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Non-digital card game and year 8 students' performance in integers

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ABSTRACT

Understanding integers is fundamental in enhancing students' performance in other mathematical concepts. However, the majority of year 8 students in the government schools in Brunei Darussalam have inadequate understanding leading to unsatisfactory performance in the operations of integers. Despite this challenge, there has not been any systematic empirical attempt to provide an intervention to enhance students' performance. In this action research study, we provided a non-digital card game intervention to assess its efficacy in improving the performance of year 8 students in the operations of integers. A total of 39 students were purposively selected. Data were collected through pre-test and post-test and analyzed with the Wilcoxon-signed rank test and the paired sample t-test. By comparing pre-test and post-test scores, the non-digital card game intervention significantly improved the performance of students in the operations of integers. Approximately 18.8% of students' performance was accounted for by the non-digital card game intervention provided. This study concluded that a non-digital card game can be a helpful tool in teaching and learning of the operations of integers.

Keywords: non-digital card game, integers, mathematics performance, Intego, Uno

INTRODUCTION

Mathematics is essential for developing critical thinking and reasoning skills that are necessary for everyday life. It is useful in shopping, cooking, finance management, architecture, and enhances positive attitudes and emotions (Balmaceda, 2020; Kollosche, 2017; López-López et al., 2021). One aspect of mathematics that is fundamental to other mathematical concepts is integers (Badarudin & Khalid, 2008; Sahat et al., 2019). Topics such as inequalities, linear and quadratic equations, and algebra require adequate knowledge in integers. These topics, amongst others, require that the operational signs attached to integers are changed when such integers move to the other side of an equation. Therefore, students may struggle to solve questions that require the calculation of integers if they are still uncertain about the concept behind the sign rules of integers.

To enhance the understanding of students of mathematical concepts including integers, teachers are encouraged to use student-centered learning. Teaching and learning mathematics require students' involvement through the use of concrete materials. This is in line with contemporary pedagogy, where student-centered approaches are encouraged in mathematics-related disciplines. Student-centered approaches have been associated with high students' participation and achievement, and teachers are encouraged to use such approaches (Al-Balushi et al., 2020). This shift in pedagogy has been recognized in Bruneian mathematics classrooms when the National Education System for the 21st century was introduced in 2008. Secondary school mathematics teachers are encouraged to use student-centered teaching to improve students' engagement and motivation (Sulaiman & Shahrill, 2015).

Existing studies have established that technology and games improve students' achievement and participation in mathematical concepts (Bunch et al., 2014; Kobayashi, 2021; Ku et al., 2014; Meister, 2018; Moyer-Packenham et al., 2018; Schmid et al., 2021; Shiue & Hsu, 2017; Umboh et al., 2021). These mathematical concepts include calculus, angles and triangles, algebraic expressions, and integers. However, previous attempts focusing on mathematical games to improve students' understanding and performance of integers have used digital compared to non-digital games (Bunch et al., 2014; Kellems et al., 2020; Kobayashi, 2021; Umboh et al., 2021). This study argues for the use of non-digital games for the following reasons. First, the use of digital games in instructional activities that involve mathematical concepts can be expensive. Second, digital games may not be reliable when there are challenges in infrastructure such as mobile phones, and computers. Lastly, students who may not afford digital equipment may not benefit from teaching and learning.

While we emphasize the use of non-digital games in teaching and learning of integers, previous attempts have not focused on Bruneian secondary schools. This study context demands a research focus because students lack the conceptual understanding

of integers, resulting in incorrect responses to related mathematics questions that involved integers (Badarudin & Khalid, 2008). Approximately 50% of year 8 students in Brunei did not pass a pre-test on mathematical calculations on integers (Sahat et al., 2018). Evidence also suggests that mathematical concepts such as integers are taught following rigid algorithms that were not effective in improving students' understanding and performance (Goh et al., 2017; Sahat et al., 2018). The use of algorithms encourages procedural skills where formulas are applied compared to teaching to improve conceptual understanding. This makes students follow what is taught and are unable to explain the process of getting their answers (Hamid et al., 2013; Sarwadi & Shahrill, 2014). Despite the difficulties of students with integers in Brunei, attempts to provide interventions to address their difficulties are not widespread. In this study, we provided an intervention using a non-digital card game to check its efficacy in enhancing year 8 students' performance in integers. This study is guided by following the hypotheses:

1. *H_0: Year 8 students' performance will not differ significantly before and after a non-digital card game lesson intervention.*
2. *H_1: Year 8 students' performance will differ significantly before and after a non-digital card game lesson intervention.*

LITERATURE REVIEW

Many secondary school students are attached to their primary school arithmetic schemas which makes them unable to manipulate calculations that involve negative integers (Makonye & Fakude, 2016). This is because they learn to count or do operations where only positive numbers are involved before they are introduced to negative integers. In this instance, the majority of the students become confused, particularly, those with lower abilities. For example, many students find it challenging to acknowledge that (-a)×(-b)=ab. This confusion may occur for two reasons. First, the lack of understanding of the rules of integers. Second, due to the wrong interpretation of the negative sign. The negative sign can be an operational sign or the nature of the integer itself, which often confuses students (Badarudin & Khalid, 2008; Fuadiah et al., 2016; Khalid & Embong, 2019). For example, most students solve 8-(-6)=2 because they fail to recognize that the negative sign after *8* is operational, while the one attached to *6* makes it an integer. Another example is when they are asked to arrange integers in ascending or descending order. The majority of them think that, -6, for instance, is bigger than -5. These and other factors that are beyond the scope of this study contributes to students' difficulties to manipulate mathematical tasks that involve integers (Rubin et al., 2014). Interestingly, mathematical games can contribute to addressing students' difficulties.

Game-based learning has been widely used by teachers in teaching different subjects. It uses a combination of game activities and instructional content. Studies have shown that game-based learning stimulates students' interest in learning, improves participation, confidence, critical thinking, and performance (Bayeck, 2020; Ku et al. 2014; Okpude & Anugwo, 2016; Qian & Clark, 2016; Shiue & Hsu, 2017). Given this emphasis, this study used a non-digital flash card game modified from the Uno card game. The Uno card game has been a well-known game that was developed in the US by Merle Robbins in 1971. The game begins by taking a card from the draw pile and then placing it facing up in the discard pile. For example, if the card on the discard pile is green 7, the first player must put down a green card or any color 7. The players have to eliminate the cards by matching colors, numbers, or action cards. Otherwise, they will end their turn by taking a card from the pile (Ramadhan et al., 2015).

Flash card games in the teaching and learning of mathematics-related subjects based on Uno are associated with and interactive teaching, which improves students' performance (Hikmah, 2017; Rajashekar & Bellad, 2016). Therefore, establishing the efficacy of non-digital car game in improving the performance of students in the operations of integers is timely. The following are a summary of the Uno action cards based on Demaine et al. (2014):

1. The *'Draw Two Card'* is used in matching colors and played on other Draw Two Cards. When it is played, the next person is responsible for drawing two cards.
2. The 'Reverse Card' is used to show the direction of the game. Also played on a matching color or on another reversed card, if turned upside down, the game begins with the dealer moving from the right.
3. The '*Skip Card'* is also played with another skip card or a matching color. By turning the skipped card up at the beginning of the game, it means that the player on the left will be skipped so that the other player on his/her left will commence the play.
4. The function of the '*Wild Card'* allows its player to call for any person to continue the game. This card can be played at any time and by turning it up, the person at the left of the dealer chooses the color to continue the game.
5. If the *'Wild Draw Four Card'* is turned up before the commencement of the play, it is returned to the deck paving the way for another card to be picked. This card is the best card a player can have because he/she chooses the next color to continue the play.

METHODS

Study Design

This was an action research study that sought to provide an intervention to improve practice (Cohen et al., 2007). Action research can be conducted to develop new pedagogical methods to replace traditional teaching methods to improve the quality of teaching and learning (O'Connor et al., 2006). This study adopted the action research approach because we sought to develop a new way of teaching the operations of integers. This was done by investigating the efficacy of a non-digital card game to address

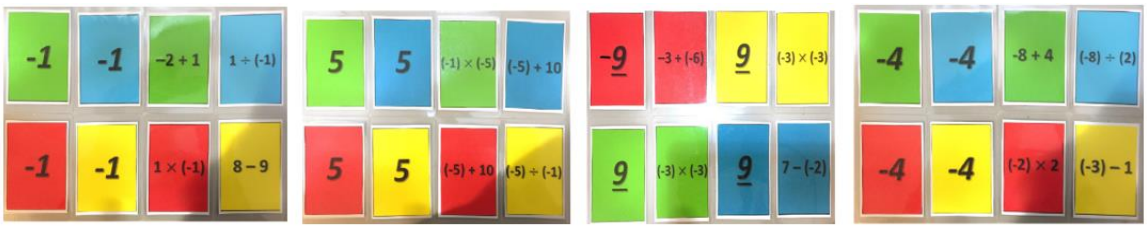

Figure 1. Sample of negative, positive, and mixed integer "*Intego*" cards

students' learning gaps in operations of integers. Our action commenced from a non-digital card game lesson planning, lesson intervention, and assessment of the lesson intervention.

