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Awareness, Attitude, and Behavior of Senior High School Students on E-Waste Recycling: Implications to Science Education

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Abstract

The use of electrical and electronic equipment has tremendously risen which also increased the production of e-waste. With this challenge that consumers like students are facing, recycling remains as the most common way of managing e-waste. This study investigated the awareness, attitude, and behavior on e-waste recycling of senior high school students from a laboratory high school of a state university. The degree of association among the three variables was also determined. The data revealed that the respondents' awareness and attitude on e-waste recycling were towards the positive side, but their behavior was neutral. In addition, a large positive correlation was established between the respondents' awareness and their attitude on e-waste recycling. The results of this study, considering the variables covered and how they are associated with one another, imply the possibilities for the enrichment of the science curriculum taking e-waste recycling into account. Additionally, since the senior high school students were more neutral as to their behavior on e-waste recycling, science educators, curriculum designers or school program implementers may consider activities and trainings that can help students practice e-waste recycling. Lastly, the need to embed it in the curriculum and lessons is desirable for the permanence of e-waste recycling practice among learners.

Keywords: E-Waste, Recycling, Awareness, Attitude, Behavior

Introduction

Rapid development has enforced the mass consumption and indispensability in society of electrical and electronic equipment or EEE. When EEE reach the end of their usefulness, they are disposed of, creating a waste stream of hazardous and valuable materials known as Waste Electrical and Electronic Equipment (WEEE), electronic and electrical wastes, or more commonly, e-waste.

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As the most common way of disposing e-waste is recycling them and failure to do so might pose danger to human lives and to the environment in general, there is reason to shed light on the awareness, attitude, and behavior of electronic product users, especially the students who have embraced the technological culture of the world.

EEE and E-Waste

The number of products considered as EEE makes e-waste a growing concern. As a starter, there are six general categories of EEE products associated with their waste management characteristics (Forti, et al., 2020). There categories are (1) temperature exchange equipment like refrigerators and heat pumps; (2) screens and monitors like televisions, laptops, and tablets; (3) lamps like fluorescent lamps and light-emitting diode; (4) large equipment like washing machine, large printing machines and photovoltaic panels; (5) small equipment like electric kettle, calculators, and video cameras; and (6) small IT and telecommunications equipment like mobile phones, printers and routers. Since such EEE products make human lives and activities easier, the consuming public is enticed to purchase such products and eventually upgrade what they already have.

Even if various EEE are useful, the e-waste which is generated from them comprise the largest growing waste stream around the globe (Lundgren, 2012), and there are serious issues associated with e-wastes. There is the generation of high volumes of e-wastes pushed by rapid obsolescence of electronics brought by the increasing demand in technology (Basel Action Network [BAN], 2011) which are also hazardous by nature (Tsydenova & Bengtsson, 2011) due to their compositions.

Another is that the complexity of e-wastes challenges recycling efforts since e-wastes contain different materials connected together (Smith et al., 2006) and there is not enough value in most e-waste to cover the costs of managing it in an environmentally-safe way. What is alarming too is that there is a lack of strong policies to regulate e-wastes considering that in 2019, there are only 78 out of 193 countries with national e-waste policy, legislation, or regulation (Forti et al., 2020).

E-Waste in the Philippines

In the Philippines, consumption of EEE products drastically increased over time, thus generating more obsolete products, thereby producing e-waste. For instance, a pioneering study of Peralta and Fontanos (2006) on Philippine domestic e-waste generation revealed that from 1995 to 2005, an approximated 25 million units of five major electronic products reached obsolescence. These five major products include air conditioners, radios, refrigerators, televisions and washing machines. Another was that from 1991 to 2007, mobile phone ownership surged from 34,000 units to 52 million units (Carisma, 2009).

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A more recent estimate by Galang and Ballesteros (2017) divulges that waste mobile phones will reach 24.9 million in 2021, which is disturbing because even if mobile phones are lighter compared to other EEE products, they have higher replacement rates driven by societal demands. While other estimates could possibly be made, what adds to the worrisome scenario is the fact that as of 2018, the Philippines has no official data available regarding the recent quantity of e-waste being generated (Celestial, et al., 2018). However, households and industries in the Philippines are not the only contributors to the generation of e-waste. The country's importation of secondhand electronics nearing end-of-life and electronic scraps for reprocessing blows up the volume of e-waste generated (Carisma, 2009).

