ISBN 978-93-84468-20-0
Proceedings of 2015 International Conference on Future Computational Technologies (ICFCT'2015)
Singapore, March 29-30, 2015, pp. 27-33

Assessing University Students' Attitude toward Green Computing Practices

Bello Abdullahi Birchi
College of Science and Technology, Hassan Usman Katsina Polytechnic, Katsina-Nigeria

Abstract: *This study explored university students' attitude toward green computing and sought to ascertain whether they were influenced by gender (Male versus Female). A total of 700 students were randomly sampled from six faculties of a Nigerian public university and participated in the survey. Students filled out a green computing questionnaire with items measuring attitude on green computing. Descriptive statistics, independent-samples t-test and Principal Components Analysis (PCA) were used to analyze the data. The PCA analysis extracted one factor, named attitude that could be used to explain students' likely intention to adopt green computing practices through their behaviour. Results show that a majority (80.2%) of students were in agreement on the issue of going green. However, the result of the t-test shows that female university students were more concern and have a significant difference positive attitude toward green environment compared to their male counterpart.*

Keywords: *green computing, attitude, intention, behaviour*

1. Introduction

Going green is fundamental and a major concern of the modern world today. The global society as a whole is going through a phase where individuals, groups, organizations, industries and governments are becoming more environmentally conscious at home and the workplace, as well as at university campuses. There is much discussion centering upon how to reduce energy consumption and carbon emissions, prevent wastage, cut costs and protect the environment through green ideas, green initiatives, green buildings and green policies. The internet literature and academic journals are awash with discussions on these issues and with solutions on how to go green, ranging from simple tips such as printing on both sides of the paper using small fonts and printing only when necessary to physical acts of greening the environment by planting more trees to offset carbon emissions to big ideas such as green buildings (Omer, 2008), virtualization, cloud computing, renewable energies, classified power capping (Wu, Giles, & Wang, 2013). All these efforts and attention reflect the growing importance of the need for sustaining a healthy environment through green behaviour.

Green computing has often been defined as the practice of keeping the environment free from pollution resulting from human activities such as using a computer and its sub-systems and other household resources efficiently with no impact to the environment (Lamb, 2009). In simple terms, it refers to the environmentally responsible use of school and other household resources such as computers, electronics and their associated subsystems, which includes buying and using energy-efficient central processing units (CPUs), servers and peripherals, reducing resource consumption, and disposing of electronic waste (e-waste) in a safe and ethical manner.

The overarching goal of green computing is to address these economic and environmental hazards of human activities. Its specific aims are multiple, i.e. to prevent energy waste, cut down costs, reduce carbon emissions into the atmosphere, minimize pollution within the environment caused by poor e-waste management, curb the effects of hazardous computer products on people and the environment, and ultimately promote responsible, energy-efficient and environmentally safe practices.

2. Research Objectives

Set within this framework, the research objectives were as follows:

1. to explore the levels of students attitude toward green computing in public universities, and
2. to determine whether gender has influence on students' attitude toward green computing.

3. Literature Review

The first green computing initiative could be traced back to 1992 with the introduction of green ICT through the Energy Star program by the U.S. government. The primary objective of the program was to identify and label computer products that succeeded in minimizing energy consumption without losing their performance efficiency. The efforts led to the introduction of the sleep mode for computer monitors and other electronics appliances, a function that allows a computer monitor or an electronic to go on standby and hibernate after a set period of being idle, thereby saving electricity (Jena, 2010). From that point onwards, many parts of the entire computer and electronic system have been vigorously researched, experimented and improved in an effort to create energy-efficient machines that align well with the notion of sustainable energy savings and protecting the environment. A list of recent green compliant ICT products include NV-RAMs (Kawahara & Yoshimura, 2013), OLED monitors, 3rd generation Intel Core processors and solid state drives (Johnston, 2011).

Green computing initiatives are already shaping the lives and practices of the world university campus populations as the highest users of ICT. A number of universities in the U.S., Canada, Australia, Europe and the U.K. have for some time been creating awareness among students through green plans and sustainability campaigns. Some are very serious about energy reduction and have gone as far as erecting carbon-neutral buildings. A case in point is the University of Copenhagen (UCPH) in Denmark which in 2009 successfully built an energy-efficient center for its student services. The building is completely carbon free and powered by a combination of solar energy, heating pumps and a district heating. The UCPH also has a Green Action plan in which it employs green ambassadors to promote good energy conservation habits among students and staff. The plan helped the university to reduce its energy consumption and carbon footprint by 2.5% in 2012. The University of Utah in Salt Lake City, U.S. also maintains a sustainability website that educates its students and staff on the ways to reduce paper and electronic waste. It has a green policy that provides guidelines on e-waste management and hardware retirement. It also implements free e-waste collections and provides a calendar specifying dates on which e-waste will be collected. In Australia, green ICT is offered as an online course by the Australian National University and the University of New South Wales as part of an effort to increase awareness in green computing, in line with the plan that green ICT education be integrated into tertiary curriculum (Harris, et. al., 2011). The universities' move to offer the courses completely online is also an act of compliant with green computing as e-learning options are hailed as a viable way of reducing energy consumption and CO_2 emissions by a substantial percentage (Akaslan & Law, 2010).

