E-Waste Recycling Awareness in Young Adults in Malaysia: An Interactive Courseware

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ABSTRACT

E-waste is becoming one of the fastest-growing waste globally with an estimation of 1.11 million metric tonnes in 2020 due to the rapid growth of electronic and electrical waste. Improper recycling of e-waste will expose the hazardous compounds contained in e-waste such as lead, mercury which harmful to human health resulting in serious illness. However, e-waste is crucial not only because of the hazardous effect of the chemical waste but also the potential for wealth creation from the proper extraction of precious materials such as silver, gold. This paper describes the requirement design and strategies for an interactive courseware to educate the youth on e-waste information and the proper way to discard them. This courseware development is guided by the Rapid Application Development (RAD) methodology. A post-study survey is conducted to get the user's feedback on E-waste interactive courseware.

Keywords: household e-waste, electronic waste recycling, awareness, courseware.

I INTRODUCTION

Electronic waste, or e-waste refers to all items of electrical and electronic equipment including its parts that have been discarded as waste (Balde et al., 2017). It includes a wide range of products which consist of almost any household or business item with circuitry or electrical components with power or battery supply. In certain regions of the globe, E-waste is also known as e-scrap. There are six e-waste categories; temperature exchange equipment, Screens, monitors, lamps, large equipment, small equipment and small IT and telecommunication equipment (Balde et al, 2015). E-waste, when not treated properly can brings harms to health since e-waste contains hazardous components, including contaminating air, water, and soil, and putting people's health at risk such as detrimental to human health affecting the system in the human bodies such as endocrine system, reproductive system and nervous system (Srivastava & Phatak, 2020).

Most of e-waste contains heavy metals, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and brominated flame retardants (Rawat, Verma, & Singh, 2020). However, e-waste is a diamond in disguise. It contains intrinsic value of critical and precious metals inside such as gold, silver, cuprum and can be recovered using wet chemical processes and electrolysis, recycling of e-waste is becoming an attractive and lucrative business opportunity (Tengku-Hamzah, Tengku, Adeline, 2011) that can contribute to Malaysian economic growth with creation of many new industries such as jewelry, pharmaceuticals and electronic and electrical industries. Department of Environment (DoE) Malaysia stated that the real facts and figures of household e-waste cannot be captured correctly since the discarded e-waste was not done through proper channels. Moreover, based on studies conducted in selected areas, the quantity of household e-waste generated is estimated to reach 53 million pieces in 2020 – 3.5 times higher than in 1995 (Department of Environment Malaysia, 2015). Yet, the awareness level among the citizens is still low about e-waste dangers and recycling activities.

Briefly, this paper presents the study that aims to develop an interactive courseware for e-waste recycling among young adults. This paper contributes to the current e-waste literature by providing the requirements analysis and design strategies for developing an interactive courseware for e-waste recycling. The phases of this application development are spelled out that can be used by others who have similar interest in developing interactive courseware for e-waste recycling. This paper is organized in the following manner. Section II of this paper reviews the background of the study Then, in Section III the adopted methodology is elaborated in detail, describing the requirements and design of the application. Finally, the paper ends with discussion and future work.

II BACKGROUND OF THE STUDY

Electronic waste or e-waste are known as discarded electrical devices, a type of scheduled waste that hazardous and harmful to human and environment but also a type of waste that can be managed to be a luxurious resource. Globally, some countries have become hazardous dump yards of e-waste especially developing countries such as China, India other developing countries that export their huge number

of wastes to other country (Perkins et al, 2014). The current incident of closure of 111 schools and toxic reported incidents reflects an example of disastrous scenario if e-waste not being handled appropriately (Free Malaysia Today, 2019).

With the increasing concerns one-waste, many countries have starting to establish vibrant national e-waste recycling schemes (ScienceDaily, 2010) and Malaysia has prepared the mechanism such as legal structure, organization, system for sustainable collection and environmentally sound recycling of household e-waste (Masrom, 2017).

