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Electronic Waste is a Mess: Awareness and Proenvironmental Behavior Among University Students in Ghana

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E-waste contains hazardous chemicals and materials that threaten the environment and human health, when improperly disposed. This study examined levels of awareness of e-waste disposal among university students in Ghana, and their proenvironmental decision-making using two outcome variables: *knowledge on environmental impact and policy issues* (EIPI) and *environmental behavior and sustainability* (EBS). Reliability estimates (Cronbach's alpha) for the two outcomes variables were 0.91 and 0.72, respectively. Exploratory and confirmatory factor analyses were used to explore and determine the underlying factor structure for the latent constructs employed as dependent variables; and to verify the factor structure while testing the relationships between observed indicators and their underlying latent constructs. Ordinary Least Square techniques were then used to examine the effects of theoretically relevant covariates on the selected dependent variables. Results indicate satisfactory model adequacy, ($\chi^2 = 33.59$, df = 29; $p < 0.255$; RMSEA = 0.01). Awareness of e-waste among the students was generally low. Students' awareness of e-waste contamination of air and soil (effects) was higher than their awareness of acceptable e-waste practices (change strategies) or environmental policy (vision). Gender and level of study were both positively related to *environmental behavior and sustainability* (EBS). Compared to females, males scored higher (b = 0.192) on EBS. Students in the lower levels of their university education scored higher (b = 0.256) on EBS, compared to those in

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upper years of university. Also, students in the lower levels of university scored higher on knowledge of environmental impact and policy (b = .0175), compared to those in upper years of university.

INTRODUCTION

E-waste is best defined as any piece of electronic equipment that is very near to or has reached the end of its useful life. E-waste contains valuable metals (copper, members of the platinum group) as well as potential environmental contaminants, especially lead, antimony, mercury, cadmium, nickel, polybrominated diphenyl ethers (PBDEs), and polychlorinated biphenyls (PCBs). Developing countries particularly those in Sub-Saharan Africa are increasingly becoming digital dumping sites (Amoyaw-Osei et al., 2011; Asante et al., 2011; Oteng-Ababio, 2010; Prakash, Manhart, Amoyaw-Osei, & Agyekum, 2010). Research on e-waste issues in Ghana has focused primarily on the socioeconomic impacts (Prakash et al., 2010), environmental impacts (Oteng-Ababio, 2010; Robinson, 2009), human exposure and health risk (Asante et al., 2011; Caravanos, Clark, Fuller, & Lambertson, 2011), and policy gaps (Brigden, Labunska, Santillo, & Johnston, 2008). However, the role of environmental education in awareness, and in shaping e-waste practices among individuals, is not fully understood. It is this gap that this article attempts to fill. Closely associated with the mounting level of e-waste in Ghana is its proliferation on university campuses, yet to date, there has been limited to no integration of e-waste issues in university curricula. A limited number of natural and applied sciences-based programs, however, encompass some e-waste information. To contribute to this literature, this study aims to examine university students' understandings of e-waste impacts and the decision-making process in Ghana. Specifically, we attempt to answer the following questions: do participants with different academic backgrounds express different understanding of environmental impacts of e-waste disposal? If so, what factors contribute to the awareness levels of these students? Do year and program of study, and gender influence level of awareness?

THEORETICAL FRAMEWORK

Central to appreciating human behavior, and its feedbacks on the environment, is the issue of values and belief systems. Fischer et al. (2012) argue that the greatest challenge to sustainability is a systemic lack of deep reflection on the value and belief systems that underpin unsustainable behaviors. There is an important need to understand how value and belief systems evolve, especially in relation to the way people interact with their environment. At the individual level, beliefs and values are influenced by age, gender, education, and social status (Rokeach, 2000). At the structural or societal level, socioeconomic development is associated with value shifts, such as from a focus on survival to a focus on self-expression (Inglehart, 2000). Motivations underlying proenvironmental behavior have become more complex with the growing popularity of recycling programs. However, Guerin, Crete, and Mercier (2001) find small but significant statistical relationships between environmental concerns and proenvironmental behavior. Several researchers also investigate the impact on behavior or intentions of specific attitudes towards recycling; in general, they conclude that these matter (McCarty & Shrum, 2001). Economic arguments suggest that convenience, and more generally costs may significantly impact proenvironmental behavior (Jenkins et al., 2003). Most environmental psychologists and educators believe that

