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Awareness of ICT's Environmental Impact and Commitment to Environmental Sustainability Among Engineering Students

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Abstract:

Information and communication technology (ICT) is developing rapidly, and high expectations are being placed on it about sustainable development. Regarding the environmental impacts of ICT, it is important to understand one's commitment to environmental sustainability. This descriptive-correlational study aimed to determine the level of awareness of the environmental impacts of ICT and the respondents' level of commitment to environmental sustainability among two hundred fifty-two (252) students at a private university in Laguna, from its various engineering programs. Among the ICT factors that have an environmental impact, recharging of laptops, energy efficiency and e-waste topped the list. Results also showed that the respondents have a very high level of environmental sustainability. Test of relationship, meanwhile, revealed that the higher the respondents' level of awareness ofthe environmental impact of ICT, the higher their level of commitment to environmental sustainability. Towards the end of the study, an action plan which focuses on educating people about how to recycle, reuse, and dispose of electronics at all levels that will teach them and their communities how to behave more responsibly towards environmental sustainability was proposed.

Keywords **—ICT, environmental sustainability, descriptive-correlational research.**

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I. INTRODUCTION

In the era of globalization, the rapid growth in the usage of information and communication technology (ICT) leads to enhanced productivity and energy efficiency in different sectors of the economy over the past three decades. However, its effect on the environment is still inconclusive and cannot be ignored in the ICT-environmental debate.[1]In theory, ICT is among the sources contributing to the increasing levels of CO_2 emissions in terms of production of ICT machinery and devices, energy consumption, and recycling of electronic waste, which harm the environment. However, ICT is expected toreduce CO_2 emissions on a global scale by developing smarter cities, transportation systems, electrical grids, industrial processes, and energy-saving gains. [2]Information and communication technologies (ICT) are increasingly permeating our daily life and we ever more commit our data to the cloud. Events like the COVID-19 pandemic put an exceptional burden upon ICT. This involves increasing the implementation and use of data centers, which increased energy use and environmental impact.[3]

To address the sustainability challenges various sustainability targets have been set globally. To ensure achievements of those targets, sustainability

assessment of various products, services and solutions, systems, industrial sectors and whole countries' production and consumption are needed. [3]Environmental sustainability is defined as meeting the resource and services needs of current and future generations without compromising the health of the ecosystems that provide them. Specifically, it could be defined as a condition of balance, resilience and interconnectedness that allows human society to satisfy its needs while neither exceeding the capacity of its supporting ecosystems to continue to regenerate the services necessary to meet those needs nor by our actions diminishing biological diversity.[4]The extraction of rare earth elements reboundsthe effect of energy consumption and e-waste contributes to CO_2 emissions. Based on the reference, production and ICT use contribute 2% to 3% of global CO_2 emissions. Electrical consumption from the use of ICT causes CO_2 emissions and electricity consumption for ICT products and services have increased from 3.9% to 4.6%. [5]

Electronic goods are classified under three major heads such as white goods (household appliances), brown goods (TVs, camcorders, cameras) and grey goods (computers, printers, fax machines, scanners, cell phones, etc). When electronic appliances become useless, come in the category of e-waste. Waste from grey goods is more toxic as compared with white and brown goods. This kind of waste is posing a serious challenge in disposal and recycling in both developed and developing countries. For example, a computer contains different types of elements, including valuable metals (gold, silver, platinum, copper etc.) as well as hazardous materials (cadmium, mercury, lead, brominated flame-retardants, etc.). Apart from these, computers, printers, and other equipment contain a sophisticated blend of plastics. These toxic materials are complex and difficult to recycle in an environmentally sound manner even in developed countries, so these materials generated from the dismantling of computers are dumped in nearby soil and water. Landfilling of this waste results in significant contamination of the soil and groundwater while incineration of waste leads to the release of toxic gases like dioxins and furans. Due to the high content of precious metals and high demand for used machines in developing countries like India, obsolete PCs are attractive to informal recyclers. The recycling of computers requires sophisticated technology and processes, which are not only very expensive but also need specific skills and training for the operation. Most of the recyclers currently engaged in recycling activities do not have this expensive technology to handle the waste. Even with all toxins removed recycling will cause impacts due to emissions while extracting valuable materials.[6]

Another reference cited that e-waste has raised concerns because many components in these products are toxic and do not biodegrade easily if at all. [7]Based on these concerns, many European countries banned e-Waste from landfills in the 1990s. Alarming levels of dioxin compounds are linked to cancer, developmental defects, and other health problems; in samples of breast milk, placenta, and hair, these compounds are linked to improper disposal of electronic products. Furthermore, surveys have indicated that much exported US e-Waste is disposed of unsafely in developing countries, leaving environmental and health problems in these regions. Due to the difficulty and cost of recycling used electronics, as well aslacklustre enforcement of legislation regarding e-Waste exports, large amounts of digital discards are transported internationally from various industrialized countries to certain destinations where lower environmental standards and working conditions make processing e-Waste more profitable. Impacts from those countries, especially in Asia, have already been reported. Meanwhile, recycling and disposal of e-Waste are also growing in regions beyond Asia, particularly in certain African countries.

