

DEVELOPING MEMENTO MAKER FOR ENVIRONMENTAL EDUCATION-CIRCULAR ECONOMY USING TECHNOLOGY READINESS LEVEL (TRL) IN SK PULAU PERHENTIAN

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Abstract – Environmental education plays a major role to preserve the environment. The global community is experiencing major challenges in sustaining economic development while minimizing harmful environmental effects, and this applies to the local community as well. To address this issue, a survey was conducted to identify the public interest and awareness pertaining to the use of future innovation as a mechanism to counter the waste management issue, in light with the importance of environmental education with the principle of circular economy. The survey contains 8 questionnaires, with 2 demographic questions, 5 Likert-Scale questions and 1 open-ended question. Next, the responses were gathered in the span of 3 weeks with a total of 65 respondents from various background. Out of 65 respondents, 54 of them agreed that Memento Maker is able to resolve the depositing waste in landfills problem. The results perceived that the public is interested in the product as a mechanism to minimise the harmful environmental effects due to the improper waste management. Thus, Memento Maker is introduced as a product that embeds the principle of Circular Economy (CE), of which it underpins the concept of recycling waste materials and regenerating them into a product of value. Memento Maker is developed using the Technology Readiness Level (TRL) framework as a guideline in every development process to produce the end product. The product aims to reduce the impact of improper solid waste management system as well as enhancing economic opportunities in the society.

Keywords – environmental education, circular economy, environmental effects, Memento Maker, recycle, Technology Readiness Level.

I. INTRODUCTION

Various definitions of the term environmental education (EE) were introduced over the years, but the most essential one was given by UNESCO: “Environmental education is a learning process that increases people's knowledge and awareness about the environment and associated challenges, develops the necessary skills and expertise to address the

challenges, and fosters attitudes, motivations, and commitments to make informed decisions and take responsible action” (Borah, 2007).

Environmental education, too, encompasses circular economy as well, as circular economy is introduced as an alternative to a more sustainable system known which is in harmony with the rest of nature. The definition of circular economy is circulating products and materials at their highest value, as highlighted by MacArthur, E (2013). It regenerates materials, and reduces waste and emissions to the environment (Khalid Khan et al., 2022). Therefore, it is a good step to reduce the global demand for virgin resources. It is a holistic approach that strengthens capacity and competence by embracing and instilling the practice of entrepreneurship, innovation, and cooperation.

We have chosen the Technology Readiness Level (TRL) as a framework which has been used in many variations across industries to provide a measurement of technology maturity from idea generation (basic principles) to commercialisation (Nakamura, 2012). By referring to this framework (Figure 1), it serves as one of the principles which allow us to comprehend the advancement of technology, specifically the product “Memento Maker”. Meanwhile, the research design uses Technology Readiness Level (TRL) as a development product.

Fundamentally, an innovation called Memento Maker is created to reduce improper waste management which combines profits with social impacts by minimising waste and making more productive use of resources. It is an alternative way of recycling plastic waste to make our environment a better place for humans. The recycled product will be sold to encourage entrepreneurship among people. In this case, equalisation promotes economic advantages while protecting the environment.

II. PROBLEM STATEMENT

The Khazanah Research Institute predicted that our nation will produce close to 15 million tonnes of rubbish by the year 2022. Waste production is only on the rise, with a nine-year compound annual growth rate of little under 2% (The Star Online, 2022). Based on an interview with the Manager of Fuze Ecoteer, who resides in Pulau Perhentian Kecil, heaps of trash have accumulated to 8 tonnes per day. The amount could reach 10 tonnes in a day, especially on weekends and public holidays, of which it was contributed not only by the locals but tourists as well. Taking into account that the amount of waste being produced has increased along with the global economy, therefore, as an act of reducing waste and creating awareness, we have come up with an

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innovation to help them in terms of minimising pollution and developing the entrepreneurship skills to create a healthy and balanced environment.

The research objective is to examine whether Memento Maker can be produced at par with products currently available on the market by integrating Technology Readiness Level (TRL) as a framework and incorporating the principle of circular economy (CE).

III. LITERATURE REVIEW

As the environment degrades, pollution may lead to health issues and climate changes, which unquestionably have an impact on people's daily lives (Fuller et al., 2022). Due to its low costs, depositing waste in landfills continues to be the most widely used waste management method worldwide (Wang et.al, 2020). Huge amounts of greenhouse gases, primarily methane (35–65%) and carbon dioxide (15–50%), are released by landfills (Bicheldey & Latushkina, 2010). This makes goal 13 in Sustainable Development Goals (UN, 2016) unachievable in the case of improper waste management which leads to environmental pollution.