environmental education (EE) is linked to environmental behavior (Bowers, 1993; Cortese, 1992; Gigliotti, 1990; Olson, Lodwick, & Dunlap, 1992; Smith, 1992). In this article, we argue that the behavior (e-waste practices) of university students might be sustainable if they are aware of environmental policy issues, and are conscious of the feedbacks that emanate from their interaction with the environment.

METHODS

Hypotheses

We developed and implemented a survey instrument for testing awareness and e-waste disposal. Our initial hypotheses were that:

1. University students differ in their demographic characteristics and in the structure of their programs.
2. Students pursuing a science-based program are more orientated toward e-waste recycling and less willing to take environmental risks than students pursuing nonscience-based programs.
3. Students pursuing science-based programs have a greater awareness of and concern for environmental problems associated with e-waste disposal than their nonscience counterparts.
4. Male and female students exhibit differential environmental behavior regarding e-waste disposal.

Questionnaire Development

A self-designed questionnaire, consisting of four main sections, was used to conduct the survey. The first part collected information about general environmental attitudes and behaviors. Its purpose was to gauge how respondents felt towards the environment and how likely they are to engage in proenvironmental behavior. The last question in this section asked respondents how willing they would be to drop-off e-waste at a recycling center. The second section assessed respondents' knowledge of e-waste and asked that they tabulate eight different categories of obsolete electronic items. The last two sections gathered demographic and socioeconomic data and asked about preferred e-waste recycling options for a contingent ranking exercise. The socioeconomic data were necessary for modeling purposes and for comparing characteristics of our respondents with data from the Ghana Population and Housing Census 2010. Participating pretests were conducted prior to the actual survey. Respondents were informed that the pretest was a practice run. The participating pretests involved interview settings where respondents were asked to explain reactions to question form, wording, and order. This kind of pretest assisted us to determine whether the questionnaire was understandable.

Data Collection

A representative sample was drawn from students of the University of Cape Coast (population of 18,600) pursuing different academic programs during the 2010/2011 academic year (Table 1). Females constituted one third of the student population compared to the male population (two thirds). In all, 1,200 questionnaires were randomly distributed out of which 1,154 were retrieved, giving a response rate of

Table 1
Faculties/Schools of the respondents

	Frequencies	Percentage
Agriculture	96	8.32
Arts	170	14.7
Biological Sciences	98	8.49
Business	94	8.15
Education	248	21.5
Medical Sciences	76	6.59
Physical Sciences	186	16.1
Social Sciences	156	13.5
No response	30	2.6
Total	1154	100

96.2%. The four sections of the questionnaire were designed to collect both qualitative and quantitative information. Three experts from the departments of Population and Health, Industrial Chemistry, and Environmental Science at the University of Cape Coast rated each question which were statistically analyzed. The questionnaire was then modified to ensure content validity.

A group of 3-point scale statements were used for the quantitative/survey aspect of the questionnaire. In addition, open-ended questions were included to enhance the quantitative findings. These questions give enough room to the respondent in framing answers that are less encumbered by a prepared set of possible replies (Oppenheim, 1986). The survey instrument included banks of items measuring various constructs. A bank of item was included that measured environmental knowledge and attitudes including the students' outlook toward e-waste-related environmental issues, general concern for the environment and motives for recycling e-waste. Another bank of items measured policy orientation and included a variety of questions about the environmental and health risks involved in unsustainable e-waste disposal. The survey instrument also included questions about students' adoption of recycling practices, essentially as a measure of sustainable environmental behavior. Students' responses were limited to six possible categories: (a) use the e-waste recycling practice now, (b) used it in the past but not now, (c) never used it, (d) never used it but plan to, (e) the practice does not apply, and (f) unfamiliar with the practice.

