.422	1.422	29.177	76.575
		FBY 2	0.412			
		FBY 3	0.588			
5	Supportability	STY1	0.817	1.690	32.085	88.421
		STY 2	0.750			
		STY 3	0.423			
6	Credibility	CBY1	0.626	2.126	17.827	88.684
		CBY 2	0.769			
		CBY 3	0.731			
7	Satisfaction	SYN1	0.561	1.909	24.801	88.442
		SYN 2	0.798			
		SYN 3	0.550			

Thus, the factor loading of each item is considered, where the factor loading values reflect the degree of influence of individual item to each underlying measured factor. Besides, all loadings of the 7 factors individual items measures were higher than 0.40 as recommended by Yuan *et al.* (2017). The higher the loading value of each item, the more a particular the individual factor contributes in confirming the feasibility of the eco-responsibility decision support tool (Anthony Jr *et al*., 2018). Hence, it is observed that the factor loadings of each item were rationally consistent and sufficient.

Furthermore, the total eigenvalues, percentage, and cumulative percentage of variance explained by each factor was observed to determine how many factors would be required to represent that set of data. Principal factor extraction was carried out through the SPSS on the 7 factors and their respective items (see Table 5) from a sample of 105 responses. Thus, the total eigenvalues, percentage, and cumulative percentage of variance explained by each factor are presented in Table 9 based on the extracted sums of squared loadings. Respectively, an eigenvalue criterion of 1 or greater is necessary as a criterion (Liargovas and Skandalis, 2012), to validate the factors and to aid in identification of clusters of related responses. Results from Table 9 suggest that all factors eigenvalue are greater 1.

In addition, results from Table 9 show that the variance of 33.4 percent is explained by usability. Next the variance of 32.7 percent is explained by efficiency, also the variance of 31.8 percent is explained by helpfulness and 29.2 percent is explained by flexibility. Next is 32.1 percent explained by supportability, and 19.8 percent is explained by credibility. Finally, the variance of 24.8 percent is explained by satisfaction of the implemented tool. Moreover, the seven factors extracted, represents 88.44 percent of the total variance in responses, which is higher than the minimum benchmark of 60 percent as advocated by Chan *et al.* (2012). As we can see from Table 9, all seven factors with total eigenvalues greater than one were extracted, explaining 88.44 percent of the total variance.

In summary, findings from the factors analysis reveal that the 7 factors provide valid measures for the variance in this study. This indicates that the factors and associated item included in the factor analysis confirms that the eco-responsibility decision support tool is feasibility based on the statistical results derived for the importance of these factors. Thus, it can be concluded that the derived seven factors are appropriate, valid and reliable to be considered in evaluating the feasibility of the developed tool.

5. Implication of Study

5.1. Practical Implication

This research developed a system deployment model that integrates software agent and CBR and an eco-responsibility decision support tool to evaluate benchmark and rate Green practice in university campuses. The tool also supports decisions making of sustainability practitioners and IT practitioners in Greening their university operations to reduce negative effect caused by IT infrastructures deployment. The implemented eco-responsibility decision support tool has practical implication towards raising the environmental awareness of sustainability practitioners and IT practitioners towards the significance of deploying a structured knowledge based best practice system.

Additionally, the tool is a valuable web based system that facilitates the collection, dissemination, exchange and retaining of knowledge across university campuses, thereby saving knowledge of domain experts in the Green case base that can diffused by other staffs in attaining environmental responsibility. Further practical implication aligns to the capability of the tool to provide information required to deploy eco-friendly practices. The eco-responsibility decision support tool provide solutions for university campuses with the goal of increasing environmental sustainability by retrieving best Green practice information for reducing global warming and climatic changes.

Similarly, this research provides an agenda for universities to incorporate Green process into their current campus operations. Therefore practitioners need not to only think Green but as well as act Green by deploying Green creation, Green distribution, Green sourcing, Green usage, end of life and water management. Additionally, our study provides a road map on sustainability attainment towards Green practice implementation for practitioners in university campuses. Furthermore, the implemented eco-responsibility decision support tool also provides a set of guidelines for determining each Green process based on several indicators to assist practitioners in reviewing, managing and improving their sustainability performance. Moreover, the eco-responsibility decision support tool can help ascertain the progress being made with the development level reached to ensure that practitioners' remains fully engaged in implementing Green practices for environmental responsibility.

