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Short Paper*

Green Computing Awareness: A Case of a Philippine Public Higher Education Institution

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Abstract

Purpose – The objective of the study is to identify the green computing awareness in the case of a Philippine public higher education institution.

Method – The study adopted a descriptive research design that describes what exists in a situation and often accomplishes this by using descriptive statistics. It made use of a structured questionnaire and used quantitative data.

Results – Generally, the employees have a commendable level of approval in line with knowledge, attitude, and behavior towards Green Computing practices.

Conclusion – Employees have a very good understanding and acceptance in terms of Green Computing practices.

Recommendations – The school management needs to provide their employees with Green Computing Awareness Trainings and Seminars to sustain their level of awareness about topics such as Green Computing trends and practices.

Research Implications – School management should formulate policies that ensure the implementation of Green Computing practices in the overall organization.

Keywords – Green Computing Awareness, Global warming, Electronic waste, Philippine Public Higher Education Institution

INTRODUCTION

The field of Information Technology (IT) has continually increased its importance at present. Data from the Philippine Statistics Authority 2012 showed that there were 2,122 establishments classified as Information Economy (IE) in 2010, an increase of 0.7 percent from 2,107 in 2009. IE industries are involved in producing and trading IT products, and those which primarily use IT in providing products and services. There was also an increasing trend in the percentage of establishments with Internet access as nine in every 10 establishments in the Philippines had Internet access in 2010. Of the 259,741 IE employees, 48.9 percent used computers routinely at work in 2012. The percentage was slightly higher than that in 2009 (46.0% of 272,063 employees) and four percentage points higher than that of 2008 (44.9% of 304,864 employees). Meanwhile, the presence of a website was reported by 43.4 percent of establishments in 2010.

However, the increases in industries coupled with technological progress have continued to affect and violate the environment in several ways. For instance, the introduction of computers and other electronic gadgets into both the home and offices has a considerable impact on the environment. The recent innovations in IT are one of the contributing factors blamed for much of the pollution that affects global warming. Environmental pollution occurs as a result of technology mismanagement and a lack of control measures. Emission of many gases such as carbon dioxide in the air by large industries causes air pollution which in turn has degraded the environment immensely. The improper disposal of electronic waste into the landfills causes toxic materials to seep into groundwater, affecting both land and sea animals causing pollution and environmental hazards. Furthermore, IT contributes to the depletion of resources. The development and usage of IT are contributing to an increase in industrial activity that requires raw material from natural resources such as metals inside gadgets, among others (Sankar Polaiah, 2016).

Consequently, because of the damaging effects of IT on the planet earth, green computing has gained significance among researchers, commercials, universities, government organizations, etc. Green computing is the study and practice of using computing resources in an energy-efficient and eco-friendly manner (Landwehr, 2005). The adoption of green computing necessitates that computer users be informed about

the various facets of the notion, what it is that constitutes environmentally sustainable computing, what features, and characteristics make such devices compliant with the green movement. Hence it is, crucial to identify what users know and do not know about green computing to help place green initiatives on the right track and in the right direction (Ahmad, Nordin, & Bello, 2013). Therefore, the focus of the study is on green computing awareness in the case of a Philippine public higher education institution.

STATEMENT OF THE PROBLEM

The purpose of the study is to describe green computing awareness in an academic setting with the following specific questions:

1. What is the level of employees' awareness in terms of the following green computing measures:
   1.1. Power down gadgets when not in use;
   1.2. Use gadget power-saving features;
   1.3. Buy energy-efficient gadgets;
   1.4. Reduce paper printing and consumption; and
   1.5. Upgrade and maintain existing gadgets instead of purchasing new?
2. Is there a difference in the adaptation among the demographics of employee respondents in terms of:
   2.1. Years of gadget usage;
   2.2. Total hours of gadget usage daily;
   2.3. Total number of gadgets owned;
   2.4. Age;
   2.5. Gender;
   2.6. Field of Study (IT/Non-IT related degree); and
   2.7. Educational Attainment?

LITERATURE REVIEW

Green Computing

In recent years, the emergence of Green Computing as a means of tackling an environmental problem caused by technological mismanagement becomes a matter of global demand. Green Computing, as stated by the International Federation of Global & Green Information Communication Technology (2019), means the practice or study of environmentally sustainable computing or Information Technology.

