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Developing *Whiteboard* Animation as an Educational Media for Electronic Waste Management in the Special Region of Yogyakarta (DIY)

Arif Ranu Wicaksono

Study Program or Visual Communication Design, Faculty of Fine Arts and Design, Universitas Sebelas Maret, Surakarta

arifranu@staff.uns.ac.id

The Electronic waste is included in the B3 (hazardous and toxic materials) waste category, requiring special handling. Based on statistical data from the Independent Waste Management Information System website managed by the Environment and Forestry Service (DLHK) of the Special Region of Yogyakarta, the daily electronic waste collected is around 78 kg. Of the 78kg of electronic waste, 48kg can be processed, consisting of 45kg of electronic waste and 30kg of used battery waste, leaving the remaining 3kg as residue. Yogyakarta City's electronic waste is expected to grow year after year, meaning that a solution is required. One of the solutions is to provide communicative and easy-to-understand educational media to the public, with a broad impact on the residents of Yogyakarta City, so that, electronic waste can be managed effectively in the future, with the hope of reducing the negative impact of environmental pollution on land, water sources, and air. Educational media about electronic waste is still limited, and residents of Yogyakarta City remain unaware of the issue, as evidenced by the fact that when disposing of electronic waste, they mix organic and inorganic waste. Researchers developed an animated video using the Whiteboard application as an educational media for electronic waste management in Yogyakarta. The Whiteboard animation video was developed using the ADDIE method (Analysis, Design, Development, Implementation, and Evaluation). It is expected that this media design will increase the awareness of Yogyakarta City residents of proper electronic waste management practices.

Keywords: electronic waste, Whiteboard animation, ADDIE

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INTRODUCTION

The Ministry of Environment and Forestry of Indonesia is concerned about electronic waste, which has been estimated to reach two million tons in Indonesia by 2021, with Java accounting for 56% of the total waste. Regarding the issue of electronic waste, Government Regulation Number 27 of 2020 controls specific waste (E-Waste) management, that electronic waste is hazardous and toxic material (so-called *B3* waste/*bahan berbahaya dan beracun* waste), necessitating special handling to avoid health problems and environmental damage.

The all-digital lifestyle increases demand for electronic goods, as does the rapid development of electronic equipment technology, resulting in shorter device lifespans. Smartphones, for example, frequently lag behind technology, although the company has recently released them. As an example, cellular networks have developed rapidly, from GPRS, 3G, and 4G, to 5G. This suggests that early-generation cell phones are no longer used, even if the smartphone is not yet broken. Electronic devices that are no longer in use due to damage or technological limitations have the potential to become electronic waste (Nahor, 2019; Pasha, 2015).

According to the Indonesia Environment & Energy Center (IEC), electronic waste refers to electronic goods that are discarded because they are damaged or no longer functional. Electronic waste must be carefully monitored because it contains thousands of materials. The majority of them are classified as toxic and hazardous materials (B3), including heavy metals, such as mercury, lead, chromium, cadmium, arsenic, silver, cobalt, palladium, copper, and others. The following are some examples of B3 waste that pose a risk. *First*, PCBs are commonly used in plastics, adhesives, transformers, capacitors, hydraulic systems, lamp ballasts, and other electronic devices. PCBs have a high risk of persistence in the environment and can easily accumulate in human and animal fat tissues. As a result, they have the potential to disrupt the digestive system and cause cancer.

Second, arsenic is used in the electronics industry to manufacture transistors, semiconductors, glass, textiles, ceramics, glue, and explosives. There is a risk that it will cause metabolic disorders in humans and animals, leading to poisoning and even death.

Third, cadmium is used to plate metals, particularly steel, iron, and copper. In addition, batteries and plastics are manufactured. Inhaling it may irritate. Long-term effects of cadmium include poisoning and disruption of organ systems in the human and animal bodies.

Special Region of Yogyakarta (Daerah Istimewa Yogyakarta/DIY) Regional Regulation Number 2 of 2012 concerning Toxic and Hazardous (B3) Waste Management states that everyone is obliged to sort household waste that is identified as B3 waste. As a follow-up, the Yogyakarta City government has provided drop boxes at seven points as particular places for electronic waste disposal.

The seven points are at the Integrated Waste Disposal Site/*Tempat Pembuangan Sampah Terpadu* (TPST) of Nitikan, Kotagede Waste Dump, Gedongkiwo Waste Dump, Mandala Krida Waste Dump, Yogyakarta City Environmental Service (*Dinas Lingkungan Hidup*) office and Tompeyan Waste Dump.

The Yogyakarta City Environmental Service continues to assist and educate the public on how to properly manage electronic waste, such as sorting, collecting, disposing, and processing B3 waste. The efforts are made because the majority of Yogyakarta City residents have yet to separate household waste from B3 waste.

To raise awareness among Yogyakarta City residents about the importance of properly managing electronic waste, media that can be easily distributed, such as social media or direct messages, is required. *Whiteboard* animation can serve as a communicative tool for socialization.

Whiteboard animation has three advantages. *First*, it can convey messages clearly and concisely. *Second*, it is easy and inexpensive to make. *Third*, it is universal and thus can be used for a variety of purposes, including animated videos offering products, learning, testimonials, outreach, and videos with other specific goals (H. Jefferly, 2019).

This study aims to contribute by developing socialization media in the form of a *Whiteboard* animation of "*Pengolahan Sampah Elektronik yang Benar* (Proper Electronic Waste Management)" as a means of communicating messages about how to manage electronic waste at the consumer or household level to reduce negative impacts on humans and the surrounding environment.

This *Whiteboard* animation would distributed via YouTube and social media. This animation has received a positive response from the audience. It is

expected that this animation can serve as an effective and efficient communication medium to educate the public, especially in the City of Yogyakarta.