Among the many unprecedented consequences of the current pandemic, municipal waste management practices are expected to become more concerning as time passes (Smart Waste Report European Union, 2020). Consequently, this leads to detrimental aftermath on society and the environment in the long run.

Increasing waste generation has become a real challenge due to population growth and rapid urbanization. Recently, it has been reported that there was a case of food poisoning after swimming in waters believed to be contaminated with untreated wastewater at Pulau Perhentian Kecil in Terengganu (The Star Online, 2022). This report indicates that pollution is a clear-cut effect which subsidizes from improper waste management. Hence, by delving into the grassroots of the issue, it is essential to address this by aligning with the Sustainable Development Goals empowered by the United Nation (UN, 2016).

Environmental education is crucial as As János Lehoczky (1999) quotes, “The goal of environmental education is multi-layered, not just the transfer of environmental knowledge. It seeks to influence the whole of the personality, including consciousness through knowledge, sentiments through experience, and the will through purposeful activities.”

Circular economy emerges as an effective way to counter the alarming amount of waste in our surroundings. Findings prove the existence of a reciprocal link between the circular economy and carbon emissions (Khalid Khan et.al, 2022). As there is a lack of innovative products to support the circular economy in the country, the superiority of our developed product, Memento Maker, is established through comments from experts and surveys conducted among foreigners and during local travelling to Pulau Perhentian. The concept of our product aligns with the second principle of the circular economy. This means keeping materials in use, either as a product or, when they can no longer be used, as components or raw materials. This way, nothing becomes waste and the intrinsic value of products and materials is retained.

The development of our product has also

incorporated the Waste Hierarchy Index (WHI), a conceptual framework designed to guide and rank waste management decisions. The WHI considers all waste operations, as well as various types of recycling and incineration processes, to support CE's mission and purpose (Pires & Martinho, 2019). Thus, our product, Memento Maker, underpins the concept of sustainability through the circulation of waste materials to a higher-value of product.

IV. METHOD

Memento Maker is developed aligned with the TRL approach. A clear road map is provided for the development of Memento Maker, which can be seen in the Figure 1.

To measure the satisfaction for this product development, we have opted to implement a survey, both online and offline. An online survey was held using Google Form, with the questionnaire containing 8 items in total, involving 2 demographic questions, 5 Likert-Scale questions and 1 open-ended question. The cross-sectional study was used in this research because the respondents needed to get feedback from the target sample. The population of interest for the online survey varies from different backgrounds such as government officers, school students, higher education students and public individuals in Malaysia.

No specific group was selected because the purpose of the survey is to identify and examine the interest towards Memento-Maker among the general population all over the country. According to Uma Sekaran (2016), questionnaires are typically designed to collect large amounts of quantitative data. They can be administered in person, electronically, or mailed to respondents. Questionnaires are less expensive and time-consuming compared to interviews and observations, but they also introduce a much higher risk of nonresponse and nonresponse errors.

The main advantage of this is that the researcher or a member of the research team can quickly collect all completed responses. Any doubts that respondents may have on any question could be cleared up right away. Thus, questionnaires are used in this research to identify the respondents' interest towards Memento Maker. It was published through WhatsApp, Telegram as well as social media like Instagram for the public to respond to in three weeks starting from 26th December 2022 until 14th January 2023. A physical interview was conducted to collect the responses among pupils in Sekolah Kebangsaan Pulau Perhentian. The interview included a poster-rating session which encompassed 8 posters altogether.

The analysis concerning descriptive were also verified based on the PROCESS macro results. All statistical analyses were performed using Jamovi (Jamovi, 2022) from the dataset available.

V. FINDINGS

The stages of development to produce Memento-Maker using the TRL framework is displayed in Figure 1. The final stage of our innovation, Memento Maker is illustrated in level 6. Each product is produced by recycling plastic elements, specifically bottle caps and straws.








TRL LEVEL	DESCRIPTION	OUTPUT
1	Basic principle observed/reported	
2	Technology concept and/or application formulated (3R; Reduce, Reuse, Recycle)	
3	Analytical and experimental critical function and/or characteristic proof-of-concept (The product will be moulded into a hexagon shape)	 
4	Component and/or mould validation in laboratory environment	
5	Component and/or mould validation in relevant environment	
6	System/subsystem model or prototype demonstration in a relevant environment	

Figure 1: Technology Readiness Level (TRL) Framework. Adapted From Nakamura (2012).

