



GREEN COMPUTING: STUDENTS, CAMPUS COMPUTING AND THE ENVIRONMENT- A CASE FOR BOTSWANA

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Abstract- How has Information Technology (IT) impacted lives, especially of students studying in higher institutions of learning in Botswana? Are IT users aware of the concept and application of Green Computing? The aim of this paper is to answer the above important questions. In this paper we will critically look at IT penetration in Botswana and how it has impacted the lives of Botswana users, both positively and negatively. The paper also aims to assess awareness levels of IT users with regards to Green Computing; that is using IT in ways that are not harmful to the environment. A recommendation will be given on how Green Computing strategies can be implemented at Botho College. Statistics were sought to have an understanding of technology presence in Botswana especially usage of technology by students in higher institutions of learning. A questionnaire and interview questions were prepared to establish the levels of awareness of negative impacts of IT and of environmental sustainability awareness or green computing. The questionnaires were given to students and staff while management and representatives from the IT department were interviewed.

The research finding established that more education is required in order to make IT users to take greener approaches of using technology and associated gadgets. The research also confirmed that an elevated level of awareness could lead to behavioural changes and welcome greener uses of IT.

Keywords- Botho College, Green Computing, E-waste, Energy Conservation, Awareness Program, Education

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Introduction

"Green Computing is the practice of using computer resources efficiently" [1]. Another definition is the one which defines green computing as the study and practice of efficient and eco-friendly computing resources. Green computing is no longer viewed as an issue of environmental organizations alone but other businesses such as commercial, universities, governments etc. have started paying attention to it as well [2].

The primary goals of green computing are:

- to reduce the use of hazardous materials
- to maximize the energy efficiency during the product's lifetime
- to promote biodegradability or recyclability of defunct products and factory waste [3].

Green computing is concerned with reducing the environmental impact of (Information Technology) IT before IT devices are purchased, during their lifetimes and after we have finished with them. Most manufacturers are improving their processes at the

different levels of the product life to lessen harm e.g. computer manufacturers are finding alternative materials to make computers. These materials are usually eco-friendly, renewable or might use less energy [4].

Computers manufacturers are striving to be ISO 14001 certified so that they are able to implement, maintain and improve an environmental management system as well as ensuring that companies comply with environmental laws and regulations [5].

Various companies are implementing the following strategies to reduce environmental impact of computers during their use; when IT devices are not in use they are put in sleep mode, IT machines are switched off when not in use, sharing documents and files on the screen or use FTP servers and only print on demand and where necessary, using virtualization software instead of physical machines/servers, printing less etc.

As for reducing environmental impact after use, some manufacturers use metal and easily separated plastics (or any components)

to maximize raw material re-use. This will ensure that after users have finished using the product, they have at their disposal some recycling schemes (e.g. bulk collections for old mobile phones). The product lives of product must be prolonged through upgrade options rather than finishing the lifespan of products. Old IT products can be donated to charities and refurbishing organizations which might increase the product life [3].

The above are some of the strides made in ensuring green computing for sustainable environment. This paper is concerned with conducting a research on measuring the awareness levels of students in a college on the issues of green computing.

The remainder of the paper is organized as follows. Section II discusses the background of IT penetration in tertiary institutions in Botswana. It presents how students are able to acquire laptops with special emphasis on the laptop scheme at Botho College. Section III is concluded by determining the number of computers at Botho College and calculating the total energy consumed by computers. Section IV discusses the methodology used in this research paper; the questionnaire which was used to measure the awareness levels of computer users and interview questions which were prepared specifically for the management of the college and personnel from the IT department. In Section V, the results of the study are discussed as well as their interpretation. Section VI presents the recommendations made for Botho College while Section VII is the conclusion of the research paper.

Background

In Botswana most students acquire laptops upon entering college. Some colleges like Botho College supply laptops to students at subsidized prices. In 2008, 689 computers were given to students with a cautionary upfront fee of P500.00 only, which students could claim back upon returning of the laptop at the end of their study. In 2009, 324 computers were issued to students. In 2010 and 2011, 165 and 22 computers were issued respectively. In total 1200 computers have been issued under this scheme. The number of laptop that the college was issuing was dwindling yearly because, the cautionary fee was increased to P2000.00 after the institution realized that the students were abusing and vandalizing the laptops.