Research in green computing is vast and multi-faced, but it is extremely limited in looking at an important group of people at the receiving end who makes a huge difference in reducing global energy consumption and, it has almost overlooked the importance and role of students as agents of CO_2 reduction, more especially in Nigeria. Students are vast users of ICTs, and hence, vast contributors of carbon emission. Assessing students' attitude toward green computing and creating awareness on green computing and getting university to act in green compliant ways is very essential.

Literature search in green computing revealed few studies that provided some insight into students' attitude and the state of green ICT awareness among students in higher education settings; few examples are those of Batlegang (2012) and Dookhitram et al. (2012). Batlegang (2012) assessed Botswanan students' awareness of green ICT vocabulary, i.e. terms associated with green computing, and the compliance of their computing practices with sustainable computing. He found that the majority of students had limited or no knowledge of green environmental issues, and frequently engaged in practices that led to unnecessary high consumption of electricity. Although the college made efforts to create energy conservation awareness via posting green ICT messages and power saving tips in all classes and computer labs, students' levels of green environmental awareness remained low and discouraging. Despite the efforts, students remained oblivious to the need to use

energy efficiently. The author concluded that green environmental knowledge and education was lacking at the college, and extensive work needed to be done to sensitize its campus population on going green.

On a lighter note, Dookhitram et al. (2012) found slightly higher levels of awareness among Mauritian students, but discovered a gap between their awareness levels and practices. Although students reported having moderate knowledge and awareness of green ICT, their daily practices were inconsistent with their self-report. Only 18% turned off their computers and other electrical appliance when not in use, and most had misconceptions about power saving practices. The authors emphasized the importance of university-led initiatives in increasing students' awareness on the need to keep the environment green, recommending a sustainability website to be put in place and the implementation of a green technology policy. In both studies, students were reported as heavy users of electrical/electronic and the internet with high degrees of computer literacy. In a U.S. study, Seitz et al. (2011) discovered students' attitudes toward green ICT and their intention to adopt it to be significantly influenced by their awareness. The respondents demonstrated positively compliant behaviors following initiatives that increased their awareness of green behaviour.

4. Attitudes and environmental education

Fishbein and Ajzen (1975) defined attitude as an evaluative mediating response, predisposing the individual to display various overt behaviour. For Luthans (2002) an attitude consists of three basic components: (1) Informational: the beliefs, knowledge, and information that an individual has about an object; (2) Emotional: a person's feelings and values (positive, neutral or negative) an object or idea; and (3) Behavioural: a person's tendency to act in a particular way towards an object or idea. In the context of this paper, Luthans (2002) position seems more relevant, since it has a broader scope and provides better linkages between knowledge, values, and actions. Attitudes are formed, and changed through the process of having a concrete experience, making observations and reflecting on that experience, then forming abstract concepts and generalizations based on these reflections, which are then tested within any new situation (Lewin, 1947). According to Luthans (2002) attitudes tend to persist unless something is done to change them, it can fall anywhere along a continuum from very favourable to very unfavorable, and are directed towards some object about which a person has feelings and beliefs. When the informational, emotional, and behavioural attitudes are consistent with each other, they are congruent (Lozano, 2009), but when they are discrepant, the knowledge, attitude and practice (KAP) gap appears (Rogers, 1995). The KAP gap is also known as the value action gap (Blake, 1999), and the Informational Emotional Behavioural (IEB) gap (Lozano, 2009).