In the discarded electronic appliances, there are many valuable materials such as gold, copper, silver that can be extracted from the motherboard or circuit board and potentially recyclable. From precious raw materials that can generate wealth, e-waste also contains toxic materials that are harmful to human health and the environment. Each computer or television display monitor contains an average of 2-4kg of lead while there are 70% of the heavy metals such as mercury and cadmium also found in landfills come from discarded electronic devices (Hawari & H. Hassan, 2010). These heavy metals and other hazardous substances can be a threat to the public health and cause environmental problems. Improper recycling of the hazardous compounds will be detrimental to human health affecting system in human body such as endocrine system, reproductive system and nervous system (Pinto, 2008). Currently, most of the electronic devices end up in landfill sites with no proper treatment because of the lack of segregation mechanism. Furthermore, over that 90% of these wastes were sending to the landfill while in other countries, a large fraction of these wastes from households ends up in the waste incinerators (Pinto, 2008).

Therefore, DoE had created an official household e-waste management portal to share many usable information of e-waste recycling in videos and pictures on the website but level of awareness is still low (Department of Environment Malaysia, 2015). It is due to website is a one-way communication to public that can be quite a challenge to gain young adults, age 15-30 years' attention. Most of the young adults possessed several e-waste items but lack of information on the process of their recycle and disposal of the items. Malaysians internet user's demographic as of July 2018 shows that the young adult that age below 20 and 20-29 years had the majority in total of 38.1% (SKMM Internet User, 2018) which means that they own at least one electronic devices to get access to the internet. Thus, it is important to create awareness among the young adults through an interactive courseware that is suitable for this group.

III METHODOLOGY

The interactive courseware was developed following the Rapid Application Development (RAD) methodology proposed by Martin (Martin, 1991). RAD is an adaptive software development approach which involves prototyping and the requirements for the systems of apps. RAD consists of 4 phases which is requirement planning, user design, construction and cutover. These phases help to ensure the project completed as planned. The flow of the phases is illustrated in Figure 1.

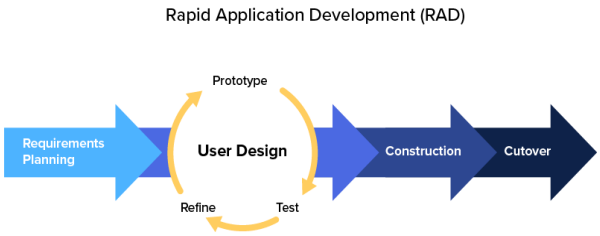

Figure 1. The phases of RAD.

This project started off with Requirement Planning Phase. Requirement Planning is the initial stage of RAD methodology model and it is meant to set the goals the elaboration including project scope and boundaries. During this stage, the project goal and the expectation was determined. User requirement was gathered from all the stakeholders involved including young adults via in depth interviews and online surveys.

In the User Design Phase, user feedbacks were gathered and the courseware architecture was developed well. During this stage, the development of user design through various prototype iterations to ensure requirement is related to the project. Interface sketches and database designs are generated using techniques such as storyboards and Unified Modelling Language (UML) models of system analysis and design. In the Rapid Construction Phase, Adobe Flash was used to develop the courseware. The project was linked to database for storing the name of the user and the total score of the Awareness Test. Lastly, during the cutover stage, the courseware was developed and involved in courseware and user testing. This project able to get 32 user testing feedbacks for initial evaluation of E-Waste Recycling Awareness.

IV DEVELOPMENT OF E-WASTE RECYCLING AWARENESS COURSEWARE

This section describes the design and development of the E-Waste Recycling Awareness interactive courseware. The section is divided into two subsections: (A) the requirements analysis and (B) the prototype development.