Study Participants

We purposely sampled a total of 39 year 8 students from one of the secondary schools in Brunei Darussalam. Of the 39 students, 19 were from Class A, while 20 were from Class B. They were already existing and intact classes involving students with mixed abilities whose ages ranged from 12 to 14 years. Year 8 students were used because integers are taught at that grade level. They needed to acquire the necessary understanding in integers to prepare them for advanced learning in mathematics. The card game intervention was provided in both classes.

Data Collection Instrument

Achievement tests on the operations of integers were designed to collect pre-test and post-test scores. The tests were designed based on the objectives of the lesson. A table of test specifications was also developed, which improved the representativeness of the content of the items in the tests (Asamoah et al., 2019). Pre-test and post-test consisted of ten multiple choice and five constructed response questions with a total of 15 marks. The questions focused on addition, subtraction, multiplication, and division of integers. They also covered the arrangement of integers from ascending to descending, or vice versa. An alternative form of the pre-test was developed to collect the post-test scores. This was done to ensure that both tests had a similar difficulty.

Pre-Lesson Intervention

Before the non-digital card game lesson intervention, a recap on the operations of integers was provided to both classes on the same day since they had earlier been taught integers. The recap lasted 45 minutes in each class. After this, the pre-test was conducted for both classes simultaneously. The same pre-test was conducted on the same day using the combined class. The time allocated for the pre-test was 30 minutes. The use of calculators was not allowed.

Lesson Intervention

One week after the pre-test, a 45-minute card game lesson was designed for both classes. The lesson was designed using a card game: *'Intego',* which is a combination of Uno and integers. Uno was not used directly because it does not include integers. For this reason, integers were incorporated into Uno and called '*Intego.*' All four operations of integers were included on the Uno cards. The rules of the game for "Intego" were modified from the Uno game rules, but the card '0' and the power card '+2' were not included. The objectives of the card game lesson were first, to improve the students' understanding in performing the four operations of integers, second, to improve their calculation skills, and third, to practice the sign rules.

Before implementation, students were introduced to the card game and the rules. The students in each class were randomly divided into four groups (with 4 to 6 members in each group). Each group was given a deck of cards to play in 30 to 45 minutes. In the game, each player was given seven cards and was supposed to take a turn to play one card or more as long as it was equivalent. That is, an integer card equivalent to a question card or the same color of the same integers. Students were supposed to withdraw four cards if a power card '+4' was played. The '+4' card could only be played once. In the game, the first player must call out *"Intego"* and eliminate all the cards, otherwise, he/she draws two cards. Students were not allowed to use calculators. **Figure 1** present samples of the "*Intego*" cards based on negative, positive, and mixed integers.

Data Collection

Data were collected through pre-test and post-test. We conducted the pre-test and scored to obtain the pre-test scores. Six days after the non-digital card game lesson intervention, the post-test was conducted to both classes simultaneously which lasted for 30 minutes. The same post-test was conducted for the combined class and was scored.

Ethical Considerations

Ethical clearance was obtained from the Ethics Committee of the Sultan Hassanal Bolkiah Institute of Education, Universiti Brunei Darussalam. This was done by completing an ethics form, which detailed how ethical issues such as voluntary participation, anonymity, confidentiality, and participants' protection were addressed. Permission was also sought from the head of school and parents for this study to be conducted in the indicated school, and to use their wards as the research participants respectively. The participants signed a consent form to confirm their participation in this study. Their identity and the information they provided were kept anonymous and confidential.

