ENGAGING CLIMATE CHANGE AWARENESS IN MATHEMATICS CLASSROOM: A STUDY IN SHAH ALAM

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ABSTRACT: *Global Citizenship Education (GCE), which focuses on civic learning, has received much attention from many disciplines. Engaging GCE through mathematics lessons exposes students to global issues and helps the students make connections between the problems with mathematical concepts. A mathematics lesson plan on Positive and Negative Decimals was developed by using Design and Development Research (DDR) in this study. Besides, survey instruments were distributed to measure students' awareness of GCE in the context of climate change before and after the mathematics lesson was conducted. The lesson was taught with 29 Form 1 students from a school located in Shah Alam, Selangor. Statistical Software for Social Science (SPSS) version 25 was used to run the analysis. Based on paired samples t-test, it was found that the mean scores of the students significantly differ before conducting the lesson and after conducting the lesson at the* 05 *levels of significance* $[t(28) = -5.672,\ p < .05]$. *Meanwhile, the independent samples t-test shows that mean scores do not differ based on gender after conducting the lesson at the* 05 *levels of significance* $[t(27) = -1.396,\ p > .05]$. *The findings have proven that GCE in climate change awareness can be supported through mathematics lessons. Through this approach, educators will make mathematics more attractive and relevant to the students as they find the connections between mathematics with global issues.*

Keywords: Climate change, global citizenship education, positive decimal, negative decimal, rational number

1. INTRODUCTION

The 21st-century learners require Global Citizenship Education (GCE) to provide them with the information, skills, and values necessary to confront the interwoven social, political, cultural, and worldwide concerns of the twenty-first century [1]. Some of the countries around the world have implemented a specific course on GCE. However, with the different interpretations of global citizenship education comes many tensions on how GCE should be implemented in schools [2]. As for now, there is still a lack of research on students' participation in classrooms that highlights the elements of global issues. According to a recent UNESCO report, many countries have not made GCE a mandatory part of their traditional teacher education programs [3].

To support UNESCO's efforts to spread more awareness on global issues, this study was conducted by promoting GCE engagement in mathematics lessons. The research objectives included in this study are (i) to develop a mathematics lesson plan on the topic Positive and Negative Decimals which engage climate change awareness among Form 1 students, (ii) to identify the engagement of GCE in the context of climate change awareness among the students before and after mathematics lesson on topic Positive and Negative Decimals, and (iii) to identify the engagement of GCE in the context of climate change awareness among the students based on gender after mathematics lesson on topic Positive and Negative Decimals. Next, this study sought to answer the following research questions: (i) how does mathematics lesson plan on topic Positive and Negative Decimals which engage GCE in the context of climate change awareness among Form 1 students is being developed?; (ii) is there any significant difference in the students' mean scores for the engagement of climate change awareness before and after mathematics lesson on topic Positive and Negative Decimals?; and (iii) is there any significant difference in the students' mean scores based on gender for the engagement of climate change awareness after mathematics lesson on topic Positive and Negative Decimals?

Based on the research questions (ii) and (iii), the researchers formulated the following research hypothesis:

H_{01}: There is no significant difference in the mean scores of Form 1 students on climate change awareness before and after mathematics lessons on Positive and Negative Decimals.

H_{02}: There is no significant difference in the mean scores of Form 1 students on climate change awareness after mathematics lesson on topic Positive and Negative Decimals based on gender.

2. GLOBAL CITIZENSHIP EDUCATION IN MATHEMATICS

KSSM Mathematics has emphasized developing various skills among the students through mathematics teaching, such as mathematical skills, 21st-century skills, and higher-order thinking skills (HOTS) [4]. Besides, the development of both mathematics values and universal values are also emphasized in the standard curriculum. KSSM also expected that the teaching and learning process would involve applying values-added elements, called Cross-curricular Elements (EMK), as additions to the other existing values listed in the content standard. GCE seems to echo with some features outlined in EMK, emphasizing the need to produce human capital that is aware of environmental sustainability, being patriotic, and performing good moral values. GCE can be achieved in our nation's curriculum by integrating global issues in the Mathematics curriculum. These global issues are essential to be included in the curriculum to increase the awareness to the current generation on the implications of these matters are taken lightly, exposing them to early precautions and developing their sense of responsibility.

4. POSITIVE AND NEGATIVE DECIMALS

In KSSM Mathematics Form 1, Rational Numbers includes some subtopics such as integers, fractions and decimals. Based on previous studies, the topic of decimals is a topic that students have always struggled with in rational numbers. Decimals are more complex than fractions since mastering decimal points and fractions are required for decimal lessons [5]. The decimal representation of rational numbers involves the merging of whole number knowledge and common fractions with very specific kinds of units. They can be viewed as both continuous and discrete [6].