The final disposal of electronics in the Philippines includes reusing, recycling, storing, and landfilling. However, no data is available showing the amount of e-waste stream to each type of disposal. Also, the Philippines has not yet legislated a policy directly addressing e-wastes. Although the Environment Management Bureau (EMB) of the country's Department of Environment and Natural Resources (DENR) tells that e-waste management falls under Republic Act 9003 or the Ecological Solid Waste Management Act of 2000, and RA 6969 or the Toxic Substances and Hazardous and Nuclear Wastes Control Act of 1990 (EMB, 2020).

The EMB (2020) articulated that the DENR's Administrative Order 2013-22 requires the generators, transporters, and treatment, storage, and disposal (TSD) facilities of hazardous waste, including e-waste to register with EMB for the documentation and detailing of each movement of the waste. Progress on regulating e-waste is slow and gradual, too, as DENR's Technical Guidelines on the Environmentally Sound Management of WEEE is still just a draft as of the writing of this paper. What currently works with e-waste management include monthly e-waste market for Ayala and SM Malls, mobile phone waste collection projects, and the take-back scheme of selected companies (Carisma, 2009), but such efforts are not enough if compared to the increasing volumes of EEE produced and purchased, and the e-waste generated thereafter.

Vital to addressing the problem of e-waste is recognizing local and regional contexts coupled with multidisciplinary and technical solutions (Lundgren, 2012). With the threat that e-wastes pose, schools cannot afford to idly stand by and wait for an official legislation. This is where the role of science education comes in where relevant knowledge about e-waste is taught among learners alongside the promotion of e-waste recycling. Among developing countries like the Philippines, one of the key drivers of change in ecosystem and services is mass illiteracy which could lead to indifference towards the environment. Before problems and issues regarding e-waste become larger than what the Philippines can efficiently manage, schools can start addressing e-waste issues with their students.

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The K-12 Science curriculum aims to develop scientific literacy among students towards application of scientific knowledge that will have social, health, and environmental impact (Department of Education [DepEd], 2012). In the curriculum guide (DepEd, 2013), topics related to proper waste management and disposal are commenced in Grades 4 where learning competencies include investigating the causes and effects of decaying materials to health and safety; identification of unused, spare, unwanted, leftover, trash materials at home, in school and in the community; and communication of the importance or benefits of proper handling of waste materials. Continuing that, in Grade 5, related competencies to proper waste management and disposal are using the 5Rs (recycle, reduce, reuse, recover, and repair) techniques for aesthetic and economic purposes; and sorting of materials at home as useful or harmful. Lastly, in Grade 8, the sole competency anchored on the topic is suggesting ways to minimize human impact on the environment. Such limitations provide learners only a tip of the iceberg knowledge on e-waste.

There is a larger possibility that e-waste may be given more attention in college, though, as one of the general education courses is Science, Technology and Society or STS where one of the outcomes is for students to imbibe the importance of science and technology in the preservation of the environment and the development of the Filipino nation (Commission on Higher Education [CHED], 2013). For instance, in the STS subject syllabi, an instructor may opt to include e-waste and e-waste management as one of the topics to be covered.

Determinants of E-Waste Recycling Behavior

Along with the consideration of addressing e-waste issues through the classroom, students' behavior towards e-waste should be considered as it is pivotal in managing and reducing e-waste. Since behavior is influenced by different factors, understanding such factors is also a key to understanding behavior.

There are influences of recycling behavior in general. Shevchenko et al. (2019) evaluated studies on recycling behavior predictors, with awareness and knowledge level, convenience, and economic incentives cited most frequently. Other key characteristics found by the same authors include gender, existing behaviors, legislative norms and trustworthiness, mindset and attitude, income, age, and level of education.

In a subsequent study, Piligrimiene et al. (2020) divided the factors that influence consumer engagement into two main categories: (1) internal factors, such as environmental attitude, perceived responsibility, and perceived behavioral efficiency; and (2) external factors, such as conditions for sustainable conditions, social environment, and promotion of sustainable conditions.