A. The Requirements Analysis

The E-Waste Recycling Awareness is an interactive courseware specifically tailored to young adult who age range between 15-30 years to raise their awareness of e-waste recycling. The requirements gathered are analyzed and categorized as functional requirements and non-functional requirements for the courseware. The high level of the functional requirements for this courseware is embedded in several scene which are:

- Start Courseware
- Choose Menu
- Play "Awareness Test"

Table 1. List of requirements for e-waste recycling awareness

No	Requirement ID	Requirement Description	Priority
1	A01	Start Courseware	
	A01_1	User must accept the user agreement to begin the courseware	M
2	A02	Choose Menu	
	A02_1	User shall choose the menu list	M
3	A03	Play "Awareness Test"	
	A03_1	User shall click to enter the next scene	M

The high-level functional requirements shown in Table 1 represented in the main pages that included several scenes of the courseware. In this study, StarUML tool was used to visualize and model the requirements of the courseware. Among the analysis UML model developed are use case, activity diagram and sequence diagrams. Figure 2 illustrates the use case diagram and the communications between the use cases and the actor. Three main use cases of E-Waste Recycling Awareness are "Start Courseware", "Choose Menu" and "Play "awareness test".

For every single use case identified in the use case diagram, a use case specification is produced. Use case specification to detail out every single step of the functions involved in the use case.

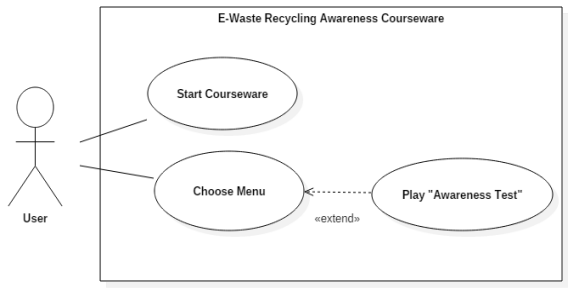

Figure 2. Use case diagram of E-Waste Recycling Awareness

Use case specification is vital to ensure all the requirements are captured correctly including all the basic flows, alternative flows and also exceptional flows. After the requirement analysis is done, the application is further continued with UML analysis and design model. UML is used to produce activity diagram for the big picture of e-waste recycling awareness courseware, followed by analysis of sequence diagram that evolved into design sequence diagram and class diagram.

The purpose of the sequence diagram was to show in timely manner the object interaction through the passing of messages between the objects involved to perform the functionalities of e-waste recycling mobile application for the basic flows, exceptional flows and alternative flows. The messages passed between the object will become the operations or methods for the related objects. A sequence diagram is produced based on each of the use case specification prepared earlier. Figure 3 shows the sequence diagram of basic flow of Start Courseware page and Figure 4 Sequence Diagram of Choose Menu page.

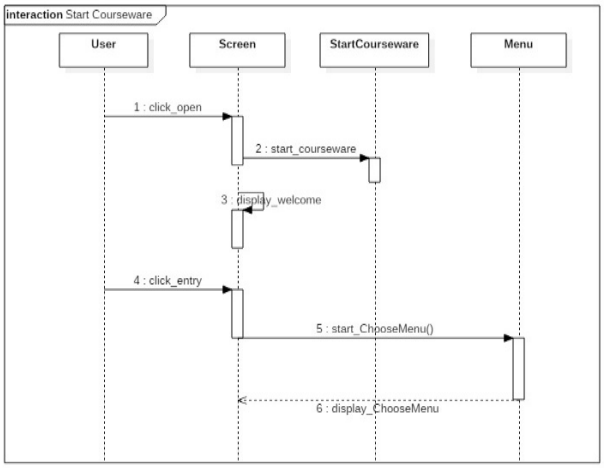

Figure 3. Sequence diagram of Start Courseware page

B. E-Waste Recycling Awareness Courseware

A prototype of the courseware was then developed to represents the requirements explained in the previous subsection. Adobe Flash was used to develop the prototype of E-Waste Recycling Awareness for creating multimedia content and animation can result in designs where browsers can immerse in an interactive experience. ActionScript 3.0 is the programming language of Adobe Flash that is in model of object-oriented programming while XXAMP is used for database and the data is stored in mySQL for storing the name of user and total score in Awareness Test page. Screenshots in Figures 5, 6, 7 and 8 show the selected interfaces of E-Waste Recycling Awareness.