Measures

A major objective of this study was to test students' awareness of e-waste, and how that translates into proenvironmental decisions. Thus, the outcome variables used in this study consist of various questions that tapped respondents' knowledge of e-waste issues including how such items are disposed or recycled. The first outcome variable, which we call *environmental impact and policy issue (*EIPI), is a latent construct and a scale measure derived from specific questions that asked students if e-waste was: (a) a problem that needed collective effort to tackle, (b) e-waste was overhyped and that there was no cause for concern, (c) burying of e-waste material in the ground leads to soil infertility, (d) burying of e-waste material leads to acid rain, (e) if stronger regulation and enforcement are needed on the part of government to ensure that companies cannot import toxic e-waste, (f) if the Environmental Protection Agency (EPA) should be resourced to monitor e-waste, and (g) if the e-waste problem is certainly undesirable and deserves more media attention and public engagement. The second outcome variable, EBS, was also derived from specific questions that asked students: (a) if they will recycle electronic items they don't need, (b) if they throw their obsolete electronic items in the waste bin, (c) if they care where such obsolete electronic items thrown into the waste bin are finally dumped, (d) if they will pay for recycling obsolete electronic items they don't need, and (e) if dumping obsolete electronic items at landfill sites is the best option. The factor scores for the underlying latent constructs are used as outcome variables. We provide global reliability estimates (Cronbach's alpha) for the two outcomes variables as 0.91 and 0.72 respectively. Independent reliability measures can also be ascertained from the confirmatory factor model presented in Figure 1.

We examine how gender (coded, male = 1 and female = 2), year of program (coded, lower years = 0 and upper years = 1), and whether respondents think there is an e-waste problem in Ghana (coded, No = 0, Yes = 1 and don't know = 2) have an impact on dependent variables: EIPI and EBS.

Data Analysis

Factor analysis was used to create outcome variables employed in this study. Factor analysis is often considered a measurement model