Recycling is the key to reducinge-waste. Recycling has environmental benefits at every stage in the life cycle of a computer product—from the raw material from which it is made to its final method of disposal. Aside from reducing greenhouse gas emissions, which contribute to global warming, recycling also reduces air and water pollution associated with making new products from raw materials. By utilizing used,

unwanted, or obsolete materials as an industrial feedstock or for new materials or products, we can do our part to make recycling work.[5]

In the Philippines, the Grade 9 Science students at President Ramon Magsaysay University are very aware of environmental concepts, the state of the environmentin environmental issues and problems. The respondents often practice the need to take action to solve environmental problems while they sometimes practice the need to possess a high degree of commitment.There is a significantly high positive relationship between environmental awareness andenvironmental practices. [9]A study stated that in evaluating the environmental awareness and practices of Senior High School students at a private school in the Philippines, the level of environmental awareness was significantly and substantially related to their extent of environmental practice.[9]Environmental commitment is the individual's pursuit of environmental sustainability, willingness to sacrifice personal enjoyment, reducing waste of resources, using environmentally friendly new products, and supporting government's adaptation strategies. In Taipei, college students showed a connection to nature enhanced social identity, place attachment, and environmental concern, which in turn increased environmental concern for sustainability.[10]

Engineering students are technically inclined, and the application of ICT is a great advantage in engineering education. It is important to know the level of awareness of the environmental impact of ICT among engineering students since environmental degradation and depletion of natural resources are realities which can no longer be denied. The concerning need for commitment to environmental sustainability is of great importance. As evidenced, environmental concerns of college students served as the mechanism for commitment and environmental values, highlighting which pathways to wisdom could produce ecosystem sustainability.[10]

This study aimed to determine the level of awareness of students atthe College of Engineering of the University of Perpetual Help System-Laguna on the environmental impacts of ICT and the respondents' level of commitment to environmental sustainability. Likewise, it also determined the significant relationship between the level of awareness of students atthe College of Engineering on the environmental impacts and respondents' level of commitment to environmental sustainability and made an action plan necessary for sustainability based on the findings.

II. METHODOLOGY

This study utilized the descriptive-correlationdesign since it describes certain phenomena, particularly the level of awareness of the environmental impacts of ICT and the level of commitment tothe environmental sustainability of students of the College of Engineering.

A request letter to the Dean of the College of Engineering was permitted, validated, and approved to get the actual population of the six programs for the school year 2020-2021. The population of the study wastwo hundred fifty-two (252) students enrolled in the second semester of the academic year 2020-2021 at the College of Engineering of the University of Perpetual Help System-Laguna. A stratified sampling method was used. The students are under the six programs of the College of Engineering, namely, Civil Engineering (CE), Computer Engineering (CpE), Electrical Engineering), ElectronicsEngineering (ECE), Industrial Engineering (IE) and Mechanical Engineering (ME)and a survey questionnaire through 4-point Likert scale in google form which was sent to students via messenger and group chat (GC). Part 1 covered the level of awareness ofthe environmental impact of ICT while Part 2 dealt with respondents' level of commitment to environmental sustainability

The instrument underwent the validation of experts in engineering, research, and statistics. It was also subjected toa reliability test which yielded Cronbach's Alpha of 0.894 (good) for the level of awareness of environmental impacts of ICT and 0.917 (excellent) for the level of commitment to environmental sustainability.

The introductory part of the instrument informed the respondents as to the purpose and importance of the study. They were also assured of the

confidentiality of their identity and responses and that the pieces of information that they provided were used for research purposes only, particularly for presentation and publication purposes. The statistical tools used for the quantitative analysis of the data gathered included weighted mean, which was used to determine the respondents'(a) level of awareness of environmental impacts of ICT, and (b) level of commitment toenvironmental sustainability. Pearson r was used to determine the significant relationship between the respondents' level of awareness ofthe environmental impacts of ICT and their level of commitment to environmental sustainability.