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In a more specific sense, as to e-waste recycling behavior, the study of Sivathanu (2016) was able to show a direct relationship between awareness and the willingness for e-waste recycling. In another study, a positive relation between attitude, social norms, self-efficacy, social media usage, and recycling intention was seen as determinants in recycling intention behavior for the consuming public (Sujata et al., 2019).

Delcea et al(2020) .'s research revealed 10 parameters related to e-waste recycling behavior. These include recycling intent, convenience, and government measures; awareness; self-efficacy; responsibility; social norms; social influence; social media; and actions by government and non-governmental organizations.

From the reviewed literature and studies, the common variables that influence e-waste recycling are related to awareness, attitude and behavior of users or consumers towards the process itself. Determining awareness of students would provide hindsight on what they know and their perceptions on e-waste recycling. Identifying students' attitudes would tell how they think or feel about e-waste recycling. Lastly, gaining information on their behavior in the process would reveal if sound environmental practices are in place, or whether they do what they know and feel is right or not.

There are reasons why students do or do not recycle e-waste. As such, understanding the awareness, attitude and behavior of students on e-waste recycling is relevant in realizing where a teacher or the school can intervene to somehow influence good change. In addition to consumer education, students' e-waste recycling has to be understood. This is due to the fact that even if the Philippines has limitations in e-waste management legislation, recycling e-waste is currently one of the most accessible means for citizens, or students, to help in managing e-waste. To influence good change in e-waste recycling is to first understand the awareness, attitude and behavior of students and design a plan that could bring about desirable change.

Conceptual Framework of the Study

The study is anchored on the concept of the interrelationship of awareness, attitude and behavior. This study focused on senior high school students' awareness, attitude and behavior on e-waste recycling. In the same manner, as shown in Figure 1, the paradigm of the study, the correlation of the three variables was attempted to be established.

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Figure 1. Paradigm of the Study

Purpose of the research

Generally, this study aimed to examine the awareness, attitude and behavior of senior high school students on e-waste recycling. Specifically, this study answered the following research questions: (1) How may the students' be described in terms of their (a) awareness; (b) attitude; and (c) behavior on e-waste recycling?; and (2) Is there relationship between students' (a) awareness and attitude; (b) awareness and behavior; and (c) attitude and behavior on e-waste recycling?

Methodology

To meet the aims of the study, a quantitative design framework was used. Specifically, correlational approach was put in place to describe the relationship among the three variables. The calculation of two or more factors to assess or approximate the degree to which the values for the factors are related or modified in an observable trend is known as correlational analysis (Muijs, 2011).

Moreover, correlational research findings can be used to assess the prevalence of variables and their relationships, as well as to predict events based on current data and information (Curtis, 2016). Correlational design allows for the use of assigned values for each variable to be correlated at the end of the study to determine the strength of relationship and to what extent these factors affect each other.

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Participants

The participants for this study were senior high school students from a state university in Region III in the Philippines. A total of 127 students voluntarily participated in the study. The population comprised 42 (33.07%) Technical-Vocational Strand and 85 (66.93%) Academic Strand students.

Data Collection Instrument and Procedures

This study adopted a portion of the questionnaire of Delcea et al., (2020) as a data collection instrument. The questionnaire was from the authors' study on the Determinants of Individuals E-Waste Recycling Behavior which had been validated using confirmatory factor analysis. In their work, the feasibility and convergent validity were tested through average variance extracted (AVE) and construct reliability (CR).

Only the items related to attitude (4 things), awareness (4 items), and recycling activity (6 items) were taken into account. All of the items in the categories were scored on a 5-point Likert scale, with 1 indicating strongly disagree, 2 indicating disagree, 3 indicating neutral, 4 indicating agree, and 5 indicating strongly agree. Aside from the questions linked with the categories, some demographic information was gathered.

The questionnaire was created and hosted using an online platform. All the questions were marked as "required" in order to submit the form, assuring in this way that there will be no empty data case. After getting permission for the conduct of the study from the top management of the research locale, the questionnaire was administered using social media platforms during a 30-day period.