5.2. Theoretical Implication

This research possesses theoretical implication to progress the Greening of university campus and also enhance Green behaviour of campus community towards environmental sustainability. Besides, the dimensions of Green practice implementation are presented in this research to facilitate practitioners in implementing Green practice with regard to enhancing their target of being an environmental sustainable university. Moreover, findings from this study helps to guide future research and development by presenting the Green process which comprises of Green creation, Green distribution, Green sourcing, Green usage, end of life and water management in supporting universities decrease the negative environmental effects of IT infrastructure usage. Furthermore, the Green dimensions or process also educates practitioners about eco-friendly behavior and also creates awareness about environmental responsibility.

Likewise, our study provide Green practice information needed for university to make decisions about eco-friendly practices, in terms of natural material consumption and energy usage, reuse, recovery, recycling and refurbishing of e-waste materials towards enhancing environmental sustainability performance. Also, the tool facilitates information sharing by synchronously disseminating real time environmental information with sustainability practitioners and IT practitioners. In addition, practitioners in university campuses can draw upon the Green process presented in Section 2.4 in measuring conditions for positive deployment of ecological friendly practices in their campus operation towards address sustainability concerns.

The factor analysis conducted in this study offers better interpretation and more insight to assist decision makers in selecting the most important and least factors and associated items to be employed in evaluating the feasibility of information systems. Moreover, the implemented tool offers a guide to practitioners in sustaining educational instructions going Green towards environmental responsibility. This help in reducing the gap between research and practice in Green practice implementation and ultimately contributes to sustainable development.

6. Conclusion, Limitation and Future Direction

Currently practitioners in university campuses are faced with difficulty of making decision in implementing eco-friendly practices for environmental responsibility. Unfortunately, this is due to lack of a Green practice approach to facilitate environmental sustainability attainment in university campuses. Therefore, this study propose an approach to aid Green practice and eco-responsibility decision support tool to assess and provide Green best practices to practitioners in university campuses for environmental responsibility. The tool is based on the application of software agents and CBR. More importantly, CBR aids in the reuses of past successful Green practice knowledge to address new problem encountered by university campus users. The tool utilizes software agents in evaluating Green practices implemented for environmental responsibility in universities. The implemented eco-responsibility decision support tool was evaluated based on a questionnaire data. Following the descriptive analysis of the survey results, factor analysis was employed on the crystallized seven underlying factor to measures and validate the feasibility of the eco-responsibility decision support tool.

Theoretically, this research approach serves as an important reference for future research in other developing countries into factors that can applied in evaluating the feasibility of implemented information system. However, the tool is susceptible to some limitation, one of the practical limitations is that the tool requires adequate number of cases in the Green case base to efficiently act and learn. Moreover, the tool involved pre-processing of information and does not process case parameters with ambiguous data. Empirically, the sample population in this study comprises only practitioners in educational institution in Malaysia. As such this paper also recommends that there is future research and development in the area of Green practice in educational institutions. Therefore, the further research is necessary into resolving case ambiguity by integrating fuzzy logic to resolve ambiguous data issues. Secondly, it is necessary to carry out a cross-country survey in collecting data from different educational institution in other geographical location to further test the tool.

References

Abran, A., Khelifi, A., Suryn, W. and Seffah, A. (2003), “Usability meanings and interpretations in ISO standards”, *Software quality journal*, Vol. 11 No. 4, pp. 325-338.

Akman, I., and Mishra, A. (2015), “Sector diversity in green information technology practices: technology acceptance model perspective”, *Computers in human behavior*, Vol. 49 No.1, pp 477-486.