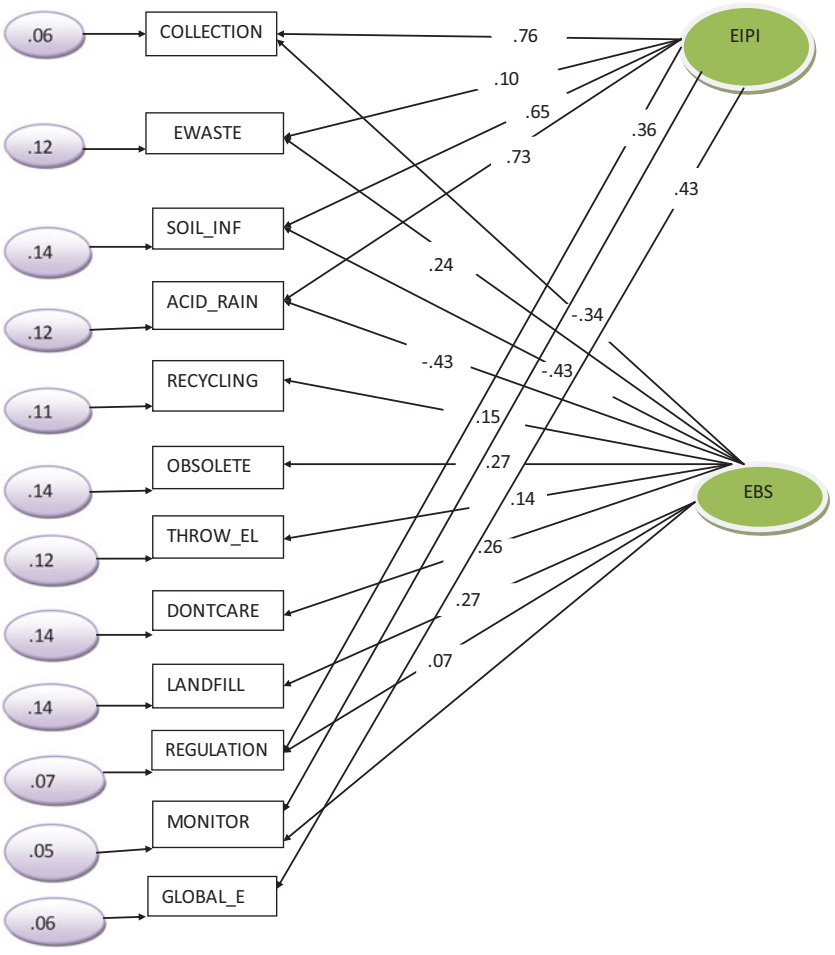

Fig. 1. A Confirmatory Factor Model of EIPI and EBS. *Note.* All standardized coefficients are significant at P < 0.05. Error terms are reported in small oval circles. Model adequacy: (χ^2 = 33.59, df = 29; p < 0.255; RMSEA = 0.01) *Key:* COLLECTION = e-waste is a problem that needs collective effort to tackle; EWASTE = e-waste is over-hyped, there is nothing to fear; SOIL_INF = burying of e-waste material in the ground leads to soil infertility; ACID RAIN = burning of e-waste materials leads to acid rain; RECYCLING = I do my best to recycle electronic items I don't need; OBSOLETE = I will pay for the cost of recycling my obsolete electronic items if a recycle center is established; THROW_EL = I throw my obsolete electronic items into waste bin; DONTCARE = I don't care where or how my obsolete electronic items put into the waste bin are finally dumped; LANDFILL = dumping obsolete electronic items at landfill site is the best way; REGULATION = stronger regulation and enforcement is still needed on the part of the government to ensure that companies cannot import toxic gadgets or e-waste; MONITOR = EPA should be resourced to monitor disposal of e-waste; GLOBAL_EL = e-waste is a global problem, certainly appalling and deserves more media attention than previously accorded (color figure available online).

that postulates the existence of unobserved variables (latent constructs) measured by some observed variables through a set of structural coefficients. Exploratory Factor Analysis (EFA) was first used to determine and explore the underlying factor structure for the observed indicators of the latent constructs employed as dependent variables. Confirmatory Factor Analysis (CFA) was then used to verify the factor structure while testing the relationships between the observed indicators and their underlying latent constructs. In employing this

technique, we are also able to examine the construct validity of our observed variables. CFA is a powerful model-testing technique that matches observed and theoretical factor structures for a given data, determining how best the observed data fits a specific theoretical model. The maximum likelihood technique is used in estimating the factor models and standardized coefficients reported to examine the relative importance of observed indicators to the underlying theoretical/latent constructs. Model fit indices, such as the model chi-square, Goodness-of-Fit Index (GFI), Comparative Fit Index (CFI), and the Root Mean Square Error of Approximation (RMSEA) are used to examine how the observed data fits the theoretical model postulated. A nonsignificant model chi-square value, GFI and CFI values of 0.90 and higher, and RMSEA value of 0.05 or less indicate good fit. Given that factor scores extracted are continuous, we use the Ordinary Least Squares (OLS) technique to examine the impact of selected covariates on the outcome variables.

Table 2
A univariate analysis of selected variables

Dependent variables	Median (%)
Environ impact and policy (range, −1.49 to 1.89)	.0187
Environ Behavior and sustainab. (range, −1.62 to 3.55)	−.483
Gender	
Male	61.5
Female	38.5
Year/level of study	
Lower years/level	30.1
Upper years/level	69.9
Program at UCC contains environmental issues?	
Yes	41.1
No	58.9
Do you think there is an e-waste problem?	
Yes	52.3
No	13.1
Don't know	34.6

RESULTS

Table 1 shows the number and proportion of students by academic programs involved in the survey. More students were drawn from the Faculty of Education, Faculty of Arts, and the School of Physical Sciences. This reflects the population in the respective academic programs.