There is a tradition of addressing individuals' attitudes towards the environment within the environmental education research, where in general, students' environmental attitudes have been examined in regards to environmental knowledge, behaviour, and socio-economic variables (Cavas et al., 2009; Hens et al., 2010; Kullmuss and Agyeman, 2002). Some examples of these approaches include: how to increase environmental awareness in the classroom (Chapman and Sharma, 2001; Mc Cormick et al., 2005; Yilmaz et al., 2004); the environmental attitudes regarding personal environmentally responsible behaviour (Kaiser et al., 1999; Scott and Gough, 2003); the role of emotions when encouraging positive environmental attitudes, especially young female students (Davidson and Freudenburg, 1996; Keles, 2011; Tikka et al., 2000); environmental sensitivity as important issue of environmental awareness (Chawla, 1999); and the reasons for and barriers to environmentally friendly behaviour, such as infrastructure (Kullmuss and Agyeman, 2002). Changes in individual attitudes (including understanding and knowledge) are focused in channeling education and awareness towards environmental conversation (Hassan et al., 2009). In the context of environmental education, Chan (1996) posited that a significant discrepancy exists between an individual's knowledge and actual behaviour, where understanding the complexities of the inter-relations between the natural environment and human activities, represent a necessary condition for environmental preservation. Teachers' attitudes towards the environment play a key role in influencing students' attitudes (Bradley et al., 1999; Summers, 2000; Stir, 2006), especially when behaviour is consistent with the interests of the society within which people live (Chapman and Sharma, 2001). As indicated, education in the early stages is fundamental, especially in school where students are still sensitive to learning and imitating (Brecko, 2005), i.e. to forming and shaping their informational attitudes that could then inform their future behaviour.

5. Methodology

Descriptive statistics and t-test were used to assess the green computing attitudes of university students towards environmental conservation. These methods allow investigating underlying interpretations of the subjects (Cargan, 2010). ABU Zaria, a university in the North-west of Nigeria, was selected as a case study to explore the students' green computing attitudes. Random samples of 700 university students from six faculties were selected. A questionnaire, based on a five point Likert-type scale, ranging from 5 (Strongly agree) to 1 (Strongly disagree) (Likert, 1967), was designed to explore the University students' attitudes toward green computing. The items were generated from a research conducted by the researchers on green computing and they went through two rounds of validation, first on green computing content by experts, and second for psychometric properties by measurement experts. The reliability index of the data was Cronbach's alpha $\alpha = 0.839$ for the Likert-type items. This index constitutes a very good indicator of data and instrument reliability for a social science research (Golafshani, 2003; Kirk & Miller, 1986).

6. Data Collection and Analysis

A total of 700 questionnaires were administered personally by hand with the help of research assistants and in class with the help of lecturers. Some respondents were given a few days to respond; others filled them out on the spot. A number of follow-up measures were used to ensure a high response rate, and 566 usable ones were returned, constituting a response rate of about 81%. The data was analyzed using the Statistical Package for the Social Sciences (SPSS) version 16.0. Assessing complex phenomena, as in the case of this study, requires that the inter-relationships among the items are contemplated (Bastic, 2006). This can be done through factor analysis, which allows examining how the underlying construct influences the responses on measured variable (DeCoster, 1998) by identifying the fundamental variable or factor that explain any correlation patterns within a set of observed variable. Factor analysis here was used to ensure that the items fall under one factor that explains the variable under study.

A combination of descriptive statistics and *t*-test techniques were used to address the research objectives. Responses to the items measuring students' attitude toward pro-green computing were summated and displayed in frequency counts and percentages to show the distribution of students (Table 1). This was first done for all respondents, and then by gender to show the differences. The summated scores on the responses were subjected to independent samples *t*-test analyses to ascertain the influence of gender on students' attitude toward green computing. The level of statistical significance adopted for the analysis was $p < 0.05$, which formed the basis of whether or not a statistically significant difference existed between the groups under study.

7. Result of the Study

Table 1 shows the percentage breakdown of students' responses on the items in the questionnaire. The result shows that only 32 (5.6%) of the respondents were of disagreement with the green computing behaviour, while majority (80.2%) of the respondents have agreed and tend to exhibit green computing practices and very few respondents (14.1%) were on either side.

TABLE I: Frequency count and Percentage of the Respondents on Agreement and Disagreement on Green Computing Practices

	Frequency	**Percent**
Strongly disagree	11	1.9%
Disagree	21	3.7%
Undecided	80	14.1%
Agree	222	39.2%
Strongly agree	232	41%

An independent-sample *t*-test was further performed on the mean scores of the respondents which show a gender influence on students' green computing practices (Table 2). Female students were reported to have higher level of agreement on green computing practices (M = 297.5, SD = 171.8) than did their male counterparts (M = 275.4, SD = 147.5). The difference in the mean scores was found to be statistically significant, ($t(564) = -1.55$, p

= 0.00), This shows that female university students were more concern about green environment and have more likely intention to adopt green computing practices than their male counterpart.