Therefore, it is transparent that Memento Maker has passed at the scale of 6 according to the TRL. A clear road map is provided for the development of Memento Maker, which can be seen in the figure above. Moving on, the findings are further interpreted through the statistical analyses using the Jamovi application is capable of executing the results which are presented in Table I to Table IX. This particular section focuses on how statistical analyses are conducted using Jamovi for descriptive statistics. A qualitative analysis of the pupils' interview is carried out to

extract the themes found in the 30-minute audio recording. The recordings from the interview sessions involving the 4 pupils are transcribed and a qualitative analysis is carried out afterwards. Three themes emerged from the analysis of the transcript from the interview conducted.

The first theme is derived from the below listed transcript:

R2: "bila Iqi tgk post dkt IG (instagram), Iqi rasa macei, ho tokleh ni tohok sapoh sini, keno tohok dale tong sampah" -

R3: "Pernah nampak (iklan), tapi lupa kat mana."

R4: "Sebab umi yang pesan, Umi kata suruh jaga kebersihan tapi kalau kat rumah adik-adik kecil selalu suka buang sampah."

R4: "Nak kutip sampah dan nak sebar poster"

R4: "Qierana faham (dari poster) yang kita ni jangan buang sampah merata-rata dan nak guna semula sampah-sampah tu."

Based on the quoted conversations, the theme of Communication/Platform Enhancement in a Cluttered Environment (CE) can be derived as the interviewees have successfully comprehended the intended message, therefore achieved the objective of media engagement.

R3: "Suka, sebab macam boleh join pertandingan pastu kita boleh kitar semula dengan bahan-bahan yang kita kumpul."

R3: "Ye, rasa nak kutip sampah dan biar pulau ni bersih."

R4: "umi akan buang kat pantai lepastu umi bakar sampah-sampah tu"

R4: "Guna macam kalau botol sabun kat rumah, umi takkan buang, umi akan guna semula botol sabun tu. nanti umi beli sabun yang isi semula tu je"

R4: "kesan dia, ada lah sekali tu kawan nak buang sampah dalam longkang tapi Qierana tegur dia suruh buang dalam tong sampah sebab tong sampah ade dekat tepi longkang tu je"

Hence, the theme of Specific Behavioral Measures and Advertising/Business Value (MEA) can be concluded based on the above examples as the interviewees have portrayed particular behaviors towards the intended purpose.

R3: "Bila zara tengok iklan tu, Rasa nak buang sampah pada tempatnya laa.. "

R3: "Rasa penting la nak jaga alam sekitar, supaya bila pelancong datang dia rasa pulau perhentian ni indah"

R3: "Rasa bangga (dapat join program)"

R3: "Excited (apabila dapat peluang join program)"

R3: "Zara nak bila pelancong datang pulau perhentian ni, di kata cantik dan bersih. Jadi zara boleh bangga la dengan tempat ni."

And the last theme is After-Campaign Diagnostic Process which refers to the impact of the previous intervention (campaigns and awareness programs).

Table I conveys the results obtained from poster rating session and an interview with the primary school pupils from Sekolah Kebangsaan Pulau Perhentian. They were asked to rate each poster using the star rating as it was easier for them instead of using the 5-Likert Scale.

TABLE I: POSTER RATING FROM SK PULAU PERHENTIAN PUPILS

Ranking	Poster's Message	Star Rating
1	Bumi Ini, Bumi Kita	28

2	Sayangi Bumi Kita	26
3	Kitar Semula Demi Alam Sekitar Kita	24
4	Terima Kasih Jaga Rumah Saya	24
5	Dah Asingkan Belum?	23
6	101 Sampah Boleh Dikitar Semula	22
7	Kitar Semula Untuk Hari Yang Lebih Baik	20
8	Buang Dengan Cermat Agar Bumi Selamat	13
9	Dialog 'Abang, Kenapa Perlu Kitar Semula?'	20
10	Kitar Semula Boleh Hasilkan Duit	19
11	Kitar Semula Amalan Bersama	18
12	Buang Dengan Cermat Agar Bumi Selamat	13
13	18 Botol Menghasilkan Sehelai Baju	12

Table I shows that the highest poster “*Bumi Ini, Bumi Kita*” received 28 stars altogether from the pupils, while the lowest rating is 12 stars, “*18 Botol Menghasilkan Sehelai Baju*”.