In other institutions the majority of students purchase laptops through savings from their living stipends and miscellaneous allowances paid by the Government of Botswana.

The laptops and PCs are primarily used for assisting students with their school work but it has become a common scene to find students playing computer games during the breaks between classes or to constantly find them on social media such as facebook and tweeter. What should be noted is that students at Botho College spend an average of six hours a day on computers, either doing their assignments, playing games and on social media everyday. What is evident is that the use of computers is growing at a phenomenal rate and naturally so is the consumption of energy. A computer is made up of many components that consume power: the CPU, hard drives, graphic cards, monitors, speakers, printers, communication devices, scanners, etc.

"Ref. [6]"state that; the average desktop computer consumes about 120 watts of electricity, on average, the monitor consumes 75 watts, and the CPU consumes 45 watts, laptops consumes between 15 and 45 watts. There are around 1300 desktop com-

puters at Botho College and if they are all left on all the time they would consume a total of 1, 366megawatts-hours per year.

Equation (1) approximates the amount of energy that will be used by the computers in a year [9].

$$\text{Power}_{\text{year}} = 1300\text{computers} * 120\text{W} * 24\text{hours} * 365 \text{ days} * 1\text{MW}/1000 \text{ 000W} \quad (1)$$

Equation (2) can be used to calculate the cost of running a computer for one year [9].

$$\text{Cost}_{\text{year}} = [\text{Average Watts/hour}] * [\text{hours run in 1 year}] * [1\text{kWh}/1000\text{W}] * [\text{Cost of electricity per kWh}] \quad (2)$$

To calculate the cost of n computers (n=any number of computers), simply calculate for one computer and multiply by n [7].

During their operations computers not only consume energy but also leave carbon foot prints. IT-related equivalent carbon dioxide (CO₂e) emissions alone have been estimated at two per cent of the world's total [3].

What prompted this research paper is the fact that, at face value, students and other computer users are oblivious to the negative impacts of computers. As stated earlier this research will attempt to establish how much Botho College community has incorporated green policy strategies into their operations.

Methodology Questionnaire

A questionnaire was designed and issued to students and academic employees at Botho College. The questionnaire was designed using the approach used in a paper titled "A vocabulary test to assess information security awareness" [8].

The questionnaire aims to measure the awareness levels of computer users with regards to green computing. The questionnaire consists of two parts-the first part to perform green computing vocabulary test and the second part to evaluate the respondent's behaviour.

The questionnaire questions are multiple choice questions with five options to choose from. This is an exploratory study to test the awareness levels of respondents on green computing hence it was decided to only ask ten elementary/general aspects of green computing.

The text below is a sample of the first part of the questionnaire

Section A

Green computing is:

- the environmentally responsible use of computers and related resources.
- the use of energy efficient technologies, techniques and devices aimed at helping the environment.
- also referred to as Green IT
- all of the above
- I do not know what the term green computing means.

Power Management is

- the creation of a virtual (rather than actual) version of something, such as a hardware platform, operating system, a storage device or network resources.
- conservation of power used by all electrical appliances.
- the same as virtualization
- all of the above
- I do not know the meaning of power management.

For the above sample snippet of the questionnaire, it is expected that a user with a good understanding of the term green computing would select option (d) as the most appropriate answer for question 1.

For question 2, the correct answer is (b).

The idea with the first section is to establish the respondent's 'green' vocabulary awareness. That part was to include basic and "generally known" perceptions and terms to establish whether respondents know the meaning of these concepts. It is assumed that a respondent with basic understanding of Green computing will be able to ace the questionnaire with little difficulty [8].

For the second part, the questionnaire aims to evaluate the respondents' behaviour independently of their vocabulary knowledge hence scenario-type questions are used.

Please see the sample below;

Section B

You are the last person to use the computer in the lab; after finishing using it, what will you do? (select ALL that apply)

- I will quickly leave the computer lab to catch a taxi before it gets dark without switching off the computers. If all people in the lab leave without switching off the computers, who am I to act otherwise?
- I will quickly switch off the computer and also ensure that all other electronic equipment's such as air conditioners and lights are switched off if the lab supervisor is not available.
- I will inform the lab supervisor if I see him that the computers, air conditioner and lights are on.
- I will not only switch off my computer, but all the other computers that are left on.