Table 2 provides a description of sample characteristics and distribution of cases for selected dependent and independent variables. The table indicates that although close to 62% of respondents identified as male, about 39% identified as females. Majority of respondents are upper year (level 300 and above) students (70%), compared to approximately 30% that reported as lower year (level 200 and below) students. When asked whether environmental issues were incorporated into their respective programs of study, about 41% of students answered in the affirmative, while 59% answered "no." Approximately, 52% of respondents think there is an e-waste problem in Ghana, about 13% disagreed that such a problem existed, but 35% of respondents reported that they did not even know if an e-waste problem existed in Ghana. Two major indicators of environmental awareness are employed as outcome variables. These include EIPI that tapped respondents' awareness of the effects of e-waste contamination of air and soil; and EBS, a construct that captures awareness on acceptable e-waste disposable practices and proenvironmental behavior. The median scores indicate that these behaviors are rather very low among students at the University of Cape Coast. It is important to indicate however that students' awareness of e-waste contamination on air and soil was higher than their awareness of acceptable e-waste disposable practices and proenvironmental behavior.

Table 3 provides analyses of bivariate relationships between selected independent and dependent variables. We compare the mean scores for the outcome measures tapping respondents' knowledge and awareness of e-waste issues in Ghana. Male respondents are significantly different and scored higher on

Table 3
Bivariate analysis of selected dependent and independent variables

Independent variables	Environ Impact and policy	Environ Behavior and Sustainability
Gender	Mean scores	Mean scores
Male	−.0133	.061***
Female	.0218	−.101
Year/level of study		
Lower years/level	.087**	.143***
Upper years/level	−.047	−.053
Program at UCC contains environmental issues?		
Yes	−.041	−.027
No	.029	.019
Do you think there is an e-waste problem?		
Yes	.137***	.087***
No	.102	.025
Don't know	−.223	−.128

Note. Beta coefficients are reported.
**$p < .05$. ***$p < .01$.

issues related to EBS compared to their female counterparts. Compared to upper-year university students, lower-year students had significantly higher mean scores for both outcomes demonstrating that they were more aware of the effects of e-waste contamination on air and soil and the acceptable e-waste disposable practices and prosocial behaviors. Similarly, students who thought Ghana had an e-waste problem had significantly higher scores on both measures of environmental awareness, compared to those who disagreed or did not know such problems exist in the country.

Figure 1 and Table 4 provide multivariate analyses of selected dependent and independent variables. First, exploratory factor analysis was performed to examine the underlying factor structure of the dependent variables, EIPI and EBS. Confirmatory factor analysis was then used to verify the underlying factor structure of the latent dependent variables.

Results of the CFA are presented in Figure 1. As with most CFA models, goodness of fit statistics were used to examine model adequacy, in which case, the difference between the correlation matrix of the model was compared with the observed data. For instance, a nonsignificant chi-square test would mean a rejection of the null hypothesis that differences exist between the correlation matrix of the estimated model and that of the observed data. This means for model fit and adequacy, the chi-square test should not be significant. Another commonly used measure of model fitness and adequacy is the Root Mean Square Error of Approximation (RMSEA) which should also be 0.05 or less to indicate close fit of the observed data to the estimated model (Byrne, 2010). Results in Figure 1 indicate satisfactory model adequacy, ($\chi^2 = 33.59$, df = 29; p <

Table 4
OLS models predicting Environ impact & policy Environ behavior & sustainability

Independent variables	B (S.E)	B (S.E)
Gender		
Male	.011 (.064)	.192 (.065)***
Female	0	0
Year/level of study		
Lower years/level	.175 (.070)***	.256 (.070)***
Upper years/level	0	0
Program at UCC contains environmental issues?		
Yes	−.058 (.063)	−.054 (.063)
No	0	0
Do you think there is an e-waste problem?		
Don't know	−.276 (.102)***	−.141 (.103)
Yes	.118 (.098)	.082 (.099)
No	0	0

Note. Beta coefficients are reported with robust standard errors in brackets.
**$p < .05$. ***$p < .01$.

