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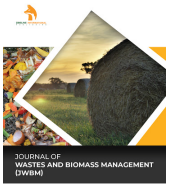

RESEARCH ARTICLE

EFFECTIVENESS OF BOARD GAME AND INFOGRAPHICS ON DELIVERING LIFE CYCLE ASSESSMENT (LCA) CONCEPTS AMONG SECONDARY SCHOOL STUDENTS

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ABSTRACT

Environmental education is important as environmental issues addressed are caused by lack of attitude, awareness and knowledge on environment. It teaches people to explore all the problems related to the environment and engage in wise ways to preserve it. The environmental knowledge needs to be disseminated among society members and Life Cycle Assessment (LCA) concept is one of the core elements. LCA helps people to understand the potential environmental impact of product consumption in daily activities. The aim of this study is to assess the effectiveness of using board game and infographic in delivering the LCA concept among lower secondary students. The students are required to take several quizzes to evaluate their understanding on LCA based on the treatment given. This study is conducted using the Solomon four-group design to achieve the research objectives; (1) identifying significant difference between pre and post-test of the two methods, and (2) identifying significant difference between the two methods itself in helping the students to learn LCA. The statistical analysis reported that there is a significant difference in levels of LCA knowledge among students before and after they were exposed to LCA ($t= 3.806$, $df= 39$, $p < .05$). However, there were no significant differences on levels of LCA knowledge between the board game and infographic method ($t= 1.593$, $df= 38$, $p > .05$). The structure of the board game and infographic provides necessary component to develop the foundation of LCA knowledge for students while they enjoy the game.

KEYWORDS

Life cycle assessment (LCA), Board game, Infographic, Solomon four-group design, Environmental education.

1. INTRODUCTION

Life Cycle Assessment (LCA) functions as an assessment tool of environmental impacts. It is a cradle-to-grave assessment used to evaluate the environmental impact of a product from its early to end stage- raw material extraction, processing of materials, manufacturing, distribution, consumption and disposal (Lewandowska, 2011). LCA assists individuals in understanding the potential environmental impacts of product usage. It is also the most important aspect for a manufacturing organization to achieve sustainable development (Said et al., 2010). Sustainable development is perceived as a proactive development idea in addressing the problems of urban demands and environmental management (Mahat and Idrus, 2016). Seeing how important the understanding of LCA is to the environment, it is unfortunately not widely accessible to people outside of organizations. This has created environmental awareness gaps among members of society.

Lay & Anuthra states that current environmental knowledge among secondary school students are low (Lay and Anuthra, 2014). Introducing students to LCA knowledge would enable sustainable lifestyle in daily consumption. A group researcehrs proved that students participating in LCA courses have greatly improve their understanding and become more familiar with ways to help improve the environmental quality of product designs (Meo et al., 2014). This study aims to deliver the understanding of LCA to the students as an environmental awareness tool.

Learning without adequate teaching aids prevents teachers from giving effective education to the students (Adam et al., 2009). There are some methods that can be used to improve students motivation to learn something especially on topics that are not very interesting, Board games is one of them (Muslabat, 2012). According to some researchers, board game is a tool that provides hands-on and heads-on skill and knowledge development for people of all ages on all subjects by providing visual metaphor to help connect information (Treher and Elizabeth, 2011). The board game learning effects can be shown in a study by Jimenez-silva, White-Taylor & Gomes on Math Board Game where the students were enjoying learning mathematics while playing the board game (Jimenez-silva et al., 2010).

Another learning method that might be of interest is infographics. Mol stated that learning by using infographics, it contributes a lot of data as a whole structure and thus presentation of complex data can be carried out in a clear and visual manner quickly (Mol, 2011). This can be supported by findings in a study where 86.4% of his respondents agreed that infographic helps them to understand better (Ozdamli et al., 2016). This is because visual graphic is a communication tool to allow easy

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understanding of lessons and is an important element of the education system.

Playing games that stresses on the importance of managing the environment can be implemented within educational settings, which in return stimulate awareness about sustainable resource planning and management among citizens who are increasingly exposed to products of the information age (Madani et al., 2017). For example, Marzuki and Sharaai [13] proved that there is interaction between utilizing card games as teaching tool and students toward knowledge on LCA (Marzuki and Sharaai, 2018). However, there are no previous studies that investigates the effectiveness both board games and infographic simultaneously and its effect on level of LCA knowledge. Moreover there are no comparison studies on the two methods. Only one paper by Cardinot & Fairfield [14] study offered a promising basis for further exploration of the integration of game-based approaches to promote active participation and interaction skill while balancing the learning objectives with play (Cardinot and Fairfield, 2019).

Hence, the research objectives of this study are:

i) To identify significant differences in LCA knowledge levels among students prior to and after introduction on LCA.
ii) To identify the significant difference between board game and infographic approaches in increasing the understanding of LCA among students.