Data Analysis

The collected data was initially downloaded from Google forms in Excel format. After reorganizing the data, it was exported to a trial version of SPSS Software. For the first research problem, frequency and percentage were used to describe the awareness, attitude and behavior on e-waste recycling of the participants in this study. Meanwhile, Pearson product-moment correlation coefficient was used to measure the correlation of the variables to answer the second research problem.

Ethical Considerations

The researchers carefully explained to the respondents the objectives of the study in which all the queries were entertained and translated in their chosen language; the data that gathered from this study was analyzed with accuracy and confidentiality; the privacy and

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confidentiality of the research participants was protected; and, the researchers informed about voluntary participation in the study. Lastly, the provisions of the Data Privacy Act of the Philippines were followed.

Results and Discussion

The respondents' awareness, attitude and behavior on e-waste recycling is presented in Figures 2 to 4. Meanwhile, the correlations are determined in Tables 1 to 3 where Pearson product-moment correlation coefficients were computed to assess the relationship between the variables.

Awareness, Attitude and Behavior on E-Waste Recycling

The level of knowledge about recycling electronic waste is displayed in Figure 2 below. This variable included four items: (1) I am aware of the benefits of recycling e-waste; (2) I am aware that electronic products contain potentially toxic substances; (3) I am aware that not recycling e-waste can cause environmental pollution; and (4) I am aware that the way we manage e-waste can harm human health. Remarkably, the more optimistic responses surfaced.

There were 33.86% who agreed and 37.01% who strongly agreed that they are aware of the benefits e-waste recycling has. It is also observable that 37.80% agreed and 44.09% strongly agreed as to knowing that electronic products contain potentially toxic substances. Noteworthy too is the fact that more than half (53.76%) of the respondents strongly agreed that not recycling e-waste can cause environmental pollution. Additionally, 38.58% agreed and 33.07% strongly agreed that the way they manage e-waste can harm human health.

Although the majority of responses were visibly on the positive side, there were still respondents who were neutral as to their awareness on e-recycling. Most notable were the 23.62% and 22.05% who were neutral as to the first and the fourth items. Lastly, respondents who either disagreed or strongly disagreed accounted only for 5.00% or less for each item.

To compare, in a study by Navarette et al. (2016) that was conducted among 402 college level respondents, 78% of the respondents had a high e-waste awareness complemented with a high awareness level for the need to properly dispose e-waste. While the contexts of this study and that of Navarette et al. (2016) differ in some manners, there is something to be asserted regarding the awareness of learners on e-waste and its potential dangers.

As it goes, those who are more aware of certain issues are more likely to make better decisions than those who lack awareness. As a form of application, the awareness of

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students on e-waste and its dangers can be used as a starting point for schools and teachers to ignite better e-waste recycling behavior.