0.255; RMSEA = 0.012). Significant standardized estimates that demonstrate relationships between observed indicators and latent dependent variables are also presented in Figure 1. Consistent with our theoretical postulations, we found that the awareness that e-waste is a problem that required collective effort (S.E = 0.76), that burying e-waste material leads to soil infertility (S.E = 0.65) and that burying of e-waste material could lead to acid rain (S.E = 0.73) were strongly and positively related to knowledge on EIPI. Other policy questions that were also positively related to knowledge on EIPI include the need for stronger regulation and enforcement on the part of government to ensure that companies cannot export toxic e-waste to Ghana, the need for the EPA to be resourced to monitor e-waste; and that the e-waste problem is certainly appalling and deserves more media attention. Other manifest variables that had a positive relationship with the latent dependent variable, EBS, include if respondents will recycle electronic items they don't need; if they throw their obsolete electronic items in the waste bin; if they care where such obsolete electronic items thrown into the waste bin are finally dumped; if they will pay for recycling obsolete electronic items they don't need, and if dumping obsolete electronic items at landfill sites is best.

Table 4 examines the net effects of selected independent (gender, level of study, if program UCC contains environmental issues and if respondents think there is an e-waste problem) on the latent outcome measures. Gender and level of study are both positively related to EBS. Compared to females, males scored higher (b = .192) on EBS. Similarly, students in the lower levels of the university scored higher (b = .256) on EBS, compared to those in upper years of the university. On knowledge regarding EIPI, students in the lower levels of university scored higher (b = .0175), compared to those in upper years of university. Also, compared to those who disagreed that e-waste problems exist, those who did not know about such problems scored low on EIPI (b = −.276).

DISCUSSION

Factors underlying environmental behavior have been studied in many contexts (Steg & Vlek, 2009; Turaga, Howarth, & Borsuk, 2010). In this study, factors underlying university students' proenvironmental behaviors particularly regarding e-waste recycling can be categorized into three: moral and normative concerns, weighing costs and benefits, and affective motives. These three domains need to be integrated into a single framework on which policy and decision-making can be based.

Although about 40% of the university students indicated their programs of study were related to the environment, awareness of e-waste was generally low. Students' academic backgrounds influenced their awareness on e-waste. This supports the findings of Palmer, Suggate, Robottom, and Hart (1999). According to Jensen (2002), awareness of environmental problems has four dimensions: causes-why; effects-what; change strategies-how; and vision-where? Assessment of students' awareness on e-waste in this study encompassed these four dimensions. Overall, students fared better on the effects aspects compared to the aspects on change strategies. For instance, students' awareness of e-waste contamination of air and soil (effects) was higher than their awareness of acceptable e-waste practices (change strategies) or environmental policy (vision).

Significant gender differences were observed for EBS unlike EIPI. That is, gender is a strong predictor of EBS but is not a predictor of knowledge on environmental impacts and policy. This is in agreement with the results of Ayodeji (2010) but inconsistent with the findings of Ehrampoush and Maghadam (2005). Males scored higher on EBS issues compared with females. Empirical findings regarding gender differences in environmental behaviors have been largely inconsistent although western scientific research since the last quarter century has suggested that women, in general, possess a higher level of concern for

the environment than men (see Greenbaum, 1995; Tindall, Davies, & Mauboules, 2003; Tikka, Kuituen, & Tynys, 2000). Many studies have found that women participate to a greater extent than men in various environmental behaviors in North America (e.g., Sherkat & Ellison, 2007), Europe (e.g., Mattheis, Kuhn, & Klockner, 2002), and in many other regions (e.g., Hunter, Hatch, & Johnson, 2004). In this context, several reasons have been assigned for why women are more responsible towards the environment. According to Greenbaum (1995), men tend to emphasize mastering nature and deriving benefits from natural resources, whereas women take a more emotional attitude toward nature. Similarly, Tikka et al. (2000) argue that women have traditionally been responsible for looking after the home and children, and men have concentrated on hunting and resource provision. The concern felt by women for nature and the environment could be regarded as a mechanism for taking care of their offspring, because a clean and safe environment is a prerequisite for welfare and survival (Sherkat & Ellison, 2007). It is also argued that benignity and universal responsibility are general guiding principles in women's lives (Tikka et al., 2000, p. 18). These values are expressed as helpfulness, responsibility, and concern for the well-being of nature and people. Appreciation of a healthy environment is included in these values. However, other research has failed to find significant gender differences in environmental behavior (e.g., Berenguer, Corraliza, & Martin, 2005; Blankenau, Snowden, & Langan, 2008). Furthermore, a few studies reported significantly higher participation in environmental behaviors for men (e.g., Aoyogi-Usui, Vinken, & Kuribayashi, 2003; Eisler, Eisler, & Yoshida, 2003).