The hypotheses formulated for this study are:

i. H_{a1}: There is a significant difference in levels of LCA knowledge among students after introduction on LCA
ii. H_{a2}: There is significant difference between board game and infographic approaches in increasing the understanding of LCA among students

2. METHODOLOGY

This study utilizes true experimental designs by using pre and post-tests within the Solomon four-group design. The Solomon four-group design is used in this experiment is to detect whether the students' understanding of LCA is affected due to the board game and infographic itself or is caused by the testing effect. This method is effective in evaluating how playing board games or infographic while learning LCA would help the students to understand what LCA is all about. This method helps to solve the errors arising from the effects of testing. It is similar to the 2 x 2 factorial design whereby two out of four groups undergo pre-test while the other two does not with two different types of treatment as portrayed in Figure 1.

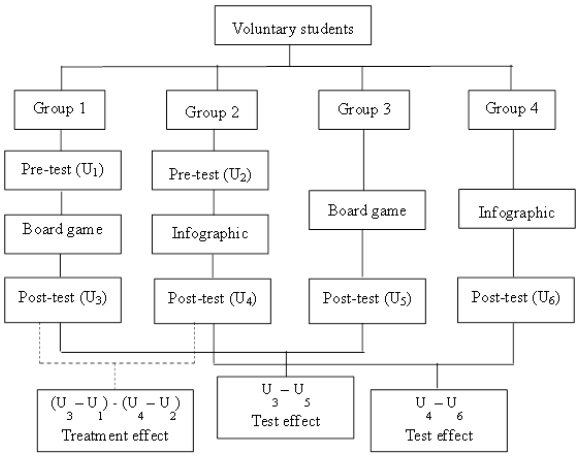

Figure 1: Solomon Four-Group Design

This study was conducted at a selected secondary school in the Negeri Sembilan state whereby its' students are respondents. The total number of voluntary respondents was 80 and divided equally into four groups. The group was divided equally using matching techniques from several criteria, namely: gender, language skills and the level of scientific knowledge.

2.1 Board Game

The board game concept was created by applying the Monopoly board game concept and renaming it as Life Cycle–Opoly. The rules and concept of this board game were also similar such as:

2.1.1 Starter Kit

Each player is given the kit with basic principles of Life Cycle Assessment. It is a helpful reference for players before buying products.

2.1.2 My Product Card

There are 16 products for the player to own on the steps of the board game and receive My Product card .The card gives description of daily used products including its process from raw material, manufacturing, distribution, usage of products to disposal cycle as well as input and output throughout the process. This helps player to learn how each of the stages in products life cycle cause impact to the environment.

2.1.3 Trespassing Card

Player also receive Trespassing card when buying a product. Trespassing card is a leverage used to ask questions to other player who trespass on owned products. Trespassing card contains facts of the products and mortgage value each product. The answers given determine how much they should pay for trespassing penalty. This card is important to test players on LCA knowledge.

2.1.4 Fun Day Card

Whenever a player reaches the Fun Day spot, he needs to answer question on a Fun Day card. This card contains some questions on general knowledge and basic concept of LCA that charges with penalty when the player fails to answer. The penalty given is light and fun between the players and no money is involved.

2.1.5 Fate and Chance Card

Player may earn or lose money according to the requirements on the Fate and Chance card given when reach its spot. The recommended number of players is four to five persons with one of them as the banker. Like Monopoly, players can buy products instead of properties through the available steps in the game. There are 16 products for the players to collect. In order to buy the products, player needs to answer questions from the banker. Any players who trespass at owned products would need to answer question from the owner. They can play until one of them goes bankrupt or they can allocate time around 30 minutes to determine the winner by calculating their products and money collected.

2.2 Infographic

An infographic consist of 16 same products used in My Product cards from the Life Cycle-Opoly board game. This information contains description of all products from cradle to grave system- raw material, manufacturing, distribution, usage of products and disposal including input and output throughout the process. This helps the students to understand the LCA concept by taking examples from products used on daily basis. To implement the role of learning through games, the students are required to take a close look at the infographic of all products within the first 10 minutes before writing them down in blanks. The one who answers the most correct is the winner.

2.3 Quiz

Quiz was the research instrument used to evaluate the levels of LCA knowledge among students before and after they played the board game and learnt through infographic. These quiz questions focused on LCA concepts, environmental impacts of each products and general knowledge on environmental issues. The quiz used is the same for both pre and post-tests to minimize errors occurring from testing on two different learning mediums. The scores from the tests are then calculated and entered into SPSS for further analysis.