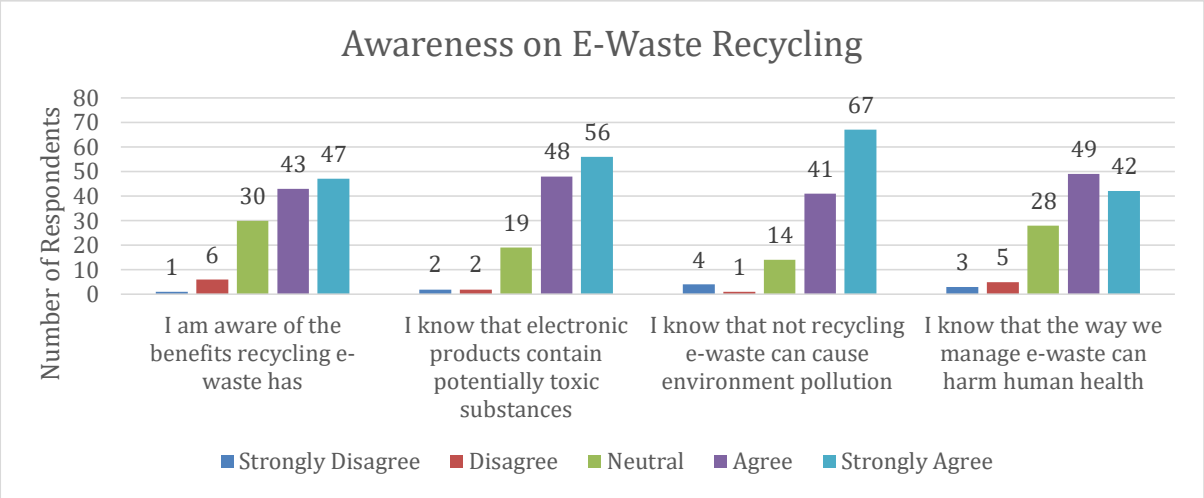

Figure 2. Awareness on E-Waste Recycling

Figure 3 depicts the attitudes of respondents towards e-waste recycling. This variable contained four elements: (1) Recycling e-waste is part of a responsible citizen's lifestyle; (2) I believe that my e-waste recycling behavior contributes significantly to a healthy environment; (3) Pro-environmental behavior is essential given the current state of development; and (4) I have a positive outlook and enjoy recycling electronic products. Initial inspection of the graph reveals that the answers were becoming increasingly positive.

It can be gleaned from the data that the majority of the respondents strongly agreed that recycling e-waste is part of a responsible citizen's life (56.69%) and they believe that their e-waste recycling behavior contributes a lot to a healthy environment (53.54%).

There were an equal number of respondents who either agreed (44.09%) or strongly agreed (44.09%) that pro-environment behavior is necessary given the current development conditions.

For the item pertaining to having a positive attitude and feeling good when recycling electronic products, there were evidently more respondents who agreed (43.31%) than those who strongly agreed (32.28%). The fourth item also yielded the greatest number of neutral responses (20.47%).

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Lastly, the number of respondents who either disagreed or strongly disagreed with the statements was relatively small, suggesting that the respondents' attitude on e-waste recycling is more on the positive side.

Similarly, Alam (2016) discovered that 69 percent of over 2,500 respondents were concerned about the impact of inappropriate e-waste disposal on human health and the environment. In comparison, the Navarette et al. (2016) study demonstrated its respondents' lack of initiative when it comes to contributing and doing their part in fixing the issue. The disparities in results could be attributed to the respondents' exposure to diverse settings, as well as the notion that attitudes about e-waste recycling could be impacted by other factors.