Amerioun, A., Alidadi, A., Zaboli, R. and Sepandi, M. (2018), “The data on exploratory factor analysis of factors influencing employees effectiveness for responding to crisis in Iran military hospitals”, *Data in Brief.*, Vol. 19 No.1, pp. 1522–1529.

Anthony Jr, B., Majid, MA. and Romli, A. (2018), "A collaborative agent based green IS practice assessment tool for environmental sustainability attainment in enterprise data centers", *Journal of Enterprise Information Management*, Vol. 31 No. 5, pp.771-795,

Anthony, B. J. (2016), “Green Information Systems Integration in Information Technology Based Organizations: An Academic Literature Review”, *Journal of Soft Computing and Decision Support Systems*, Vol. 3 No. 6, pp. 45-66.

Anthony, B., Abdul Majid, M. and Romli, A. (2018), “Heterogeneous agent-enabled decision system for evaluating Green IT performance in industrial environments”, *Journal of Decision Systems*, Vol. 27 No. 1, pp. 37-62.

Ayog, J. L. Bolong, N. and Makinda, J. (2015), “Feasibility Study of Rainwater Harvesting in Universiti Malaysia Sabah’s Residential Colleges in Support of the Eco-Campus Initiative”, in 2nd *Regional Conference on Campus Sustainability: Capacity Building in Enhancing Campus Sustainability*, Kota Kinabalu, Malaysia, pp. 206-216.

Bai, C. and Sarkis, J. (2013), "Green information technology strategic justification and evaluation", *Information Systems Frontiers*, Vol. 15 No. 5, pp. 831-847.

Chan, J. H., Chan, D. W., Chan, A. P. and Lam, P. T. (2012), "Risk mitigation strategies for guaranteed maximum price and target cost contracts in construction: A factor analysis approach", *Journal of facilities management*, Vol. *10* No. 1, pp. 6-25.

Chang, J. W., Lee, M. C. and Wang, T. I. (2016), "Integrating a semantic-based retrieval agent into case-based reasoning systems: A case study of an online bookstore", *Computers in Industry*, Vol.78 No.1, pp. 29-42.

Chen, A. J., Boudreau, M. C. and Watson, R. T. (2008), "Information systems and ecological sustainability", *Journal of Systems and Information Technology*, Vol. *10* No. 3, pp. 186-201.

Cheng, J. C. and Ma, L. J. (2015), "A non-linear case-based reasoning approach for retrieval of similar cases and selection of target credits in LEED projects", *Building and Environment*, Vol. 93 No.1, pp. 349-361.

Chong, H. Y. and Mohamad Zin, R. (2012), "Selection of dispute resolution methods: factor analysis approach", *Engineering, Construction and Architectural Management*, Vol. 19 No. 4, pp. 428-443.

Ciocoiu, N.C. and Ciolac, C.E. (2009), "Automated framework for Green IT classification using software agents", in *2nd IEEE International Conference on Computer Science and Information Technology,* pp. 279-283

Cohen, J., Cohen, P., West, S. G. and Aiken, L. S (2013), "*Applied multiple regression/correlation analysis for the behavioral sciences*", Routledge.

Dalvi-Esfahani, M., Dalvi-Esfahani, M., Ramayah, T., Ramayah, T., Rahman, A. A. and Rahman, A. A. (2017), "Moderating role of personal values on managers' intention to adopt Green IS: Examining norm activation theory", *Industrial Management & Data Systems*, Vol. 117 No. 3, pp. 582-604.

De Marsico, M. and Levialdi, S. (2004), "Evaluating web sites: exploiting user's expectations", *International Journal of Human-Computer Studies*, Vol. 60 No. 3, pp. 381-416.

Deng, H., Molla, A. and Corbitt, B. (2009), "A fuzzy logic based green information technology readiness model", in *International Conference on Artificial Intelligence and Computational Intelligence,* pp. 465-470.

Dennis, A., Wixom, B. H., and Roth, R. M. (2008), "Systems analysis and design", John wiley & sons.

Downing, C. E. and Liu, C. (2011), "Assessing web site usability in retail electronic commerce", *35th Annual Computer Software and Applications Conference,* pp. 144-151.