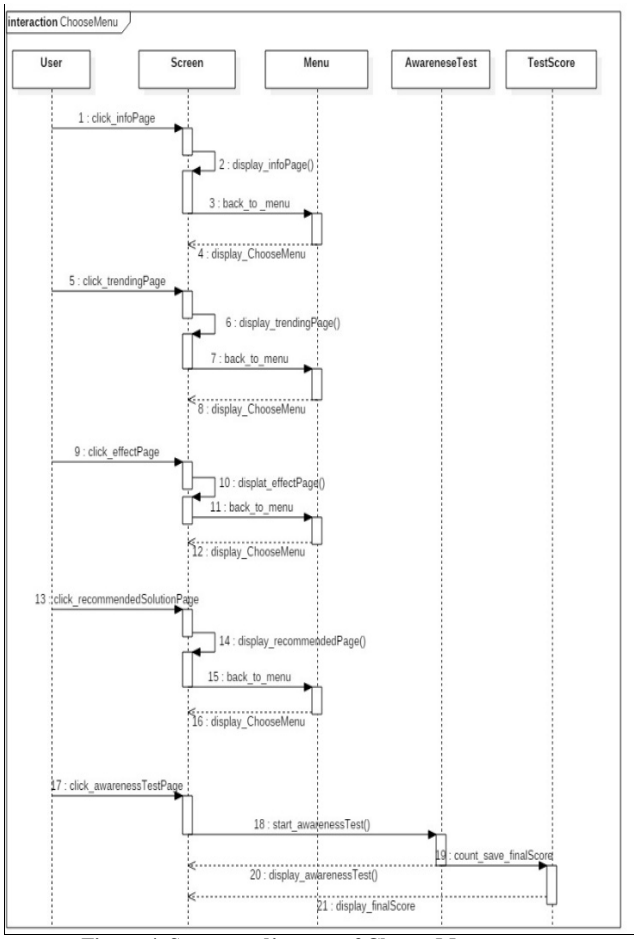

Figure 4. Sequence diagram of Choose Menu page

Figure 5. The interface of Start Courseware page of E-Waste Recycling Awareness

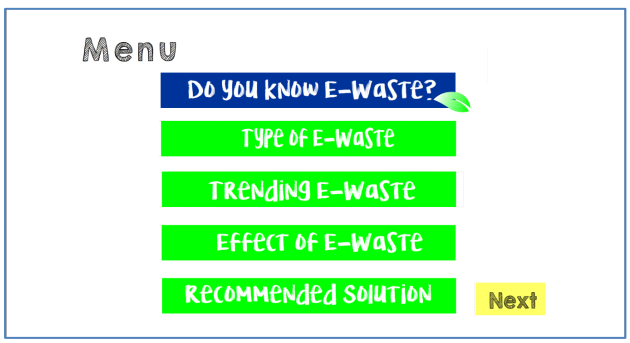

Figure 6. The interface of Choose Menu page of E-Waste Recycling Awareness

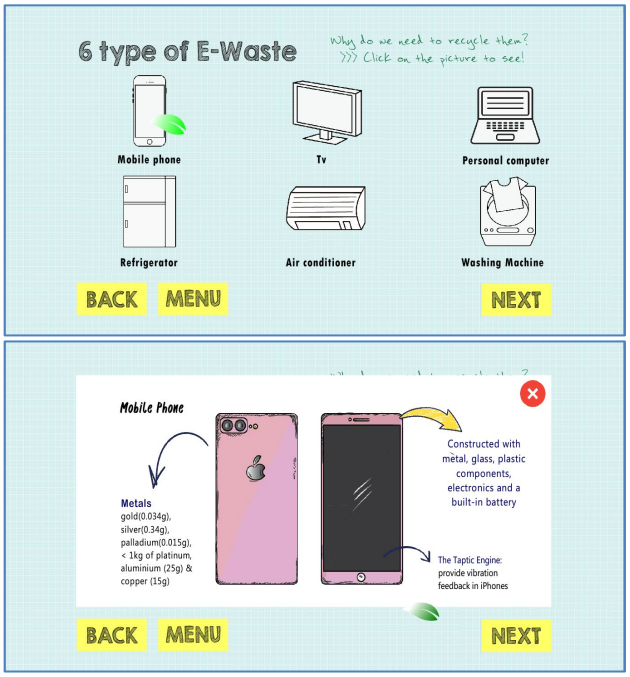

Figure 7. The interface of "Type of E-Waste" of E-Waste Recycling Awareness

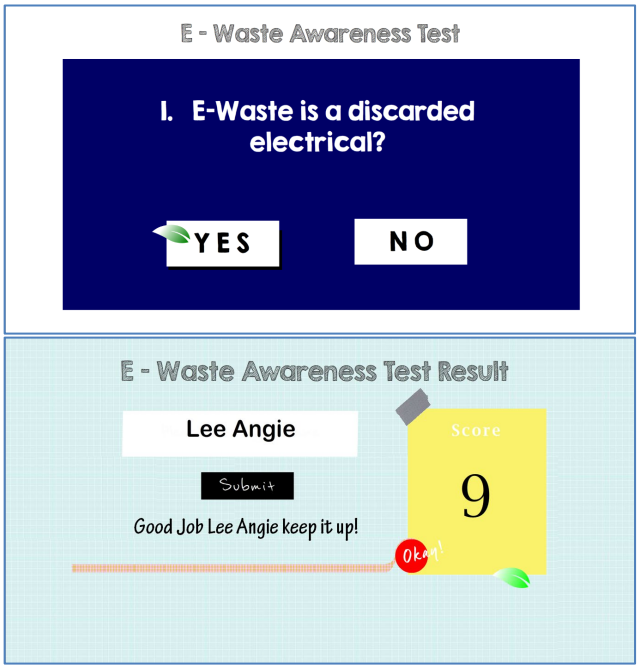

Figure 8. The interface of Play "Awareness Test" of E-Waste Recycling Awareness

V EVALUATION OF E-WASTE RECYCLING AWARENESS COURSEWARE

A. The Evaluation Setting

A usability evaluation was conducted on 32 respondents who are in between 15-30 years of age. The respondents were approached face to face and through online and participated in the study on a voluntary basis. The instruments used for the evaluation were the E-Waste Recycling swf file and

a post-task questionnaire. The post-task questionnaire consists of 4 sections which are demographic information, screen, action and navigation and overall performance that was adopted from (Elissavet & Economides, 2003). The five-point Likert scale is used to indicate extent for each question (Preedy & Watson, 2010). The respondents performed the following instructions for the evaluation: (1) read the consent form, (2) interacted with E-Waste Recycling Awareness and completed the E-Waste Recycling Awareness Test, and (3) answered the post-task questionnaire.

B. The Respondents' Demographic Information

From the demographic information revealed that 50% of the respondents is female. 94% of respondents are young adults who is between 15 to 30 years older. All respondents are Malaysians from three major races of Malay, Chinese and Indian. Most are the respondents (81%) stated they have the experience to use mobile application ICT more than 3 years. There are majority 53% of the respondents used 9 hours and above for their daily usage of ICT devices.

C. The Usability of E-Waste Recycling Awareness

Section B to Section D captured the respondents' perception towards E-Waste Recycling Awareness in terms of usability, deliverable level of awareness and satisfaction. The frequency and percentage of the responses as shown in Fig 9, 10, and 11 From the responses, the respondents generally rated four or five of the post-task scales. Some of the respondents rated neural and only a few rated Disagree.