Table 1. Descriptive statistics of the pre-test for Classes A, B, & combined class

	N	Mean	SD	Minimum	Maximum
Class A	19	10.632	2.113	8	14
Class B	20	8.400	2.137	3	12
Combined class	39	9.487	2.382	3	14

Note. N: Number of participants; SD: Standard deviation

Table 2. Wilcoxon signed-rank test of pre-test and post-test for Class A

	Pre-test		Post-test			
	Median	IQR	Median	IQR	Z	p-value*
Class A	10.00	3.00	12.00	2.50	-0.0997	0.014

Note. IQR: Inter-quartile range; Effect size (d)=0.023; Mean difference=2.00

Table 3. Paired sample t-test of pre-test and post-test for Class B

	Pre-test		Post-test					
	Mean	SD	Mean	SD	MD(95% CI)	t-stats	df	p-value
Class B	8.400	2.137	9.550	2.151	1.15(1.1398, 1.1602)	2.095	19	0.0498

Note. MD: Mean difference; df: Degree of freedom

Table 4. Paired sample t-test of pre-test and post-test for combined class

	Pre-test		Post-test					
	Mean	SD	Mean	SD	MD(95% CI)	t-stats	df	p-value
Combined class	9.487	2.383	10.641	2.311	1.15(1.1309, 1.1768)	3.437	38	0.0014

Note. MD: Mean difference; df: Degree of freedom

Data Analysis

Pre-test and post-test scores were subjected to statistical analysis in R Studio. Pre-test scores for Class A met the normality requirement, but post-test scores violated the normality requirement (pre-test, p=0.056, and post-test, p=0.0399). Pre-test and post-test scores for Class B, and the combined class observed a normal distribution (pre-test, p=0.967, post-test, p=0.154) and (pre-test, p=0.52, post-test, p=0.57), respectively. Following the normality statistics, the Wilcoxon-signed rank test and the paired sample t-test were used to analyze the data. The research hypothesis was tested at 0.05 alpha level.

FINDINGS

We tested the research hypothesis (H_1) that '*The performance of year 8 students will differ significantly before and after the non-digital card game lesson intervention.'* In our analysis, we first compare the pre-test scores for both classes and the combined class to analyse the entry performance of the participants. We proceed to compare the pre-test and post-test scores for each class, and the combined class.

The pre-test scores are presented in **Table 1**. From **Table 1**, Class A obtained a relatively higher mean (mean=10.632, SD=2.113) compared to Class B (mean=8.400, SD=2.137). Participants in Class A performed slightly better than their counterparts in Class B. Further analysis confirmed that participants in Class A differed significantly in their pre-test scores from their counterparts in Class B (p=0.008<0.05). When the classes were combined, the mean and SD were 9.487 and 2.382, respectively.

Pre-test and post-test scores for Class A are presented in **Table 2**. The results in **Table 2** show a statistically significant difference in pre-test scores (median=10.00, IQR=3.00) and post-test scores (median=12.00, IQR=2.50), with [p=0.014<0.05 and z=-0.0997]. The participants in Class A relatively improved their performance in the operations of integers with a significant median difference of 2.00. Despite the significant difference between pre-test and post-test scores, the effect of the card game lesson intervention is small (d=0.023 based on Cohen, 1992).

Class B pre-test and post-test scores are presented in **Table 3**. Results in **Table 3** show that there is a statistically significant mean difference between pre-test (mean=8.400, SD=2.137) and post-test scores (mean=9.550, SD=2.151), with [t(19)=2.095, p=0.0498]. Students' performance in integers improved after the non-digital card game lesson intervention, with a significant mean difference of 1.15 and small effect size (d=0.1876).

Pre-test and post-test scores for the combined class is presented **Table 4**. From **Table 4**, the combined class performed relatively well on the operations of integers after the non-digital card game lesson intervention. There is a statistically significant mean difference between the pre-test (mean=9.487, SD=2.383) and post-test scores (mean=10.641, SD=2.311), with [t(38)=2.095, p=0.0014]. The significant mean difference is 1.15, with a relatively small effect size (d=0.1876).