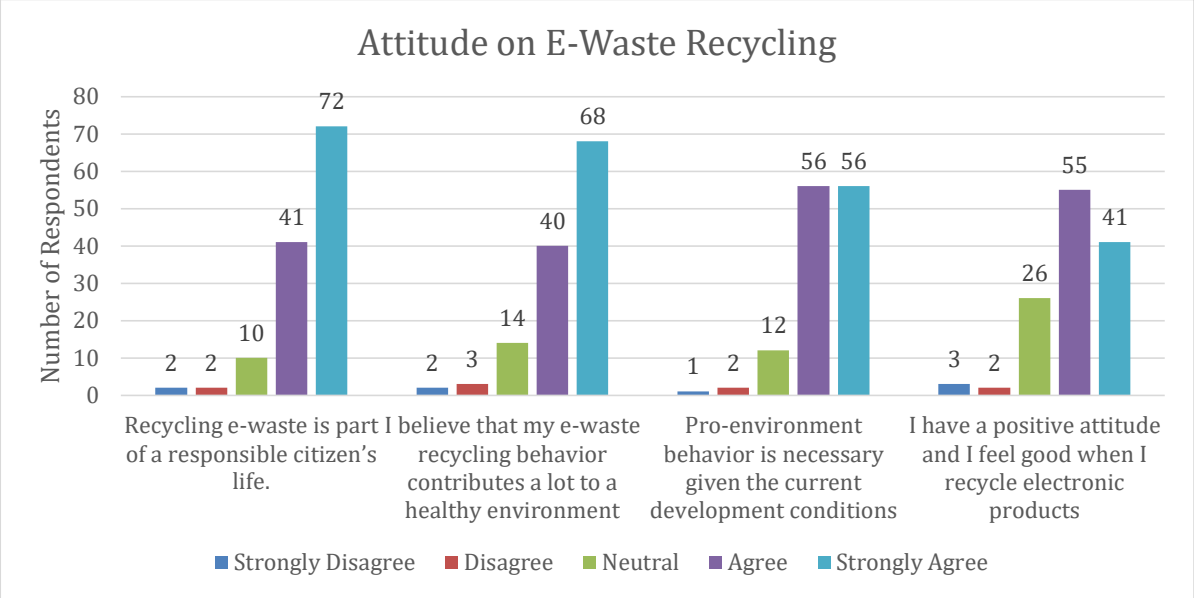

Figure 3. Attitude on E-Waste Recycling

Responses from the survey participants' recycling behaviors are shown in Figure 4. This variable included the following six options: (1)I recycle large home appliances (such as washers, dryers, air conditioners, refrigerators, microwaves, etc.); (2) small home appliances (such as toasters, vacuum cleaners, coffee machines, appliances for toothbrushing, shaving, hair drying, etc.); (3) information technology and telecommunications equipment (such as laptops, personal computers, notebooks, telephones, cell phones, printers, etc.); (4) consumer equipment (such as stereos, televisions, video game consoles, etc). (not listed above, e.g., electrical and electronic tools, leisure equipment, medical devices, monitoring and control instruments, automatic dispensers, etc.).

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The figure reveals that there were more neutral responses on four out of the six items. In particular, those items pertained to recycling large household appliances (30.71%); small household appliances (33.86%); consumer equipment (37.80%); and other categories of e-waste (41.73%).

Even though there were more respondents who agreed that they recycle information technology and telecommunications equipment (35.43%) and light equipment (43.31%), there were still a considerable number of respondents who responded with neutrality in the said items. Overall, as to their behavior on e-waste recycling, the respondents leaned towards the neutral side, suggesting that they may or may not be recycling e-waste.

From a perspective, the seemingly neutral stance of the respondents in this study is similar to the results of the study of Alam (2016) who conducted a survey among almost 2,500 respondents. Alam's study showed that although a majority were actually concerned about the impact of improper disposal of e-waste on human health and environment, a very low percentage of people actually recycled their products.

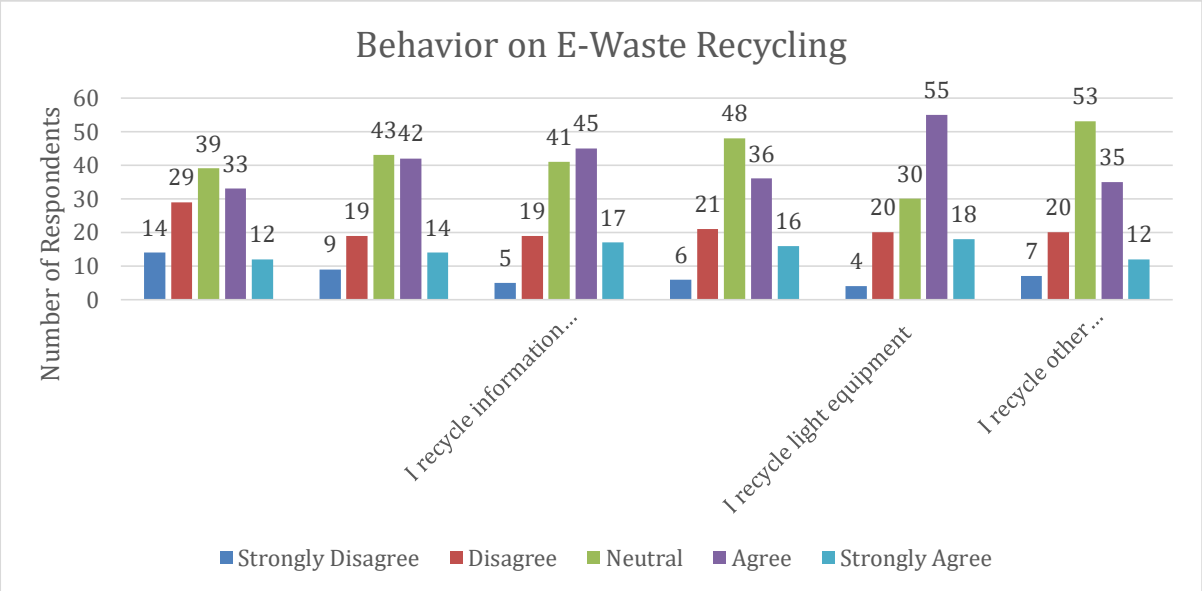

Figure 4. Behavior on E-Waste Recycling

Correlation of Awareness, Attitude and Behavior on E-Waste Recycling

As observed in Table 1, Correlation between Attitude and Awareness, the correlation coefficient (r) is 0.690 suggesting a highly significant large positive correlation between awareness and attitude. This points out that awareness in e-waste recycling is associated

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with attitudes in e-recycling among senior high school students. In the same manner, the association of awareness and attitude on e-waste management was observed by Akhtar, Masud and Afroz (2014) after conducting their survey among 200 households in Malaysia.