Techopedia (2019) further explained that Green computing is environmentally responsible and eco-friendly use of computers and their resources. In broader terms, it is also defined as the study of designing, engineering, manufacturing, using, and disposing of computing devices in a way that reduces their environmental impact. Green computing aims to attain economic viability and improve the way computing devices are used. Green

IT practices include the development of environmentally sustainable production practices, energy-efficient computers, and improved disposal and recycling procedures.

Negative Effects of Information Technology on the Environment

MySecureCyberspace (2019) of the Carnegie Mellon University enumerated some ways that Information Technology can cause harm to the environment. According to them, many of the technologies we use every day consume a lot more resources and power than they need to and using and manufacturing them can create a mess. Here are a few of the ways that technology can harm the environment:

- **Pollution** - Air, water, heat, and noise pollution can all be caused by producing and using technology. The computer is using electricity, and so is a mobile device and a video game system. Carbon emissions that are released to the atmosphere, mostly carbon dioxide and carbon monoxide, are greenhouse gasses that are produced by people using electricity.
- **Consuming resources** - Non-renewable resources, including precious metals like gold, are used to make technology. Many others, such as coal, are consumed to generate the electricity to use technology. Even some renewable resources, like trees and water, are becoming contaminated or are used up faster than they can renew themselves because of technology.
- **Waste** - Manufacturing technology creates large amounts of waste and used computers and electronics get thrown out when they break or become outdated. Electronic waste contains all sorts of hazardous materials that are very unsafe for the environment.
- **Disrupting ecology** - Clearing land where animals used to live to build factories and allowing pollution to contaminate the food chain can greatly affect the environment's natural cycles.
- **Health hazards** - Using toxic materials that can harm our health can cause cancer, and technology addiction can lead to other health problems like obesity and carpal tunnel syndrome.

Green Computing Awareness

To achieve the behavioral change spoken of by Schauer (2008) as cited by Boloz (2015) people need to be educated first. Ahmad and Nordin (2014) as discussed by Boloz (2015) point out that for an individual to begin to adopt an idea, system, or device, that individual needs to know something about it first. Surprisingly, many educated people in the field of Information Technology, including faculty and students, are incognizant of the importance of sustainability issues and of the impact of Green Computing efforts on the environment (Sendall, Shannon, Peslak & Saulnier, 2011 as cited in Boloz, 2015).

Government Initiatives toward Green Computing around the World

Visalakshi, Paul, and Mandal (2013) discussed that many governmental agencies have continued to implement standards and regulations that encourage green computing. In 1992, the U.S. Environmental Protection Agency launched Energy Star, a voluntary labeling program that is designed to promote and recognize the energy efficiency in monitors, climate control equipment, and other technologies. This resulted in the widespread adoption of sleep mode among consumer electronics. The Energy Star program was revised in October 2006 to include stricter efficiency requirements for computer equipment, along with a tiered ranking system for approved products. From 1992 to 2018, Energy Star and its partners helped American families and businesses save nearly 4 trillion kilowatt-hours of electricity. There are currently 26 states in the United States that have established state-wide recycling programs for obsolete computers and consumer electronics equipment. The statutes either impose an "advance recovery fee" for each unit sold at retail or require the manufacturers to reclaim the equipment at disposal. In 2010, the American Recovery and Reinvestment Act (ARRA) was signed into legislation by President Obama. The bill allocated over $90 billion to be invested in green initiatives (renewable energy, smart grids, energy efficiency, etc.). In January 2010, the U.S. Energy Department granted $47 million of the ARRA money towards projects that aim to improve the energy efficiency of data centers. The projects will provide research on the following three areas: optimize data center hardware and software, improve power supply chain, and data center cooling technologies.

Sourabh, Aqib, and Elahi (2017) reported that in 1998, the China National Development and Reform Commission (NDRC) founded the China Energy Conservation Program (CECP), a nonprofit organization in charge of the administration, management, and implementation of the certification for energy- conserving, water-saving, and environmentally friendly products.

Green Computing Initiatives in the Philippines

Hernandez (2017) explored the Green computing practices of higher education institutions in the Philippines, where a qualitative multiple-case study is used. The study found that higher education institutions Green IT adoption covers the use of paperless and digital archiving systems, resource-efficient IT equipment, responsible electronic waste disposal, recycling, and reuse, and initiated awareness programs to educate the employees about Green IT and sustainability. The study also found that these practices are in their early stage of adoption in higher education institutions in the Philippines. This article also presents practical and research implications to further the uptake of Green IT in higher education institutions.