The summary of the descriptive statistics of pre-test and post-test scores for Class A, Class B, and the combined class is presented in **Table 5**. Comparing the pre-test and post-test scores, it is observed that pre-test scores for Class A (mean=10.632 or median=10.00), Class B (mean=8.400) and the combined class (mean=10.641) significantly differed from the post-test scores for Class A (mean=11.789 or median=12.00), Class B (8.950) and the combined class (mean=10.641). This confirms that the participants improved their performance in the operations of integers after the non-digital card game lesson intervention at all levels. The

Table 5. Descriptive statistics on pre-test and post-test scores of all class levels

	N	Minimum		Maximum		Mean/median		SD/IQR	
		Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
Class A	19	8	8	14	15	10.632	11.789	3.00	2.500
Class B	20	3	6	12	13	8.400	8.950	2.137	2.114
Combined	39	3	6	14	15	9.487	10.641	2.383	2.311

hypothesis that "*year 8 students' performance will not significantly differ before and after a non-digital card game lesson intervention"* is rejected. Based on the results of this study, the non-digital card game lesson intervention is effective in improving the performance of year 8 students in the operations of integers. Approximately 18.8% of students' performance was accounted for by the non-digital card game intervention provided.

DISCUSSION

The results provide some evidence that non-digital card game is effective in improving students' performance in the operations of integers. Although the effect of the card game intervention is small, the results shed light on the efficacy of the card game intervention as students in all the classes performed relatively well. We acknowledge that the performance of the students varied in our attempt to trace their consistent performance through separate and combined classes. However, they significantly improved their performance at all levels.

The results do not only add to the literature by providing empirical evidence on the efficacy of a non-digital card game in improving students' performance in the operations of integers, but also acknowledge the relevance of using games to improve students' understanding of mathematical concepts (Kobayashi, 2021; Moyer-Packenham et al., 2018; Schmid et al., 2021; Umboh et al., 2021).

We believe that the slight increase in the performance of the students might have resulted from the kind of cooperation, motivation, and group activities that encouraged student-centered learning. It was observed that at all levels students exhibited these traits as they played the game. This is what characterizes the use of games in mathematics lessons (Sulaiman & Shahrill, 2015; Sulaiman et al., 2020). Students did not follow rigid algorithms that may have occurred in a traditional pedagogical style of teaching integers (Hamid et al., 2013; Sarwadi & Shahrill, 2014). In contrast, the game allowed them to think critically and discovered how to treat the sign roles in the operations of integers.

The expectation from the observation is that the participants should improve their conceptual and procedural understanding. This might have contributed to the observed improvement in their performance (Rubin et al., 2014; Sahat et al., 2018). The results of this study agree with previous studies on the effectiveness of games in improving students' performance in mathematical lessons (Bayeck, 2020; Kobayashi, 2021; Okpube & Anugwo, 2016; Shiue & Hsu, 2017) and the efficacy of flash cards in improving students' performance in the operations of integers (Hikmah, 2017; Rajashekar & Bellad, 2016).

CONCLUSION

This study aimed at investigating the efficacy of a non-digital card game in improving year 8 students' performance in the operations of integers. After providing a non-digital card game lesson intervention based on *"Intego",* we found that the students performed relatively well in their post-test scores in comparison with their pre-test scores. Although the non-digital card game lesson intervention we provided had a relatively small effect on students' performance in the operations of integers, the effect was significant, suggesting that the non-digital card game significantly improved students' performance. The results of this study imply that the non-digital card game can be a helpful tool in the teaching and learning of integers. Aside from using this game as an interventional strategy, it can also serve as a teaching and learning aid. Effective use of the non-digital card game encourages concrete mathematics instruction that can contribute to the development of critical thinking and problem-solving skills among students. It generally encourages student-centered learning in mathematics instruction.

Although this study draws this important conclusion, we acknowledge that it came with limitations. First, we used a relatively small sample size due to the nature of the non-digital card game lesson. We needed a sizable number of students that we could control to improve our lesson intervention. Secondly, action research comes with personal biases and subjectivity. To control these limitations, we traced students' performance from varied groups to minimize the biases that may have resulted in our conclusion on the efficacy of our lesson intervention. Experienced mathematics teachers, other than the first author, also scored both the pre-test and post-test to minimize biases.

Despite these limitations, the significant impact of our intervention is promising in contributing to the efficacy of non-digital card games in teaching and learning of integers. It also serves as an empirical intervention from the Bruneian context. Based on our results, mathematics teachers are encouraged to cultivate the habit of developing and using non-digital card games in teaching and learning of the operations of integers. In addition, future researchers may consider replicating this study to validate our results. This can be done by using larger samples, and through mixed-methods approaches.

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improvements on the manuscript. All authors commented and edited subsequent versions of the manuscript and agreed with the results and conclusions.

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