Elling, S., Lentz, L., de Jong, M. and Van den Bergh, H. (2012), "Measuring the quality of governmental websites in a controlled versus an online setting with the 'Website Evaluation Questionnaire'", *Government information quarterly*, Vol. 29 No. 3, pp. 383-393.

Fang, F. and Wong, T. N. (2010), "Applying hybrid case-based reasoning in agent-based negotiations for supply chain management", *Expert Systems with Applications*, Vol. *37*, No. 12, pp. 8322-8332.

Farooq, M. K., Khan, M. J., Shamail, S. and Awais, M. M. (2009), "Intelligent project approval cycle for local government: case-based reasoning approach", ACM *Proceedings of the 3rd international conference on Theory and practice of electronic governance*, pp. 68-73.

Field, A. (2009), "*Discovering Statistics Using SPSS*" 3rd Edition, Sage, Los Angeles, USA.

Foogooa, R. and Dookhitram, K. (2014), "A self green ICT maturity assessment tool for SMEs", *IST-Africa Conference Proceedings,* pp. 1-9.

Fornell, C. and Larcker, D.F. (1981), "Evaluating structural equation models with unobservable variables and measurement error", *Journal of Marketing Research,* Vol. 18 No. 1, pp. 39-50.

Gawali, R. D. and Meshram, B. B. (2009), "Agent-based autonomous examination systems", in *International Conference on Intelligent Agent and Multi-Agent Systems*, pp. 1-7.

Ghazalli, Z., & Murata, A. (2011), "Development of an AHP–CBR evaluation system for remanufacturing: end-of-life selection strategy", *International Journal of Sustainable Engineering*, Vol. *4* No. 1, pp. 2-15.

Gholami, R., Sulaiman, A. B., Ramayah, T., and Molla, A. (2013), "Senior managers' perception on green information systems (IS) adoption and environmental performance: Results from a field survey", *Information & Management*, Vol. 50 No. 7, pp. 431-438.

Hankel, A. and Lago, P. (2016), "How organisations can assess and improve their green ICT activities in a standard and efficient way", *ITU Kaleidoscope: ICTs for a Sustainable World*, pp. 1-6.

Hankel, A., Heimeriks, G. and Lago, P. (2016), "Green ICT Assessment for Organisations", *Journal of ICT Standardization*, Vol. 4 No. 2, pp. 87-110.

Huang, J. and Lin, C. (2013), "Agent-based green web service selection and dynamic speed scaling", *20th International Conference on Web Services,* pp. 91-98.

ISO. (2004a). "International Standard ISO 14001: Environmental management systems-Requirements with guidance for use", second edition, pp. 1-32.

ISO. (2004b). "ISO/IEC 15504 Information Technology Process assessment", ISO.

Jahani, A., Azmi Murad, M. A., bin Sulaiman, M. N. and Selamat, M. H. (2015), "An agent-based supplier selection framework: Fuzzy case-based reasoning perspective", *Strategic Outsourcing: An International Journal*, Vol. 8 No. 2/3, pp. 180-205.

Jain, R., Benbunan-Fich, R., and Mohan, K. (2011), "Assessing green IT initiatives using the balanced scorecard", *IT professional*, Vol. 13 No. 1, pp. 26-32.

Jeong, M.G., Morrison, J.R. and Suh, H.W. (2013), "Approximate life cycle assessment using case-based reasoning for the eco design of products", *IEEE International Conference on Automation Science and Engineering,* pp. 486-491.

Jnr, B. A., Majid, M. A. and Romli, A. (2017b), "Application of Intelligent Agents and Case Based Reasoning Techniques for Green Software Development", *Technics Technologies Education Management*, Vol. 12 No. 1, pp. 30-43.

Jnr, B. A., Majid, M. A., and Romli, A., A (2018),"Proposed Model for Green Practice Adoption and Implementation in Information Technology Based Organizations", *Problemy Ekorozwoju – Problems of Sustainable Development*, Vol. 13 No. 1, pp. 95-112.