Table 1. Correlation between Attitude and Awareness

		Attitude	Awareness
Attitude	Pearson Correlation	1	.690**
	Sig. (2-tailed)		<.001
	N	127	127
Awareness	Pearson Correlation	.690**	1
	Sig. (2-tailed)	<.001	
	N	127	127

** Correlation is significant at the 0.01 level (2-tailed)

It can be seen in Table 2, the correlation between awareness and behavior, that the correlation coefficient (r) is 0.421 suggesting a highly significant moderate positive correlation between awareness and behavior. This means that, in a way, awareness in e-waste recycling is moderately associated with behavior in e-waste recycling among senior high school students. In another perspective, the study of Nguyen, et al., (2018) which surveyed 520 respondents in Vietnam found out that environmental awareness positively influenced e-waste recycling behavior.

Table 2. Correlation between Awareness and Behavior

		Awareness	Behavior
Awareness	Pearson Correlation	1	.421**
	Sig. (2-tailed)		<.001
	N	127	127
Behavior	Pearson Correlation	.421**	1
	Sig. (2-tailed)	<.001	
	N	127	127

** Correlation is significant at the 0.01 level (2-tailed)

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Lastly, it can be taken from Table 3, Correlation between Attitude and Behavior, that the correlation coefficient (r) is 0.467, suggesting a highly significant moderate positive correlation between attitude and behavior. This leads to the idea that attitude in e-waste recycling is moderately associated with behavior in e-waste recycling among senior high school students. Similarly, the association of environmental attitude to e-waste recycling was also observed by Wang et al. (2016) who conducted their study in China.

Table 3. Correlation between Attitude and Behavior

		Attitude	**Behavior**
Attitude	Pearson Correlation	1	.467**
	Sig. (2-tailed)		<.001
	N	127	127
Behavior	Pearson Correlation	.467**	1
	Sig. (2-tailed)	<.001	
	N	127	127

** Correlation is significant at the 0.01 level (2-tailed)

Conclusions

This study investigated the awareness, attitude and behavior on e-waste recycling of senior high school students, and how the three variables are associated with each other. After careful examination of data, this study was able to draw the following conclusions:

1. Senior high school students are leaned towards the more positive side as to their awareness and attitude on e-waste recycling. However, they expressed neutrality when it came to their behavior on e-waste recycling. Neutrality would suggest that they might or might not at all be demonstrating behavior anchored to recycling e-waste.
2. There is a large association between the senior high school students' awareness and their attitude on e-waste recycling. The same variables are also associated with behavior, but in a moderate manner.

Implications and Recommendations

In light of the conclusions from this study, the following are implied and recommended:

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1. The results of this study, considering the variables covered and how they are associated with each other, imply the possibilities for the enrichment of the science curriculum taking e-waste recycling into account. Also, since senior high school students were more neutral as to their behavior on e-waste recycling, science educators, curriculum designers or school program implementers may consider activities and training that could help students practice e-waste recycling. Activities may include simulations and actual recycling of e-waste that could be done consistently. As the theory of practice implies, when a behavior is rehearsed frequently or consistently, it becomes permanent or eventually, part of a routine.
2. As there are no national policies which directly tackle e-waste nor learning competencies in school curricula which target e-waste with specificity, and owing to the fact that e-waste is growing by heaps as years pass, there is a need to present the issue among learners. This is pressing as the learners of today are digital natives – gadgets and various devices are already part of their daily lives. It can be discussed in class as a socio-scientific issue, be a theme for debate, a class project, or even be under participatory action research.
3. Other variables which have not been included in this study, but are related to e-waste recycling, may be investigated. Such variables may be identified through extant literature and studies.

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