5. METHODOLOGY

Design and Development Research model (DDR) and quantitative survey design were two research designs used in this study. The mathematics lesson plan that emphasized climate change issues in Positive and Negative Decimals was developed using the DDR model. By using the 6-phase model proposed [7], researchers identified the research problems, described the objectives, designed and developed the lesson plan, tested the lesson plan on the samples, evaluated the lesson through survey items, and lastly, communicated with the data analyzed. Meanwhile, the development of a survey instrument used to study climate change awareness in mathematics lessons before and after the lesson adopted the five steps proposed [8]. The steps included the identification of research purpose, research objectives, research questions, and research hypothesis, determination of respondents, generation of survey statements by transforming content (from theoretical framework/ literature/module) into questions or statements, statements writing, selection of measurement scale, and survey layout.

Participants

Population refers to all the individuals, objects, organizations, or events in a specific group to be generalized by the researcher in any study [9]. It is considered an abstract element due to the properties of the subjects that are not consistent and difficult to measure precisely. Hence, the sampling procedure functions to overcome this problem by selecting samples to represent the population [10]. The target population in this study was Form 1 students from a school located in Shah Alam, Selangor. Convenience sampling was employed in selecting the samples as the participants were willing and available to be studied [11]. In this study, a survey instrument was used to measure students' awareness of climate change through mathematics lessons, and indirectly will give feedback on how well the mathematics lesson plan engages the students with climate change. In order to quantify a subject's response to a particular variable, scales can be used [8]. A 5 point Likert-scales interpreted as 1=Strongly Disagree, 2=Disagree, 3=Averagely Agree, 4=Agree and 5=Strongly Agree, was used for the purpose [12].

Validity and Reliability

Validity simply means that a measure is truthful and genuine [13]. It also refers to which extent a research instrument really measures a construct being studied precisely and measures what should be measured [14, 15]. In order to validate the survey items in the aspects of face validity and content validity, researchers appointed two experts in the field of GCE and mathematics education. For the face validity, general comments and suggestions will be given by the experts based on the instrument's appearance in the aspects of formatting and style consistency, readability, its feasibility, and language clarity [16]. Meanwhile, content validity can be achieved if all the items represented in a construct are able to measure all the properties to be measured. In other words, a measurement should include all the domains in the construct we wish to study [17]. All items were accepted by the experts, with some minor amendments. Comments and suggestions from the experts were then taken into consideration to improve the instrument. Table 1 shows the finalized items after experts' validation.

Table 1: Survey items

Code	Statement
C1	Mathematics lessons make me realize the changing climate in this country.
C2	Mathematics lessons make me concerned about global climate change.
C3	Mathematics lessons make me believe that there is evidence of global climate change.
C4	Mathematics lessons teach me that global climate change will impact the environment.
C5	Mathematics lessons make me realize that global climate change will impact future generations.
C6	Mathematics lessons teach me that illegal human activities cause global climate change.
C7	Mathematics lessons teach me that climate change harms our lives.
C8	Mathematics lessons make me act environment friendly to make the world a better place for the future.

After all the items were validated, a pilot study was conducted. İt is a small-scale study administered to determine the feasibility and relevancy of the research we wish to conduct [10]. Besides, this process aims to identify any problem that might occur in research apart from assessing the validity and reliability of an instrument [18]. Through the pilot study, construct validity was determined using Exploratory Factor Analysis (EFA), and Cronbach's Alpha was used to measure the instrument's reliability. The sample size in a pilot study is recommended to be kept as small as lesser than 100 respondents [19]. A total of 50 Form 1 students from a school in Perak took part in the pilot study. It was found that all the items were accepted with factor loadings

ranging from .794 to .916, exceeding the suggested minimum value of ± 0.30 [20]. The factor loading of each item produced by the rotated component matrix in EFA is shown in Table 2.

Table 2: Rotated component matrix

Items	Climate Change Awareness
	Factor loadings
C7	.916
C3	.912
C4	.903
C8	.893
C6	.873
C5	.847
C1	.804
C2	.794

Based on the results, there was no issue about the convergent validity of the pilot test' construct. Next, the data were also used to measure the instrument's reliability. The reliability of an instrument refers to its consistency in measuring what we intend to measure [21]. Cronbach's alpha coefficient was used, and the least Cronbach's Alpha value for the item to be accepted is 0.60 [22]. An accepted value of Cronbach's alpha was recorded ($\alpha = .904$).

All the eight items developed were retained and can be further used in the actual study.

6. RESULTS

A total of 29 students were involved in this study, 21 of them were females, and 8 were males. Table 3 shows the distribution of the students based on gender.