Jnr, B.A., Majid, M.A. and Romli, A. (2017a), "A Green information technology governance framework for eco-environmental risk mitigation", *Progress in Industrial Ecology, an International Journal*, Vol. 11 No. 1, pp. 30-48.

Kwon, O., Im, G. and Lee, K. C. (2005), "MACE-SCM: An effective supply chain decision making approach based on multi-agent and case-based reasoning", *Proceedings of the 38th Annual Hawaii International Conference on System Sciences,* pp. 1-10.

Lee, Y. and Kozar, K. A. (2012), "Understanding of website usability: Specifying and measuring constructs and their relationships", *Decision support systems*, Vol. 52 No. 2, pp. 450-463.

Lewis, J. R. (2006), "*Usability testing*", In G. Salvendy (ed.), Handbook of Human Factors and Ergonomics, Hoboken, NJ: John Wiley, pp. 1275-1316.

Liargovas, P. G. and Skandalis, K. S. (2012), "Motivations of migrant entrepreneurship in Greece: a factor analysis approach", *Journal of Small Business and Enterprise Development*, Vol. 19 No. 4, pp. 627-639.

Madan, A. and Dubey, S. K. (2012), "Usability evaluation methods: a literature review", *International Journal of Engineering Science and Technology*, Vol. 4 No. 2, pp. 590-599.

Molla, A., and Abareshi, A. (2012), "Organizational green motivations for information technology: empirical study', *Journal of Computer Information Systems*, Vol. 52 No. 3, pp.92-102.

Muladi, N., and Surendro, K. (2014), "The readiness self-assessment model for green IT implementation in organizations", International *Conference of Advanced Informatics: Concept, Theory and Application*, pp. 146-151.

Nifa, F. A. A., Nawi, M. N. M., Nadzri, W. and Osman, S. A. R. (2015), "Towards Development of Sustainable Design In Malaysian University Campus: A Preliminary Framework for Universiti Utara Malaysia", *Jurnal Teknologi*, Vol. 77 No. 5, pp. 43–49.

Odeh, K. and Meszaros, J. (2012), "SustainaBits: A framework and rating system for sustainable IT", *International Green Computing Conference*, pp. 1-9.

Olsson, E. and Funk, P. (2009), "Agent-based monitoring using case-based reasoning for experience reuse and improved quality", *Journal of Quality in Maintenance Engineering*, Vol. 15 No. 2, pp. 179-192.

Palmer, J. W. (2002), "Web site usability, design, and performance metrics" *Information systems research*, Vol. 13 No. 2, pp. 151-167.

Park, S. H., Eo, J. and Lee, J. J. (2012), "Assessing and Managing an Organization's Green IT Maturity", *MIS Quarterly Executive*, Vol. 11 No. 3, pp. 127-140.

Pawlish, M.J. and Varde, A.S. (2010), "A decision support system for green data centers", *Proceedings of the 3rd workshop on Ph. D. students in information and knowledge management*, pp. 47-56.

Poelmans, S., Wessa, P., Milis, K., Bloemen, E. and Doom, C. (2008), "Usability and acceptance of e-learning in statistics education, based on the compendium platform", *Proceedings of the International Conference of Education, Research and Innovation*, pp. 1-10.

Rahim, R. E. A. and Rahman, A. A. (2013), "Feasibility of resource-based environmental studies in Green IT", *Journal of Systems and Information Technology*, Vol. 15 No. 3, pp. 269-286.

Ramli, N. A., Zen, I. S., Bandi, M. and Tajuddin, H. A. (2014), "Reduction in Carbon Dioxide Emissions and Global Climate in Campus: From Policy into Action", pp. 1-24.

Raza, K., Patle, V. K. and Arya, S. (2012), "A review on green computing for eco-friendly and sustainable IT", *Journal of Computational Intelligence and Electronic Systems*, Vol. 1 No. 1, pp. 3-16.