III. RESULTS AND DISCUSSIONS

This study aimed to determine the level of awareness of students of the College of Engineering of the University of Perpetual Help System-Laguna on the environmental impacts of ICT and their level of commitment to environmental sustainability. Likewise, it also determined the significant relationship between the respondents' level of awareness of the environmental impact of ICT and their level of commitment to environmental sustainability.

A. The Respondents' Level of Awareness on Environmental Impact of ICT

TABLE I
RESPONDENTS' LEVEL OF AWARENESS ON ENVIRONMENTAL IMPACT OF ICT

Indicators	Weighted Mean	Interpretation	Rank
1. e- waste	2.90	High	3
2. energy efficiency	2.99	High	2
3. power management	2.89	High	4
4. proper computer and devices disposal	2.65	High	6
5. proper phone disposal	2.63	High	7
6. proper battery disposal	2.72	High	5
7. proper recharging of laptop	3.08	High	1
Average Weighted Mean	2.84	High	

As shown in Table I, there was a high level of awareness on environmental impact of ICT like proper recharging of laptop (WM = 3.08), energy efficiency (WM = 2.99), e-waste (WM = 2.90), power management (WM = 2.89), proper battery disposal (WM = 2.72), proper computer and devices disposal (WM = 2.65) and proper phone disposal (WM = 2.63). In connection thereto, an average weighted mean of 2.84 showed that the respondents have a high level of awareness of the environmental impact of ICT, indicating that the respondents are aware of proper recharging of devices, knowledge of e-waste, energy efficiency and management which attributed by the knowledge gained in courses related to this. The results also suggest that proper disposal of batteries, phone, computer, and devices be the basis of an action plan.

In evaluating the environmental awareness and practices of Senior High School students at a private school in the Philippines [9], the level of environmental awareness was significantly and substantially related to their extent of environmental practice.

B. The Respondents' Level of Commitment to Environmental Sustainability

TABLE III
RESPONDENTS' LEVEL OF COMMITMENT TO ENVIRONMENTAL SUSTAINABILITY

Indicators	Weighted Mean	Interpretation	Rank
1. reduce paper waste	3.54	Very High	9
2. recycle more	3.62	Very High	3.5
3. reduce energy consumption	3.57	Very High	8
4. choose environmentally friendly packaging	3.61	Very High	5.5
5. think twice before buying (reduce, reuse, recycle)	3.62	Very High	3.5
6. purchase energy efficient appliances/gadgets	3.52	Very High	10.5
7. use energy saving lightbulbs	3.56	Very High	7
8. use reusable and eco-friendly alternatives	3.61	Very High	5.5
9. donate unused items	3.52	Very High	10.5
10. conserve water	3.68	Very High	1
11. use eco-friendly cleaning products	3.67	Very High	2
Average Weighted Mean	3.59	Very High	

As shown in Table II, the respondents have a very high level of commitment in terms of conservation of water (WM = 3.68), use eco-friendly cleaning products (WM = 3.67), think twice before buying (reduce, re-use, recycle) (WM

= 3.62), recycle more (WM = 3.62), choose environmentally friendly packaging (WM = 3.61), use reusable and eco-friendly alternatives (WM = 3.61), use energy saving light bulbs (WM = 3.56), reduce energy consumption (WM = 3.57), reduce paper waste (WM = 3.54), purchase energy efficient appliances/gadgets (WM = 3.52) and donate unused items (WM = 3.52).

An average weighted mean of 3.59 indicates a "very high" level of respondents' commitment to sustainability, indicating that conservation of water and application of 3Rs (Reduce, Reuse, Recycle) is applied in choosing products. This can be attributed to the knowledge obtained in environmental science courses. The results also suggest that reduction of paper waste, purchasing energy-efficient appliances/gadgets and donating unused items be the basis of an action plan.

Personal environmental commitment refers to perceived feelings of obligation toward the environment, with people who have some environmental concern and resulting in environmental sustainability.[10] This showed environmental commitment as an individual's pursuit of environmental sustainability, willingness to sacrifice personal enjoyment, reducing waste of resources, using environmentally friendly new products, and supporting government's adaptation strategies.