Table 3: Frequency table of Form 1 students

		Male	Female	Total
Gender	Frequency	8	21	29
	Percent	27.6	72.4	100.0
	Valid Percent	27.6	72.4	100.0
	Cumulative Percent	27.6	100.0	

The paired samples t-test was run in SPSS to determine any significant difference in the mean scores before and after the lesson. Results of the paired samples t-test showed that the mean scores of 29 students who participated in this study differed before conducting the lesson ($M = 3.832,\ SD = .614$) and after conducting the lesson ($M = 4.284,\ SD = .613$) at the .05 level of significance ($t = -5.672,\ df = 28,\ N = 29,\ p < .05, 95\%\ CI$ for mean difference $-.616$ to $-.289$, $r = .75$). On average, the score was about .453 points higher after conducting the lesson than before the lesson. Meanwhile, we found that there was not enough evidence to prove H_{01}. And hence, the null hypothesis of H_{01} was rejected (Results shown in Table 4, Table 5, and Table 6). This finding indirectly showed that lack of climate change awareness was emphasized in previous mathematics lessons. Mathematics can be made more relevant to students when connected to real-life contexts created [23]. For example, in previous research [23], engaging environmental issues in mathematics classrooms resulted in statistically significant mathematics scores.

Table 4: Paired samples statistics of pre-lesson and post-lesson

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre	3.832	29	.614	.114
	Post	4.284	29	.613	.114

Table 5: Paired samples correlation

Paired Samples Correlation				
		N	Correlation	Sig
Pair 1	Pre & Post	29	.755	.000

Table 6: Paired samples test

Paired Differences							df	Sig. (2 −tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pre − Post	−.453	−.430	−.080	−.616	−.289	−5.672	28	.000

In addition, independent samples t-test was run in SPSS to determine whether there is any significant difference in the mean scores based on gender after conducting the lesson. Results of Levene's Test for Equality of Variances show a non-significant value of $p = .964$. It is suggested that for Levene's test with a significance value greater than .05, we can conclude that the assumption of equal variance was not violated (equal variances is assumed) [12]. The results of this independent samples t-test also showed that mean scores did not differ for both males ($M = 4.031,\ SD = .604$) and females ($M = 4.381,\ SD = .603$) after conducting the lesson at the .05 level of significance ($t = -1.396,\ df = 27,\ N = 29,\ p > .05, 95\%\ CI$ for mean difference $-.864$ to -.164. On average, females' score was about .350 points higher after conducting the lesson. Meanwhile, we found enough evidence to prove H_{02}, and hence, we failed to reject

the null hypothesis of H_{02} (Results shown in Table 7 and Table 8). The finding in this study contradicted previous findings [24]. The findings found that females expressed slightly more significant concern about climate change than males [24]. However, let's look at the average scores from this study. We agree that females' score was about .350 points higher after conducting the lesson, showing their awareness about climate change was also much higher than males.

Table 7: Mean scores based on gender after conducting the lesson

Paired Samples Statistics					
	Gender	N	Mean	Std. Deviation	Std. Error Mean
Post	Male	8	4.031	.604	.214
	Female	21	4.381	.603	.132

Table 8. Independent samples t-test results for scores based on gender after the lesson

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig		df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Post	Equal variances assumed	.002	.964	−1.396	27	.174	−.350	.251	−.864	.164
	Equal variances not assumed			−1.394	12.677	.187	−.350	.251	−.893	.194

7. CONCLUSION

DDR is one of the most suitable models a teacher can refer to in planning and developing a lesson plan. Based on the study conducted, it showed a significant difference in the mean scores of Form 1 students for the engagement of climate change awareness before and after mathematics lesson on the topic Positive and Negative Decimals. The outcomes gave a clear overview to the teachers that students get exposed to climate change awareness through the conducted lesson. The findings also proved that there was no significant difference in the mean scores of Form 1 students based on gender for the engagement of climate change awareness after mathematics lessons on the topic Positive and Negative Decimals. We can conclude that this study could engage students with GCE in the context of climate change awareness through mathematics lessons.

The study recommends including a larger scale of samples to be included in the analysis. Besides, the ratio of males to females involved in this study can also be stratified equally. Meanwhile, mathematics teachers may find the outcomes from this research beneficial as they can use global citizenship education in climate change awareness to improve their teaching methods. In addition to that, the Ministry of Education also should consider the implementation of global citizenship education in the current mathematics classrooms, supporting UNESCO efforts to improve the quality of education worldwide while still engaging students with global issues happening every day. Next, the lesson can also be enhanced and used to test whether students understand mathematics concepts better by merging climate change awareness with the lesson. It is hoped that the students, teachers and education management will find this approach beneficial for them.

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