If you have to rush out for 30 minutes to 1 hour, you will (select ALL that apply).

- Switch off your computer and switch it on when you come back.
- Ensure that the screen saver appears on my screen as this saves energy, before leaving.
- I will put the machine in sleep mode and leave.
- Since I will be back in less than an hour, it does not make sense to frequently switch on and off my machine as this can reduce its life span.
- I will lock my computer so that unauthorized users are not able to access it.

The second part of the questionnaire as already stated contained scenario-type questions. Five questions which were designed by the researcher after studying various text and websites were asked.

The questions will establish how the respondents will generally behave with regards to issues related to energy use/conservation as well as green computing in general.

The questionnaire was distributed among students studying different courses, at different levels at Botho College as well as to a few members of staff. The level of study of the students ranged from year 1 to year 4 (undergraduate) as well as Masters (postgraduate) students. The questionnaires were distributed during class times; and each class sits a maximum of 30 students. The participants study different courses such as IT, business and accounts.

A total of 110 participants were used for answering the question-

naire. The technique used is sampling but the researcher made it a point to distribute the question paper to a wide variety of students and members of staff at Botho College.

The student and staff population is about 5000 and 170 respectively and future research work will use more participants depending on the availability of resources.

Table below shows a summary of the allocation of the questionnaire and what transpired.

Table 1- Summary Of Questionnaire Allocation And Response

	Number of questionnaires distributed per class	Number of responses received	Year of study/ work
	20	20	1
	20	20	2
	20	20	3
	20	20	4
	10	10	Masters
	20	20	Member of staff
Total	110	110	

Interview question

A set of interview questions were prepared for the management of the school and personnel from the IT department. The whole idea behind the interview questions is to establish if there are any green initiatives at the institution, if there are green policies for sustainable environment etc. please see the sample interview questions below.

- What are some of the green IT initiatives by the institution?
- Do you have any established green purchasing policy for computers and associated peripherals? If it is there please state it.
- Are there any equipment disposal procedures in the institution? If it is there please elaborate.
- Does the institution have the capability to monitor and measure the electric consumption of individual buildings? If not, are there any future plans to do that?
- Have you ever held an energy awareness program in the institution? If not, are there any future plans to do that?

Results

Demographic details

From the 110 responses, 48 were male and 62 were female.

The pie chart below represents the percentage number of respondents for each level of study.

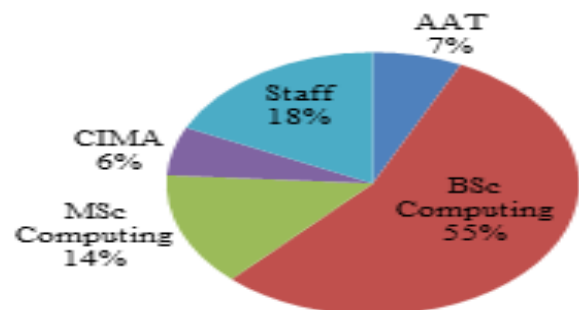


Fig. 1- Percentage of respondents per level of study

Interpretation of questionnaire data

The following table shows how respondents answered each question.

Table 2- Summary of Cumulative Questionnaire Results

Question Number	The no. of part question selected for each question	Correct responses in %	Incorrect responses
Section A			
1 (a)	17		
(b)	33		
(c)	6	9	91
(d)	10		
(e)	27		
2 (a)	61		
(b)	22		
(c)	0	75	25
(d)	0		
(e)	10		
Section B			
1 (a)	4		
(b)	6		
(c)	28	52	48
(d)	33		
(e)	39		
2 (a)	47		
(b)	5		
(c)	30	28	72
(d)	2		
(e)	26		
Average		38	62

The results show that, in general; the majority of respondents have limited or no knowledge on issues of green computing. In section A, 40.8% of the respondents answered the questions correctly. This means that 59.2% was not able to answer the questions satisfactorily.

What can be inferred from the above results is that the majority of student and staff population at Botho College lack basic knowledge of Green Computing.