METHOD

This study employed the ADDIE model, including Analysis, Design, Development, Implementation, and Evaluation (Arifin, 2018). A description of the completed development process is provided in Figure 1.

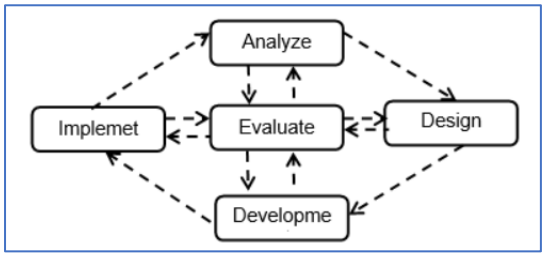

Figure 1. ADDIE model development procedure

During the analysis stage, researchers collected information about the potential risks of electronic waste as well as the negative consequences of improper electronic waste management. The researchers also considered suitable animations used as a tool for socialization.

The analysis stage was followed by the design stage. After deciding the type of animation to create, researchers divided the production process into three stages, including pre-production, production, and post-production. The development stage marked that the development process of the design was almost completed. During this time, researchers worked on a variety of projects, including content development, feasibility testing, and animation media adaptation.

The media was then validated by some experts. The next stage was implementation, in which the researchers distributed the animation product via social media to make it more accessible to Yogyakarta residents. The final stage was evaluation, which entails reviewing each stage, from feasibility testing to implementation.

The five ADDIE stages used to create animation are simple and well-organized, making it easier for researchers to create animated medium. This animation was distributed to 25 residents of Yogyakarta to gauge their reactions. A prepared questionnaire was then used to gather their responses.

RESULTS AND DISCUSSION

The results of developing animation media using the ADDIE model are presented as follows.

Analysis

Two steps were carried out during the analysis stage, namely examining content requirements and whiteboard animation media requirements.

Content analysis

At this stage, problems in the field were analyzed and divided into story plots that would be narrated in *Whiteboard* animation:

the impact of electronic waste on health and the environment;

the steps for managing electronic waste based on government and regional regulations; and

community engagement in electronic waste management.

Media analysis

Because of the complexity of the electronic waste problems, *Whiteboard animation* is an effective media for socializing electronic waste management.

Design

This stage includes three activities, pre-production, production, and post-production.

Pre-production

This stage entails creating a *Whiteboard* animation storyline, preparing production funds, making a schedule, and creating a production design.

Production

This stage targeted the visualization of the storyline through *Whiteboard* animation. This stage includes a series of activities, such as creating illustrative images based on the story, setting the text for the animation, preparing voiceovers and music, compositing animations, and rendering.

Figure 2. Production process

Post-production

Following the completion of shooting and sound recording, the rough or offline editing process was done.

Development

After finalizing the animation, an in-depth review of the content to be published was conducted. Expert validation was also carried out to ensure the content's suitability for publication.

Implementation

The *Whiteboard* animation clip of "*Pengelolaan Sampah Elektronik yang Benar* (Proper Electronic Waste Management" was distributed through social media, particularly YouTube.

Figure 3. Whiteboard animation of "*Pengelolaan Sampah Elektronik yang Benar* (Proper Electronic Waste Management)"

Evaluation

The evaluation stage of this study involved testing the level of audience satisfaction using the Mean Opinion Score (MOS) measurement standard (Elmansyah, 2013). MOS provides a numerical indication to measure the quality of a service or media. Technically, participants were asked to access socialization media of a Whiteboard animation *Pengelolaan Sampah Elektronik yang Benar* (Proper Electronic Waste Management) and provide feedback through a questionnaire with a score range of 1 to 5. The questionnaire was distributed to a total of 25 participants to determine the means and percentage of ease of accessing media, visual appeal, and clarity of the message conveyed. The collected data were examined using statistical analysis. The following table presents the results of the calculated and analyzed distributed questionnaires.

Table 1. Mean Opinion Score

MOS	Description	Score
SA	Strongly agree	5
A	Agree	4
N	Neutral	3
D	Disagree	2
SD	Strongly disagree	1

$$\mathbf{MOS} = \frac{\sum_{i}^{n} 0^{\,x(i).\,k}}{N}$$

Figure 4 . MOS formula

Notes:

X(*i*) = Value of the *i* sample

K = Total score

N = Number of observations

Table 2 presents the results of the analysis of questionnaires filled out by 25 respondents regarding their perceptions of the *Whiteboard* animation entitled "*Pengeloalaan Sampah Elektronik yang Benar*".

Table 2. Results of questionnaire analysis and MOS

NO.	Question	SA	A	N	D	SD	MOS
1.	The animation is accessed easily online on YouTube.	10	9	5	1	0	4.12
2	The animation display is attractive.	3	10	10	2	0	3.56
3.	The message of the animation is easy to understand.	10	13	1	1	0	4.28

The results of the analysis of the responses suggest that 76% of respondents believe that the *Whiteboard* animation "*Pengelolaan Sampah Elektronik yang Benar*" is easily accessible online through YouTube. The animated display was rated as attractive by 52% of respondents. Moreover, 92% of the message contained in the animation produced is clear.

CONCLUSION

After conducting research and implementing the Whiteboard animation entitled "Pengelolaan Sampah Elektronik/Correct Electronic Waste Management", as well as distributing questionnaires to measure public responses, it can be concluded that the Whiteboard animation of "Pengelolaan Sampah Elektronik yang Benar" is worthy of publication and can be used as an educational medium for the people of Yogyakarta City. Education on environmental issues, particularly electronic waste management, is not solely the responsibility of governments. However, the larger community and individuals must also participate in socializing good and proper electronic waste management to ensure the long-term viability of the environment.

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