C. The Relationship between the Respondents' Level of Awareness on Environmental Impacts of ICT and their Level of Commitment to Environmental Sustainability

TABLE IIIII
RELATIONSHIP BETWEEN THE RESPONDENTS' LEVEL OF AWARENESS ON ENVIRONMENTAL IMPACTS OF ICT AND THEIR LEVEL OF COMMITMENT TO ENVIRONMENTAL SUSTAINABILITY

Variables	Pearson r	p-value	Interpretation
Level of Awareness on Environmental Impacts of ICT and their Level of Commitment to Environmental Sustainability	0.196 (Very weak relationship)	0.024	Significant

Note: Significant @ 0.05

As shown in Table III, for the relationship between the respondents' level of awareness of environmental impacts of ICT and their level of commitment to environmental sustainability, a Pearson r value of 0.196 was obtained, indicating a very weak relationship. A p-value of 0.024 was obtained which was lower than the 0.05 level of significance showing that there is a significant relationship between the respondents' level of awareness ofthe environmental impacts of ICT and their level of commitment to environmental sustainability. This implies that their high level of awareness of the environmental impact of ICT partly contributes to their very high level of commitment to environmental sustainability, suggesting that there are other strong factors like family influence, school influence and wider cultural environmental practices that affect their commitment to environmental sustainability.

Recycling has environmental benefits at every stage in the life cycle like a computer product—from the raw material from which it is made to its final method of disposal[5]. Aside from reducing greenhouse gas emissions, which contribute to global warming, recycling also reduces air and water pollution associated with making new products from raw materials. Thus, recycling contributes to environmental sustainability.

D. The Plan of Action

The action plan was proposed to improve the respondents' level of awareness on proper disposal of batteries, phone, computer, and devices and to elevate the respondents' commitment to environmental sustainability in reduction of paper waste, purchasing energy-efficient appliances/gadgets and donating unused items that will teach them and their communities how to behave more responsibly towards environmental sustainability.

TABLE IVV
THE PROPOSED PLAN OF ACTION

Strategy	Brief Description
1.Educate Perpetualite community about the importance of recycling e-waste	Share the knowledge of recycling e-waste to reduce waste, save energy and be aware of the hazards e-waste poses.
2. Find partnership with an experienced recycling firm.	The university will look for partnership with experienced recycling firm which will meet the highest standards on recycling e-waste and ensure

	that nothing of value within any devices gets wasted.
3. Educate students to look for an environmentally friendly label when buying electronic products.	Disseminate information about Electronic Products with Energy Star or certified by electronic Product Environmental Assessment Tool have low environmental impact.
4. Reuse as often as possible.	If the parts and equipment are still working, try repairing the electronic device before getting a new one.
5. Teach kids about e-waste	Children are our future, and it helps if we can insist within them at a young age their commitment to e-waste recycling.
6. Consider limiting the number of electronics owned.	Look for devices that have multiple functions.
7. Provide a bin for used and non-functioning batteries and phones.	College of Engineering will collect used and non-functioning batteries when there is partnership with an experienced recycling firm.
8. Educate students the importance of donating unused items like electronic gadget but making sure that it is in working condition.	Electronics for reuse extends the lives of valuable products and keeps them out of the waste management system for a longer time.
9. Promote paperless transactions.	It will lessen the use of consumables and expenses,

The crafted ecological management plan implementation will increase the degree of commitment of students toward ecological conservation [8]. Likewise, the action plan presented will increase the students' level of awareness of the environmental impact of ICT and their commitment to environmental sustainability.

IV. CONCLUSIONS AND RECOMMENDATIONS

Based on the findings, it can be concluded that the students at the College of Engineering of the University of Perpetual Help System-Laguna have a high level of awareness of the environmental impact of ICT and have a very high level of commitment to environmental sustainability.A very weak relationship was found between the two variables, implying that their high level of awareness of the environmental impact of ICT partly contributes to their very high level of commitment to environmental sustainability.

The action plan was proposed based on the factors which received the lowest summative means namely proper disposal of batteries, phone, computer, and devices to increase the students' level of awareness of the environmental impact of ICT andreduction of paper waste, purchasing energy-efficient appliances/gadgets and donating unused items to increase the student's level commitment to environmental sustainability.

Based on the conclusions drawn for future directions, it is recommended that the faculty members teaching environmental engineering courses should emphasize the environmental impact of ICT and an act of commitment to environmental sustainability. There should be seminars about proper e-waste management and recycling e-waste. Likewise, NGOs should adopt a participatory approach in the management of e-waste. The university may also upgrade the quality of facilities laboratories to continuously enhance the knowledge and skills of the students necessary for proper e-waste management. Future researchers may conduct similar studies covering students' profiles as well as other variables may be included. Multiple higher education institutions (HEIs) can also be covered.

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