The Philippine Government has also formulated a law that promotes Green Computing initiatives. President Rodrigo Duterte has signed into law a bill requiring the creation of an advanced energy and green building technologies curriculum for both

undergraduate and graduate students. Duterte signed Republic Act No. 11393 or "Advanced Energy and Green Building Technologies Curriculum Act" on August 22, 2019. The law recognizes the importance of assisting higher education institutions (HEIs) "in preparing the next wave of design and construction professionals as well as the existing pool of architects, engineers, landscape engineers, landscape architects, and planners all over the country, to become adept in the incorporation of advanced energy and green building technologies in the design and construction of green or high-performance buildings." Under the law, the Commission on Higher Education (CHED), in consultation with the Department of Energy (DOE), and CHED-recognized higher education institutions (HEIs) will be tasked to develop a curriculum on advanced energy and green building technologies at the undergraduate and graduate levels. The curriculum shall focus on "design resilience, natural resource conservation, and sustainable design and building practices, among others, to prepare students for future careers in advanced energy and green building technologies to enable future engineers, architects, and urban planners to incorporate advanced energy and green building technologies in the design of high-performance buildings." The CHED, in consultation with the DOE, will also be "mandated to develop graduate education curriculum related to advanced energy technology research, development, demonstration, and commercial application activities about energy research and development." Both agencies, as well as concerned stakeholders, will be tasked to promulgate the implementing rules and regulations (IRR) necessary to ensure the efficient implementation of the act. Also, under the law, advanced energy refers to technologies and services which are delivering a secure, clean, and affordable energy system. A green building refers to a building that, in its design construction or operation, reduces or eliminates the negative impact on the climate and natural environment of an area and the country in general. On the other hand, a high-performance building refers to a form of green building with a singular focus on its energy performance and which integrates and optimizes all major high-performance building attributes. The law requires that a green or high-performance building shall use all forms of renewable energy, provides good indoor or environmental air quality, and consider environment-friendly design, construction, and operation (Parrocha, 2019).

METHODOLOGY

The study adopted a descriptive research design that describes what exists in a situation and often accomplishes this by using descriptive statistics. It made use of a structured questionnaire and used quantitative data. Descriptive research design describes what exists in a situation and often accomplishes this by using descriptive statistics. It made use of a structured questionnaire and used quantitative data (Hair, et al. 2015; Penwarden, 2019; Given, 2019).

Research Locale

The study was carried out in a selected college in a Philippine public higher education institution. The selected institution is managed under a City Local Government Unit in the Philippines. The identity of the respondent institution was kept confidential or not revealed because of confidentiality concerns that were covered in the study. Some details of the institution that might lead to its identification were not disclosed.

Population of the Study

The respondents of the study were the Dean, Chairpersons, Area Coordinators, faculty, and staff of the selected College in the Philippine public higher institution. The selected college was the College of Information Technology and Computer Studies. The study made use of total enumeration or the entire population as the respondent of the study. The Green Computing awareness (Problem No. 1) was answered by the Dean, Program Chairpersons, Area Coordinators, Faculty, and Staff. Table 1 detailed the number of respondents of the study in the respondent school per function. The overall retrieval rate is 96% which comprises all the employees who answered the questionnaire out of the 125-total population.

Table 1. Respondents of the Study

Position	Population	Actual Response	Retrieval Rate (%)
Dean	1	1	100.00
Program Chairpersons	3	3	100.00
Area Coordinators	6	6	100.00
Faculty	113	108	95.58
Staff	2	2	100.00
Total	125	120	96.00

Research Instrument

The researcher prepared the questionnaires to be used as a research instrument based on the statement of the problem. The first questionnaire is a Green Computing awareness questionnaire in terms of knowledge, attitude, and behavior (Problem No. 1). The items from the questionnaire were adopted from the study of Dookhitram, et al. (2013) and Boloz (2015) in assessing Green Computing awareness. The questionnaire for the Green Computing awareness consists of 18 items. Table 2 presents the item specification of the questionnaire.