TABLE II: *Summary of Independent Sample t-Test Result on the Influence of Gender on Students' Intention to Green Computing Practices (N=566)*

Respondent	N	Df	M	SD	T	p-value
Gender						
▪ Male	359	564	275.4	147.5	- 1.55	*P* = 0.00
▪ Female	207		297.5	171.8		

Significant at p > 0.05

8. Conclusion

Going green is the central issue of the much discussion that centered upon how to reduce energy consumption and carbon emissions, prevent wastage, cut costs and protect the environment through green ideas, green initiatives, green buildings and green policies must be considered. The behavior of university student who constitutes a good percentage of world population and who are the largest users of electric/electronic equipment need to be moulded toward green practices. Therefore, this study makes an effort to assess university students' behavior toward green computing so that the result of the study may add some knowledge to the existing literature.

9. Recommendation

- The Nigerian Government should mount a campaign on the need for green computing practices in school and colleges.

- Universities authorities in Nigeria should include pro-environmental behaviour courses and make it compulsory in their curriculum.

- Tree planting and maintenance strategies campaign should be mounted in order to absorb the carbon dioxide emitted resulting from computing practices.

- Male university students should be encouraged to as a matter of urgency improve their attitude positively toward green environment.

10. References

[1] Akaslan, D., Law, E.L.C. (2010). E-learning in the science of electricity in higher education in turkey in terms of environment and energy. *Proceedings of Postgraduate Research Student Conference 2010: Perspectives in Society*, Nottingham, UK.

[2] Bastic, M. (2006). *Research Methods.* University of Maribor, Faculty of Economics and Business, Maribor, Slovenia.

[3] Batlegang, B. (2012). Green computing: students, campus computing and the environment: a case for Botswana. *Journal of Information Systems and Communication, 3* (1), 256-260.

[4] Blake, J. (1999). Overcoming the "valueeaction gap" in environmental policy and local experience. *Local Environment 4 (3),* 257-278. http://dx.doi.org/10.1080/13549839908725599

[5] Bradley, J.C., Waliczek, T.M., Zajicek, J.M. (1999). The relationship between environmental knowledge and environmental attitude of high school students. *Journal of Environmental Education 30 (3),* 17-21. http://dx.doi.org/10.1080/00958969909601873

[6] Brecko, D. (2005). Teamwork: Internal Study Material of the Workshop in Mercator. Presented at the University of Maribor, Faculty of Organizational Sciences, Kranj.

[7] Cargan, B. (2010). *Basic Methodologies of Pedagogical Research*. University of Maribor. Faculty of Pedagogy, Maribor (in Slovene).

[8] Cavas, B., Cavas, P., Tekkaya, C., Cakiroglu, J., Kesercioglu, T. (2009). Turkish students' views on environmental challenges with respect to gender: an analysis of ROSE data. *Science Education International 20 (1&2),* 69-78.

[9] Chan, K.K.W. (1996). Environmental attitudes and behaviour of secondary school students in Hong Kong. *The Environmentalist 16 (4),* 297-306. http://dx.doi.org/10.1007/BF02239656

[10] Chapman, D., Sharma, K. (2001). Environmental attitudes and behaviour of primary and secondary students in Asian cities: an overview strategy for implementing an eco-schools programme. *The Environmentalist 21,* 265-272.