Our findings indicate that students in the lower levels of university scored higher on EBS compared to those in upper years of university. This finding may seem counterintuitive as it is expected that longer years spent in university may be associated with higher exposure to environment-related university courses. We argue, however, that in Ghana, it is usually the case that lower level university students may be less familiar with environmental practices acceptable and widespread on campus and are therefore more cautious. As they progress along the educational ladder, they become less concerned about proenvironmental behavior due to familiarity with the lapses in environmental monitoring on campus. Also, students in lower levels of university scored higher on awareness of environmental impact and policy compared to those in upper years of university.

Policy Implications

The results of this study hold several implications for policy in terms of university curricula, and the legal and institutional framework for e-waste management in Ghana. An effective e-waste policy should be premised on a thorough understanding of the moral and normative concerns, weighing costs and benefits, and affective motives of individuals. The university curricula should be updated to encompass courses on e-waste and deleterious environmental and human health hazards. The current regulatory structure involves no or very limited prohibition on imports and limited options for reuse or recycling (although, those options will likely increase as e-waste collection increases). As long as there are legitimate reuse markets and recycling operations in developing countries, and for that matter Ghana, an absolute prohibition on imports would be problematic, particularly when limited opportunities for recycling exist in the developed world. This presents policy-makers with multiple challenges: Principal among them are how to address the obstacles that limit domestic e-waste recycling, and how one might establish import controls that facilitate reuse and recycling but prohibit delivery of e-waste to operations that do not protect workers or their environment.

Also, there are implications for environmental education and communication given that sustainable management of e-waste include creating awareness and promoting an

understanding of the feedback relationships between the environment and e-waste generation; recognizing student's relationship, responsibility, attitudes, and commitment to the environment; and developing efficient and effective e-waste management skills for the survival of present and future generations. We propose environmental education and communication campaigns on university campuses that target several stages in the electronic device's lifecycle. For instance, there could be messages promoting the proper disposal of old electronics or encouraging students and faculty to donate their old products to communities in need. At present, social media is a very powerful tool in this regard. It is also one of the most cost-efficient ways to promote messages on e-waste. Student activists on e-waste could organize social media movements to get their peers thinking about their e-waste (this could later be joined by a television, radio, and visual campaigns). To improve the effectiveness of campus campaigns the e-waste message should become ingrained in popular culture. In addition to such campaigns, intrainstitution and interinstitution quiz competitions could be organized to increase awareness and motivate students (Ballantyne et al., 2006).

CONCLUSION

The study assessed students awareness of the human and environmental health hazards associated with e-waste. Generally, awareness of e-waste issues among the students is low and lags behind use and imports of e-waste. Tertiary level academic courses are important predictors of awareness of environmental issues in Ghana. Students' academic backgrounds influenced awareness on e-waste. Poor public awareness on e-waste especially among university students remains one of main barriers to proenvironmental behavior on e-waste. Significant gender differences were observed for EBS unlike EIPI. That is, gender is a strong predictor of EBS but is not a predictor of knowledge on environmental impacts and policy. Given that e-waste is increasingly becoming a large part of campus life, the results of the study hold several implications for policy in terms of university curricula, and the legal and institutional framework for e-waste management in Ghana.

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