Table 2. Green Computing Awareness Questionnaire Items Specification

Item Number	Green Computing Measures					Awareness Measurement Model		
	Power down gadgets when not in use	Use gadget power-saving features	Buy energy-efficient gadgets	Reduce paper printing and consumption	Upgrade and maintain existing gadgets instead of purchasing new	Knowledge	Attitude	Behavior
1	✓					✓		
2		✓				✓		
3			✓			✓		
4				✓		✓		
5					✓	✓		
6	✓						✓	
7		✓					✓	
8			✓				✓	
9				✓			✓	
10					✓		✓	
11	✓							✓
12	✓							✓
13		✓						✓
14			✓					✓
15				✓				✓
16				✓				✓
17					✓			✓
18					✓			✓
Total Items	**4**	**3**	**3**	**4**	**4**	**5**	**5**	**8**

The Questionnaire made use of the following Semantic differential scale:

5 0

Strongly Agree **Strongly Disagree**

Descriptive Statistics using Microsoft Excel

The quantitative data from the research questionnaire were electronically tallied in Microsoft Office Excel. The PivotTable feature of Excel was used in the statistical analysis of the mean of the responses. Mean refers to the sum of all scores in a distribution divided by the total number of items in a distribution (Jelen & Alexander, 2013), to write:

$$\bar{x} = \frac{x_1 + x_2 + \ldots + x_n}{n} = \frac{\sum_{i=1}^{n} x_1}{n} = \frac{\sum x}{n}$$

Equation 1

where x = scores
n = number of items

Green Computing Awareness

The Level of Green Computing Awareness was presented in Table 3 using the computed mean values and the following matrix of interpretations:

Table 3. Matrix for Interpreting Means of Green Computing Awareness

Mean	Interpretation
4.01-5.0	Strongly Agree
3.01-4.00	Agree
2.01-3.00	Neither agree or disagree
1.01-2.00	Disagree
0.0-1.00	Strongly Disagree

Inferential Statistics using Microsoft Excel

The measurement difference of the respondents' level of awareness according to the demographics of the respondents (Statement of the Problem No. 2) made use of the inferential statistical technique as presented in Table 4. It made use of 0.05 Alpha Level respectively. ANOVA and t-test were also computed using Excel Analysis ToolPak.

Table 4 summarizes the differences in the perceived level of awareness among the employee respondents according to their profile as an outcome of findings for the Statement of the Problem No. 2. Using t-test and ANOVA at 0.05 Alpha Level respectively, data revealed that their profile such as Years of gadget usage, Total hours of gadget usage daily, Age, Field of Study (IT/Non-IT related), and Educational Attainment can be associated to their level of awareness (With Difference). Meanwhile, the total number of gadgets owned, and Gender cannot be associated with their level of awareness (No Difference). The findings could provide good input for the school management in assessing the needs of their employees for Green Computing awareness training with regards to the different demographic groups.

Table 4. Inferential Statistic Technique

Profile	Statistical Test	Computed value (∝=0.05)	Tabular (Critical value)	Decision	Interpretation
Years of Gadget Usage	ANOVA	4.16	3.07	Reject Null Hypothesis	With Difference
Average Hour of Gadget Usage Daily	ANOVA	5.34	3.44	Reject Null Hypothesis	With Difference
Total Number of Gadgets Owned	ANOVA	2.05	3.44	Accept the Null Hypothesis	No Difference
Age	ANOVA	4.20	3.07	Reject Null Hypothesis	With Difference
Gender	t-test	2.15	2.89	Accept the Null Hypothesis	No Difference
Field of study (IT/Non-IT related degree)	t-test	3.80	2.36	Reject Null Hypothesis	With Difference
Educational Attainment	ANOVA	4.52	3.44	Reject Null Hypothesis	With Difference

Cronbach's alpha and internal consistency of the Questionnaire

The questionnaire was pre-tested in a selected college (not included in the respondents) to test its validity. A statistician made use of Cronbach's alpha to measure the internal consistency and reliability of the questionnaire items with the computed value of 0.91. The Cronbach's alpha was interpreted as "Excellent" using a matrix from Westland (2015).

RESULTS AND DISCUSSIONS

Data from Table 5 presents that the employees strongly agree in their awareness in terms of Power down gadgets when not in use (4.36), Use gadget power saving features (4.50), Buy energy-efficient gadgets (4.27), Reduce paper printing and consumption (4.53), and Upgrade and maintain existing gadgets instead of purchasing new (4.19). The employees' high level of response rate revealed that they value much the conservation of the environment. Green Computing awareness training will further strengthen the employees' involvement in saving the planet.