http://dx.doi.org/10.1023/A:1012996016601
[11] Chawla, L. (1999). Life paths into effective environmental action. *Journal of Environmental Education 31 (1),* 15-26. http://dx.doi.org/10.1080/00958969909598628
[12] Davidson, D., Freudenburg, (1996). Gender and environmental risk concerns: A review of available research. *Environmental Behaviour 28,* 302-339. http://dx.doi.org/10.1177/0013916596283003
[13] DeCoster, J. (1998). Overview of Factor Analysis Available online: http://www.stathelp.com/notes.html
[14] Dookhitram, K., Narsoo, J., Sunhaloo, M. S., Sukhoo, A. & Soobron, M. (2012). Green computing: an awareness survey among university of technology, mauritius students. *Conference Proceeding of International Conference on Higher Education and Economic Development, Mauritius,* 3-5, 2012.
[15] Fishbein, M., Ajzen, I. (1975). *Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research.* Addison-Wesley, Reading, MA.
[16] Golafshani, N. (2003). Understanding reliability and validity in qualitative research. *Qualitative Report, 8* (4), 597-607.
[17] Hassan, A., Juahir, H., Jamaludin, N.S. (2009). The level of environmental awareness among students to fulfill the aspiration of National Philosophy of Education. *American Journal of Scientific Research 5,* 50-58.
[18] Hens, L., Wiedemann, T., Raath, S., Stone, R., Renders, P., Craenhals, E., Richter, B. (2010). Monitoring environmental management at primary schools in South Africa. *Journal of Cleaner Production 18 (7),* 666-677. http://dx.doi.org/10.1016/j.jclepro.2009.11.001
[19] Jena, R.K. (2010). Green computing: need of the hour. *Communications in Computer and Information Science, 112,* 312-318. http://dx.doi.org/10.1007/978-3-642-16324-1_33
[20] Johnston, C. (2011). Ask ars: are "green" hard drives really all that green? *Ars Technica: Gear and Gadgets, Product News and Reviews*
[21] Kaiser, F.G., Wolfing, S., Fuhrer, U. 1999. Environmental attitude and ecological behaviour. *Journal of Environmental Psychology* 19, 1-19 http://dx.doi.org/10.1006/jevp.1998.0107
[22] Kawahara, T., & Yoshimura, C. (2013). Low power processing with NV-RAM. In Takayuki Kawahara & Hiroyuki Mizuno (Eds.), *Green Computing with Emerging Memory: Low-Power Computation for Social Innovation* (183-206). New York: Springer.
[23] Keles, O. (2011). Evaluation of primary school students' thought about behaviour and attitudes towards environment. *Energy Education and Technology Part B, Social and Educational Studies 3 (3),* 343-359.
[24] Kirk, J. & Miller, M. (1986). *Reliability and validity in qualitative research methods.* London, U.K: SAGE University Press.
[25] Kullmuss, A., Agyeman, J. (2002). Mind the Gap: why do people act environmentally and what are the barriers to pro-environmental behaviour? *Environmental Education Research 8 (3),* 239-260. http://dx.doi.org/10.1080/13504620220145401
[26] Lamb, J. (2009). *The greening of IT: how companies can make a difference for the environment.* Boston, MA: Pearson, IBM Press.
[27] Lewin, K. (1947). Frontiers in group dynamics. Concept, method and reality in social science; social equilibria and social change. *Human Relations 1 (1),* 5-41. http://dx.doi.org/10.1177/001872674700100103
[28] Likert, R. (1967). *The Method of Constructing an Attitude Scale. Readings in Attitude Theory and Measurement.* Wiley, New York.
[29] Lozano, R. (2009). Orchestrating Organisational Change for Corporate Sustainability. Strategies to overcome resistance to change and to facilitate institutionalization. Unpublished Doctoral, Cardiff University, Cardiff.
[30] Luthans, F. (2002). *Organizational Behavior.* McGraw-Hill, New York.
[31] Mc Cormick, K., Mühlhäuser, E., Nordén, B., Hansson, L., Foung, C., Arnfalk, P., Karlsson, M., Pigretti, D. (2005). Education for sustainable development and the Young Master Programme. *Journal of Cleaner Production 13,* 1107-1112. http://dx.doi.org/10.1016/j.jclepro.2004.12.007
[32] Omer, A.M. (2008). Green energies and the environment. *Renewable and Sustainable Energy Reviews, 12,* 1789–1821. http://dx.doi.org/10.1016/j.rser.2006.05.009
[33] Rogers, E. M. (1995) *Diffusion of innovations,* Free Press, New York.
[34] Scott, W., Gough, S. (2003). *Sustainable Development and Learning: Framing the Issues*. Routledge-Falmer, London. http://dx.doi.org/10.4324/9780203464625

[35] Seitz, V., Yanti, F., & Karant, Y. (2011). Attitudes toward green computing in the US: can they change? *Scientific Annals of the "Alexandru Ioan Cuza" University of Iasi, Economic Sciences Section (SAAIC), 2011SE*, 151-158.

[36] Stir, J. (2006). Restructuring teacher education for sustainability: student involvement through a strengths model. *Journal of Cleaner Production 14 (11),* 830-836.
http://dx.doi.org/10.1016/j.jclepro.2005.11.051

[37] Summers, M. (2000). Primary teachers' understanding of environmental issues: and interview study. *Environmental Education Research 31 (3),* 12-19.
http://dx.doi.org/10.1080/713664700

[38] Tikka, P.M., Kuitunen, Tynys, S.M. (2000). Effects of educational background on students' attitudes, activity levels and knowledge concerning the environment. *Journal of Environmental Education* 31, 12-19.
http://dx.doi.org/10.1080/00958960009598640

[39] Wu, Z., Giles, C., & Wang. J. (2013). Classified power capping by network distribution trees for green computing. *Cluster Computing*, *16* (1), 17-26.
http://dx.doi.org/10.1007/s10586-011-0173-8

[40] Yilmaz, O., Boone, W.J., Anderson, O. (2004). Views of elementary and middle school Turkish students towards environmental issues. *International Journal of Science Education 26 (12),* 1527-1546.
http://dx.doi.org/10.1080/0950069042000177280