What is also disturbing from the above results is the number of respondents who chose the 'I do not know' choice. 32% of respondents chose this option which further iterates that green computing knowledge or education is lacking at Botho College.

As for Section B, 35.4% of respondents answered the questions correctly. This shows how green computing techniques and strategies are applied on average at the college. This figure shows that a lot of work needs to be done to sensitize the college population on green computing.

The response for all questions in that section except for question 1 reflect that, practices that can lead to unnecessary high consumption of energy power through behaviours such as plugging devices when not necessary, leaving air conditioners unnecessarily on etc. are practiced by both staff and students.

Interpretation of interview data

From the interview the following can be concluded

- Botho College does not have explicit policies on environmental sustainability.
- There is an energy awareness program as in all classes and the computer labs-there are messages that encourages students and faculties to ensure that lights, computers and air conditioners are switched off if the class is the last of the day. There are also some power saving tips stuck on each class door and notice board.
- The college has only purchased computers with the energy

star logos and strives to purchase equipment that uses as little energy as possible.

- When the laptops and computers get old, they are sold to staff and students at cheap prices.
- For energy consumption figures, the college relies on Botswana Power Corporation to hand them a bill at the end of the month.
- The college has an agreement with their computer suppliers that allows them to return old computers.

Recommendation

The recommendations that follow below are adopted from various texts studied; from journals, books and the Internet especially the recommendation by [9].

Campus Position and Policy

Botho College must define sustainability policies and green initiatives that are managed by environmental advisory boards, institutes or committees. The college must revisit its policies and create an institutional environmental mandate to build a strong foundation of green policies, initiatives and programs.

College Awareness Program

To start with Botho College needs to create a sustainability website which will have a list of energy saving tips, e waste management procedures, campus green position and policy and any other information related to green computing.

Botho College can come up with innovative strategies that will ensure maximum participation by all stakeholders in ensuring energy reduction practices and e-waste management practices. A campaign will have to be developed that is based on social marketing theory, moving beyond information provision to motivation and persuasion techniques, identifying effective short-term incentives and long-term behaviour modification strategies. Lastly the awareness program will have to be measured and evaluated.

Energy Conservation and Strategies and Practices

Users must be encouraged to implement power management options on their machines.

- Reducing the overall time the system as a whole and monitor is on.
- Ensuring that peripherals that are not in use are switched off as well as switching off air conditioners and lights that are not in use.

Improve electrical metering practices in order to enable the development of an energy consumption measurement program and energy indicators that break down energy consumption in a way that is easily communicable and relevant to the campus.

Fig. 2 below shows comparative results of a study that was done to show the power consumption (in watts) of 20" Dell LCD monitors at different states [7].

Note that from Fig. 2; when unplugged the monitor does not use any energy, but when it is off it can still use some bit of energy. In sleep mode it will use more energy than when it is off. Observe how, the study revealed elevated consumption of energy when the monitor is on [7].

Fig. 3 below shows the desktop and laptop power consumption (in watts). Please note the differences in power consumptions for unplugged, off, sleep mode, hibernate, idle and max CPU [7].

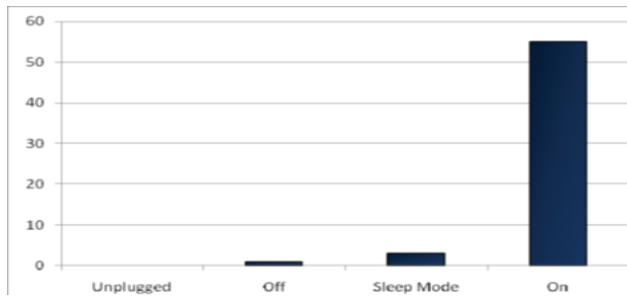


Fig. 2- Dell 20" LCD monitor power consumption (watts)

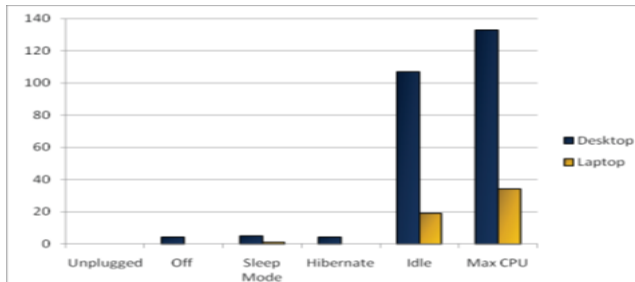


Fig. 3- Desktop and laptop power consumption (watts)