Table 5. Summary of Green Computing Awareness

Domains	Knowledge	Attitude	Behavior	Awareness/ KAB Mean
Power down g-adgets when not in use	4.55 Strongly Agree	4.55 Strongly Agree	3.98 Agree	4.36 Strongly Agree
Use gadget power-saving features	4.48 Strongly Agree	4.69 Strongly Agree	4.32 Strongly Agree	4.50 Strongly Agree
Buy energy-efficient gadgets	4.21 Strongly Agree	4.52 Strongly Agree	4.08 Strongly Agree	4.27 Strongly Agree
Reduce paper printing and consumption	4.65 Strongly Agree	4.52 Strongly Agree	4.42 Strongly Agree	4.53 Strongly Agree
Upgrade and maintain existing gadgets instead of purchasing new	4.49 Strongly Agree	3.92 Agree	4.17 Strongly Agree	4.19 Strongly Agree
Grand Mean	4.48 Strongly Agree	4.44 Strongly Agree	4.19 Strongly Agree	4.37 Strongly Agree

The difference in the Perceived Level of Awareness among the Demographics of Employee Respondents

Table 6 summarizes the differences in the perceived level of awareness among the employee respondents according to their profile. Using t-test and ANOVA at 0.05 Alpha Level respectively, data revealed that their profile such as Years of gadget usage, Total hours of gadget usage daily, Age, Field of Study (IT/Non-IT related), and Educational Attainment can be associated to their level of awareness (With Difference). Meanwhile, the total number of gadgets owned, and gender cannot be associated with their level of awareness (No Difference). The findings could provide good input for the school management in assessing the needs of their employees for Green Computing awareness training with regards to the different demographic groups.

Table 6. Differences in the Perceived Level of Green Computing Awareness among the Employee Respondents

Profile	Inferential Statistic Technique	Computed value (α=0.05)	Tabular (Critical value)	Decision	Interpretation
Years of gadget usage	ANOVA	4.16	3.07	Reject Null Hypothesis	With Difference
Total hours of gadget usage daily	ANOVA	5.34	3.44	Reject Null Hypothesis	With Difference
Total number of gadgets owned	ANOVA	2.05	3.44	Accept the Null Hypothesis	No Difference
Age	ANOVA	4.20	3.07	Reject Null Hypothesis	With Difference
Gender	t-test	2.15	2.89	Accept the Null Hypothesis	No Difference
Field of Study (IT/Non-IT related degree)	t-test	3.80	2.36	Reject Null Hypothesis	With Difference
Educational Attainment	ANOVA	4.52	3.44	Reject Null Hypothesis	With Difference

CONCLUSIONS AND RECOMMENDATIONS

Generally, the employees have a very good understanding and acceptance in terms of Green Computing practices. Green Computing Awareness is affected by factors such as employee's years of gadget usage, total hours of gadget usage daily, age, a field of study (IT/Non-IT related degree), and educational attainment.

The school management needs to provide their employees with Green Computing Awareness Trainings and Seminars to sustain their level of awareness about topics such as current Green Computing trends and practices. Moreover, such Green Computing Awareness Training should have a focus on areas that reveal a low level of awareness, and the profile has a difference.

Green Computing is every employee's concern because it is our ethical responsibility as global citizens to make use of technology while not harming the environment. This will allow the institution to further evolve and adapt to meet the new and continuing challenges and demands faced every day. An environmentally aware institution considers more than just an excellent school operation, but it considers its impact on society and the environment.

RESEARCH IMPLICATIONS

The study implies that the School management should formulate policies that ensure the implementation of Green Computing practices such as conservation of electricity, purchasing of energy-efficient gadgets, printing on both sides of the paper if possible, electronic gadget upgrade and maintenance to extend the machine lifespan, appropriate ways of electronic disposal, among others. Green Computing policies are imperative because they address pertinent issues, such as what constitutes acceptable behavior by employees toward the proper use of technology.

The School should continually improve their Green Computing measures and practices especially that technological change takes place in a very fast phase. Green Computing practices benchmarking will assist to gain an independent perspective about how well the institution perform compared to others. It also enables a culture of a growth mindset for the institution.

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