Table II indicates the survey’s results, which further shows the frequency of background among the respondents whereas Table III shows the frequency of occupation, ranging from 14 different occupations.

TABLE II: FREQUENCIES OF BACKGROUND.

Background	Counts	% of Total	Cumulative %
Government officers	2	3.1 %	3.1 %
High school/primary school students	3	4.6 %	7.7 %
IPGM students	28	43.1 %	50.8 %
IPTA/IPTS students	20	30.8 %	81.5 %
Public individuals	12	18.5 %	100.0 %

A total of 65 respondents responded to all of the above items for background and occupations. The highest frequency for the background is 43.1% (IPGM students), while the lowest count is government officers, with a frequency of 3.1%.

IPGM students have the highest frequency of 43.1% as the distribution and promotion of the questionnaire to them is rather more convenient and within reach compared to other respondents with different backgrounds.

There are various occupations ranging from environmental scientist, engineers, an administrator from Nestle Products Sdn Bhd, accountant etc, where the majority of respondents were among students. Various respondents from multiple occupations is shown in Table III.

TABLE III: FREQUENCIES OF OCCUPATION FOR PUBLIC INDIVIDUALS.

For public individuals, state your occupation.	Counts	% of Total	Cumulative %
ccountant	1	1.6 %	1.6 %
Clerk	1	1.6 %	3.2 %
Engineer	2	3.2 %	6.3 %

For public individuals, state your occupation.	Counts	% of Total	Cumulative %
Environmental scientist	1	1.6 %	7.9 %
Government officers	1	1.6 %	9.5 %
High school student	2	3.2 %	12.7 %
IPGM students	28	44.4 %	57.1 %
IPTA/IPTS students	20	31.7 %	88.9 %
Maintenance worker	1	1.6 %	90.5 %
Manager	1	1.6 %	92.1 %
Manufacturing Technician	1	1.6 %	93.7 %
Nestle Products Sdn Bhd	1	1.6 %	95.2 %
Teacher	1	1.6 %	96.8 %
Technician	2	3.2 %	100.0 %

The responses of the respondents on whether they agree that the Memento-Maker is able to resolve the depositing waste in landfills problem are presented in Table IV.

TABLE IV: FREQUENCIES OF IS MEMENTO-MAKER ABLE TO RESOLVE THE DEPOSITING WASTE

Is Memento-Maker able to resolve the depositing waste in the landfills problem?	Counts	% of Total	Cumulative %
Maybe	11	16.9 %	16.9 %
Yes	54	83.1 %	100.0 %

83.11% of the respondents believe that Memento-Maker is able to overcome it while the remaining 16.9% only partially agree. The responses pertaining to whether the respondents agree if Memento-Maker is useful for daily life is depicted in Table V.

TABLE V: FREQUENCIES OF DO YOU FIND MEMENTO-MAKER USEFUL FOR DAILY LIFE

Do you find Memento-Maker useful for daily life?	Counts	% of Total	Cumulative %
Maybe	22	33.8 %	33.8 %
No	2	3.1 %	36.9 %
Yes	41	63.1 %	100.0 %

It is seen from Table V that 63.1% of the respondents found the Memento-Maker is useful for daily life while 3.1% of them responded the opposite. The other 33.8% is not sure whether it would come in handy.

TABLE VI: TENDENCY OF THE RESPONDENTS TO PURCHASE MEMENTO-MAKER.

Would you buy Memento-Maker with the price of RM10?	Counts	% of Total	Cumulative %
Maybe	25	38.5 %	38.5 %

TABLE VI: TENDENCY OF THE RESPONDENTS TO PURCHASE MEMENTO-MAKER.

Would you buy Memento-Maker with the price of RM10?	Counts	% of Total	Cumulative %
No	3	4.6 %	43.1 %
Yes	37	56.9 %	100.0 %

Table VI displays the tendency of the respondents to purchase Memento-Maker with the cost RM10. 56.9% which is the majority of the respondents claimed that they would buy it with the said price, 4.6% claimed they would not and 38.5% are reluctant to. The frequency of rating the respondents gave to Memento-Maker regarding its worth is exhibited in Table VII.