2.4 Statistical Analysis

Since the number of samples in this study was not exceeding 200, Shapiro-Wilk test was used. Shapiro-Wilk test showed the normality result was not significant which is $p > .05$, thus the data was normally distributed and parametric statistic test can be used. The mean score between pre-test and post-test for board game ($U_1 – U_3$) and infographic ($U_2 – U_4$) were analysed using paired sample t-tests. This would analyse significant difference on level of LCA knowledge among students before and after LCA knowledge exposure. The calculation of mean score difference $[(U_3 – U_1) - (U_4 – U_2)]$ is analysed using independent sample t-test to identify whether there is a significant difference of LCA knowledge between board game and infographics. The score difference taken in this statistical analysis is important to calculate the treatment effect and testing effect.

3. Results and Discussion

Table 1 demonstrates the quiz score from all tests. The result of the paired sample t-test in Table 2 shows that there is significant difference in levels of LCA knowledge among students before and after they were introduced to LCA ($t= 3.81$, $df= 39$, $p < .05$). Therefore, H_{a1} is accepted. The students understand LCA concepts better after being exposed, as proven from the score increase after taking the test for the second time. The positive effect seen here is similar to results demonstrated in previous studies where students' knowledge increased after educated using alternative education tools (Cardinot and Fairfield, 2019; Hung et al., 2013).

As mentioned earlier, t-test was used to determine if the effectiveness of the two methods is greater than traditional teaching concepts to develop the understanding of LCA in lower secondary school students. The result of t-test in Table 3 indicates no significant difference on the score difference on LCA between board game and infographic method ($t= 1.59$, $df= 38$, $p > .05$). Table 4 proves further that the mean value for score difference is not far off between board game ($M=-1.55$) and infographic ($M=3.20$). Therefore, this study rejects H_{a2}.

Table 1: Quiz Score on LCA

	Group 1		Group 2		Group 3	Group 4
Respondents	U_1	U_3	U_2	U_4	U_5	U_6
1	31	36	27	33	30	13
2	19	24	23	32	33	23
3	24	20	17	18	28	34
4	24	24	26	33	25	33
5	22	22	26	34	26	34
6	21	21	24	32	27	35
7	31	30	9	23	14	24
8	19	20	21	34	18	30
9	20	18	19	28	13	22
10	21	17	19	30	11	29
11	20	19	13	22	13	28
12	32	32	25	29	24	16
13	14	18	22	33	21	21
14	18	21	10	35	25	18
15	28	32	23	27	21	21
16	25	21	30	32	25	33
17	9	10	28	30	33	29
18	26	27	25	33	18	30
19	7	11	23	30	33	25
20	25	22	20	22	27	28

Table 2: Paired Sample t-test between Pre and Post Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pre - Post Test	-3.70	6.15	.97	-5.67	-1.73	-3.81	39	.00

Table 3: Independent Samples Test between Board Game and Infographic

						95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	lower	upper
Score Difference	-1.59	38	.12	-4.75	2.98	-10.79	1.29

Table 4: Group Statistics on LCA Knowledge Score

	Group	N	Mean	Std. Deviation	Std. Error Mean
Knowledge Score	Board Game	20	-1.55	10.36	2.32
	Infographic	20	3.20	8.402	1.88

The results also demonstrate the testing effect to be almost absent, indicating that the H_{a1} approves the treatment effect on level of LCA knowledge among students. Looking back at how the games are constructed, the playing structures may have assisted in stimulating their interest and comprehension capabilities regarding life cycle concepts in product consumption. Milczynski [16] iterates in his paper that a board game is similar to playing a themed game that provides contextual information to the players and acts as a core element in the learning process (Milczynski, 2011). The Life Cycle-Opoly board game is constructed for players to familiarise themselves with life cycle concepts by owning the products and avoid losing money when answering questions Findings prove that infographics is an effective tool in teaching and improve learning outcomes for students by the help of links between concepts, processes, and daily life examples (Alshehri and Ebaid, 2016). LCA learning focuses on said elements (concepts, processes, and daily life examples), hence infographics provide the needed details and communicate it well to the students. The quiz at the end of the infographic session helps students focus more on gathering information as students are competing each other to get the most questions correct.

4. Conclusions

The study experiments the effectiveness of self-designed board game and infographic as LCA learning tool towards lower secondary school students. While the LCA input in both game-based learning methods are of the same materials, both games deliver information accordingly and its shows from the increasing mean score between pre-test and post-test. Further analysis of the effectiveness between the two methods shows that there is not much different on how efficient board game and infographic towards educating LCA on students. While the games are played differently, they share the same objective that is to provide needed information on LCA for the students to learn. The instructions embedded within the game play are able to allow the students to enjoy the game without ignoring the learning objective. The self-designed board game and infographic are introduced to educate the students to be familiar with the LCA concept and hopefully motivates and inspires them to instill sustainably thinking into their daily life.

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