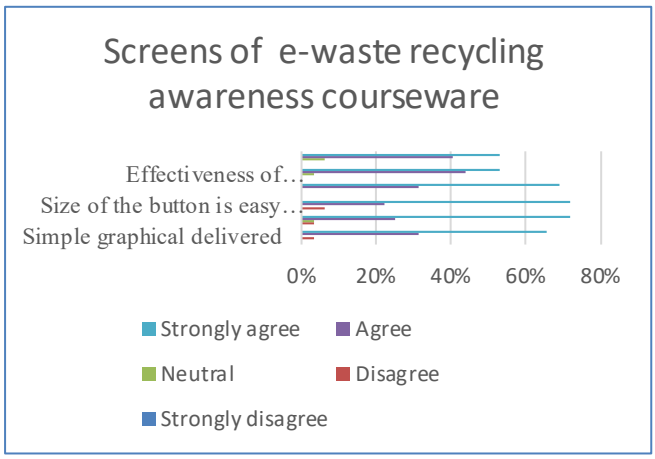

Figure 9. The respondents' responses on section b: screen for e-waste recycling awareness

From the results of the evaluation showed that E-Waste Recycling Awareness is easy to use and majority of the respondents are satisfied with it. They are overall content with the courseware as well. Analysis of the respondents' responses shows that most of the respondents agree that the courseware is understandable and the content delivered is clear. Most of the respondents stated that E-Waste Recycling Awareness was ease to use and works interactively and attractively.

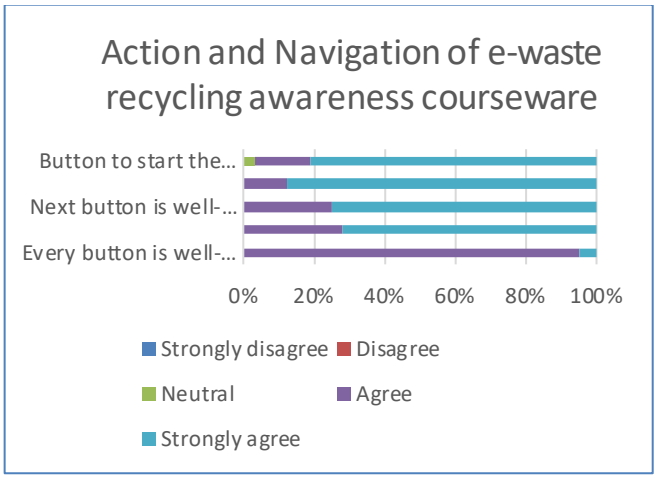

Figure 10. The respondents' responses on section c: action and navigation for e-waste recycling awareness

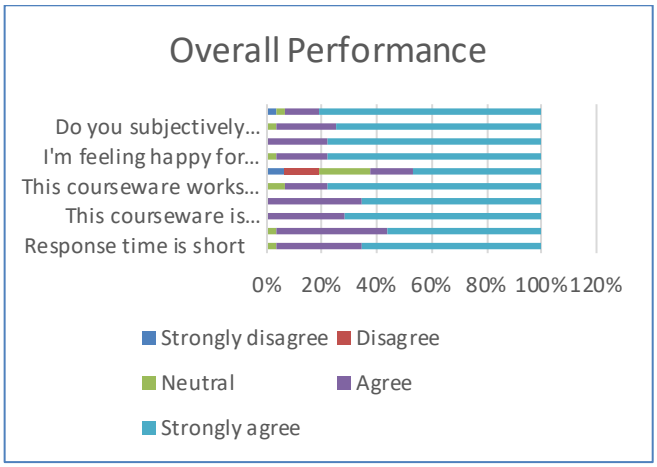

Figure 11. The respondents' responses on section d: overall performance for e-waste recycling awareness

VI DISCUSSION AND FUTURE WORK

This paper presented the development of e-waste recycling courseware that is interactive to create awareness for young adults. This application tried to utilizes the advantage of mobile technology to educate people on e-waste recycling. It also opens up opportunities to provide information to people on how generate income from the recycling of e-waste, to ease the work of e-waste collectors and to save the environment from hazardous chemicals from the e-waste if they are not disposed properly. In the future, we would like to further enhance the courseware for other age and targeted groups such as kids and rural people.

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