TABLE VII: FREQUENCIES OF HOW WOULD YOU RATE MEMENTO-MAKER'S VALUE FOR MONEY

How would you rate Memento-Maker's value for money?	Counts	% of Total	Cumulative %
Not sure	20	30.8 %	30.8 %
Reasonable	30	46.2 %	76.9 %
Most reasonable	15	23.1 %	100.0 %

46.2% of the respondents rated the Memento-Maker as reasonable, while 23.1% rated it as most reasonable. The remaining 30.8% responded to it as undecided. The frequency of respondents' likelihood to recommend the product to other people is demonstrated in Table VIII.

TABLE VIII: FREQUENCIES OF HOW LIKELY ARE YOU GOING TO RECOMMEND MEMENTO-MAKER TO OTHER PEOPLE

How likely are you going to recommend Memento-Maker to other people?	Counts	% of Total	Cumulative %
Possibly	11	16.9 %	16.9 %
Probably	25	38.5 %	55.4 %
Definitely	29	44.6 %	100.0 %

44.6% which is the majority of the respondents will definitely recommend it to other people, 38.5% think they probably will and the other 16.9% they possibly will.

The mean and standard deviation of the two questions with Likert scale (1-5) are indicated in Table IX.

TABLE IX: QUESTIONNAIRES WITH LIKERT SCALE (1-5)

Questions	Mean	Standard Deviation
Q1: How would you rate Memento-Maker's value for money?	3.92	0.735
Q2: How likely are you going to recommend Memento-Maker to other people?	4.28	0.740

The mean for the first question (3.92) "How would you rate Memento-Maker's value for money?" Perpendicularly, the mean for the second question (4.28) "How likely are you going to recommend Memento-Maker to other people?"

The mean score of both questions is calculated as high, because according to Fernandes (2017) suggests the following categories for the average score: < 1.5 is categorized as very low, $1.5 \leq 2.5$ is categorized as low, $2.5 \leq 3.5$ is categorized as moderate, $3.5 \leq 4.5$ is categorized as high, and > 4.5 is categorized as very high.

Figure 2 illustrates the end product of Memento Maker, of which the materials to produce it are derived from waste materials; used plastic straws and plastic bottle caps.



Figure 2: End Product Called Memento Maker

VI. DISCUSSION

The research objective aims to examine whether Memento Maker can be produced at par with products currently available on the market by embedding the principle of circular economy (CE) for the purpose of environmental education (EE). Hence, the result of the findings has been deemed to be successful in developing Memento Maker. On the other hand, we followed the Technology Readiness Level (TRL) as a guideline to further develop our product. As of now, we have surpassed level 6, which is a system/subsystem model or prototype demonstration in a relevant environment.

Based on result of online survey, it can be agreed that the majority of respondents agree that Memento-Maker is able to help the public in maintaining environmental sustainability. It is reflected from the findings that Memento Maker is proven to be a product worth of money and is

deemed valuable to be sold as souvenirs.

On the other hand, the qualitative analysis based on the interview's transcription has successfully derived a total of three major themes; Communication/Platform Enhancement in a Cluttered Environment (CE), Specific Behavioral Measures and Advertising/Business Value (MEA) and After-Campaign Diagnostic Process.

VII. CONCLUSION

Our limitation concerns the time, as there is insufficient time to complete the entire process of producing Memento Maker. The whole process includes designing, manufacturing and testing the products may take up to months to be completed. Another limitation is to closely follow the TRL level scale allocation, and also limited financial resources. The total cost to produce the product encompasses machine rental cost (Mr. Shredder), miscellaneous expenses such as plastic bags, gloves, hand sanitizer etc.

Aside from that, the limitation also arises in terms of design. The high price of metal mould affects the variety of products generated, as these molds are frequently made of various grades of steel or aluminium. The material used for the mould will most likely be determined by the number of parts to be produced. The better and more expensive grade of steel should be used as the number of parts increases. As for now, we only have one mould which contributes to less variations of products. Thus, to create a more interesting and varied design, a high cost would be needed to develop more molds.

As a whole, we also earned credits for our product, Memento-Maker as we received positive remarks from the respondents; of which it is deemed as interesting. Responses obtained included anticipation from respondents towards our upcoming innovation.

Above all, Memento Maker is inclined towards betterment by taking into consideration the feedback from the respondents. We look forward to making improvements on a few aspects such as the design and the packaging of the end product. We also hope to gain opportunities to leverage this innovation and expand our product on a wider scale in the future.

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