Rogers, K., Jenkin, T.A., Corbett, J. and Webster, J. (2013), "The Effects of' Green 'on IT/S Projects: Recycling the Garbage Can Model", 46th *Hawaii International Conference on System Sciences,* pp. 974-983.

Romli, A., Prickett, P., Setchi, R. and Soe, S., (2015), "Integrated eco-design decision-making for sustainable product development", *International Journal of Production Research*, Vol. 53 No. 2, pp. 549-571.

Saha, B. (2014), "Green computing", *International Journal of Computer Trends and Technology,* Vol. 14 No. 2, pp. 46-50.

Seffah, A., Donyaee, M., Kline, R. B. and Padda, H. K. (2006), "Usability measurement and metrics: A consolidated model", *Software Quality Journal*, Vol. 14 No. 2, pp. 159-178.

Shen, Y., Colloc, J., Jacquet-Andrieu, A. and Lei, K. (2015), "Emerging medical informatics with case-based reasoning for aiding clinical decision in multi-agent system", *Journal of biomedical informatics*, Vol. 56 No.1, pp. 307-317.

Silva, L.C., Poleto, T., De Moura, J.A., Daher, S.D.F.D. and Costa, A.P.C. (2013), "Group decision approach to adopt Green IT practices based on SWOT analysis.", *IEEE International Conference on Systems, Man, and Cybernetics,* pp.747-751.

Sissa, G. (2012), "An Agent Based approach for sustainable ICT services toward environmental sustainability: The use of Agent Based Models to explain the ICT-driven (societal) behavioural changes and their effects on environmental sustainability", *6th IEEE International Conference on Digital Ecosystems Technologies,* pp. 1-6.

Sonetti, G., Lombardi, P. and Chelleri, L. (2016), "True Green and Sustainable University Campuses? Toward a Clusters Approach", *Sustainability*, Vol. 8 No. 1, pp. 1-23.

Tojib, D. R., Sugianto, L. F. and Sendjaya, S. (2008), "User satisfaction with business-to-employee portals: conceptualization and scale development", *European Journal of Information Systems*, Vol. *17* No. 6, pp. 649-667.

UI Green Metric. (2016), "*Guideline of UI GreenMetric World University Ranking 2016 from Policy to Action"*, Universitas Indoenesia, pp. 1-34.

Ulkhaq, M. M., Prayogo, P. I., Firmansyah, M. and Agustina, D. (2016), "Assessing campus sustainability: a report from Diponegoro University, Indonesia", *International Journal of Information and Education Technology*, Vol. 6 No. 8, pp. 616-621

Wang, C., Vaughan, J., Mercer, J. and Zhao, Y. (2011), "A case-based model facilitating retailing operations going "green": A proposed research agenda with a consideration of recession", *IEEE International Summer Conference of Asia Pacific Business Innovation and Technology Management,* pp.1-4.

Wang, J. and Senecal, S. (2007), "Measuring perceived website usability", *Journal of Internet Commerce*, Vol. *6* No. 4, pp. 97-112.

Wooldridge, M. and Jennings, N.R. (1995), "Intelligent agents: theory and practice", *The Knowledge Engineering Review*, Vol. 10 No. 2, pp. 115-152

Wu, L. and Zang, Y. (2009), "A multi-agent and case-based reasoning framework for knowledge sharing in supply chain", *International Conference on Intelligent Computing and Intelligent Systems,* pp. 575-579.

Yang, S. Y. (2013), "Developing an energy-saving and case-based reasoning information agent with Web service and ontology techniques", *Expert Systems with Applications*, Vol. 40 No. 9, pp. 3351-3369.

Yuan, Q., Li, X., Wang, C., Li, Y. and Gao, Y. (2017), "Cluster and factor analysis on data of fatal traffic crashes in China", *4th International Conference on Transportation Information and Safety,* pp. 211-224.

Zouhair, A., Amami, B., Boukachour, H., Person, P. and Bertelle, C. (2014), "Modelisation and implementation of our system incremental dynamic case based reasoning founded In the MAS under JADE plate-form", in *International Conference on Multimedia Computing and Systems,* pp. 1031-1036.