Computer procurement

The university must define a policy and statement that espouse socially responsible environment procurement of computers. The above policy and statement must reflect a desire on behalf of the college to give consideration to those companies that address the environmental impacts through production, sale, recycling / disposal of the goods and services provided. The college must consider companies which manufacture computers and operate in environmentally sensitive ways. The college must consider companies which manufacture; to Energy star electrical efficiency standards; products which are environmentally sensitive in daily operations; and research new equipment / improve equipment in an effort to consume fewer resources or consume recyclable resources through-out its useful life.

Botho College must strive to include and conduct life cycle analysis when evaluating equipment, goods or services.

Computer Equipment Disposal Procedures

Botho College must design and define a recycling program. In addition to a computer recycling program, a statement within the policy advocating or explicitly recommending reuse before recycling must be defined.

Though e-waste treatment and disposal methods are not common in Botswana. Botho College can be at the forefront of environmentally safe disposal and recycling of computers.

The following strategy can be used by Botho College:

Recycling of e-waste: Monitors especially Cathode Ray Tube (CRT) monitors, keyboards, laptops, modems, telephone boards, hard drives, floppy drives, compact disks, mobiles, fax machines, printers, CPUs, memory chips, connecting wires and cables can be recycled. The different devices will have to be dismantled, that is, removal of different parts of e-waste containing harmful substances such as mercury, separation of plastic, removal of CRT, segregation of ferrous and non-ferrous metals and printed circuit boards.

Reuse: The institution can consider giving out some of its old devices and computers to charity organizations and to remote areas of Botswana where the technology penetration is low. This can greatly help to bridge the digital divide in the country. Also since the institution has a strong IT department, they should consider modifying some functionality of some equipment such as computer, so as to make the equipment relevant even in future. It is quite encouraging that some of the suppliers of Botho College actually buy back old used equipment but Botho College can go a step further by ensuring that the same companies use proper treatment and disposal of e-waste by authorized processes as this can considerably reduce the volume of e- waste generation.

Conclusion

This paper was motivated by the rising cost of energy in Botswana, depletion of natural resources, increasing concern for the environment by the Botho College population. The main aim of this paper was to measure awareness levels of students and staff at Botho College with regards to Green Computing. The research established that the awareness levels are low hence most users are oblivious to energy saving techniques. The research also established that they are no explicit green computing and sustainability policies at the institution. The college website does not have any sustainability activities.

After advancing reasons why the college should adopt green computing procedures and programs the author gave recommendations after studying similar research papers and considering the nature of the institution.

To conclude, the author is confident that incorporating the green computing techniques discussed in this paper into Botho College campus can have an immediate impact by reducing power consumption by computers and associated peripherals. Raising green computing awareness and having a campaign based on social marketing theory which will not only include information provision but also incorporate motivation and persuasion techniques can have a huge desired impact on the power usage and reduction of CO2e emissions especially when all the stakeholders are involved.

References

- [1] Chakraborty P., Bhattacharyya D., Nargiza Y. and Bedajna N. (2009) *International Journal of Grid and Distributed Computing*.
- [2] Gingichashvili S. (2007) *Green Computing*.
- [3] Tebbutt D., Atherton M. and Lock T. (2009) *Green IT For Dummies, John Wiley & Sons Ltd*.
- [4] Orfano F. (2009) *How Computer manufacturers are using eco-friendly materials to reduce toxins*.
- [5] Stenzel P.L. (2004) *Encyclopedia of Business, ISO 14000*.
- [6] Stenzel P.L. (2005) *Sleeping Computers Help Keep Trent Green*.
- [7] Talebi M. and Way T. (2009) *Methods, Metrics and Motivation for a Green Computer Science Program*,
- [8] Kruger H., Drevin L. and Steyn T. (2010) *A vocabulary test to assess information security awareness*.
- [9] Steeves C., Abram A., Maurice G., Nonnecke B., Stevanus D. and Walker J. (2006) *Campus Computing and the Environment*.