Mnemonics and Gaming: Scaffolding Learning of Integers

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Date Received: November 14, 2014; Date Revised: December 16, 2014

Abstract *–Published literature and classroom experience agree that students have difficulty understanding the basic concepts and principles of integers. This learning difficulty is attributed to students' memory deficits and negative attitudes towards mathematics and teachers' poor instructional methods. An integer operation card game combining gameplay and mnemonics was developed to address this issue. The card game was tested for teaching effectiveness in an experiment involving two groups of Grade 7 students. Results revealed that the experimental group outperformed the control group in operating integers, and the difference between performances was statistically significant. It was concluded that the developed card game and mnemonics effectively facilitated students' learning of integer operations.*

Keywords – *integers, game, mnemonic devices, mathematics, learning and teaching.*

INTRODUCTION

Low achievement is a significant problem in mathematics education. It has been an ongoing cause for concern and a major factor in mathematics education reform. In the Philippines, Lapid (2007) stated that in the field of mathematics, high school seniors' ability to manipulate numbers and equations (e.g. algebra) is weak. Problem solving using mathematical concepts and established logic and equations is poor. Furthermore, Cruz (2008) cited the report of Science, Mathematics and Education Panel of Congressional Commission on Science, Technology, and Engineering (COMSTE) that the competitiveness of the Philippines has slid down from 47 in 2001 to 77 in 2007 out of 117 countries that were evaluated. This was due to the poor quality of the country's basic education, which has been described by critics as being in a worrisome condition. Over the years performance levels of students in international assessment tests have indicated unsatisfactory competencies in mathematics and science (Ogena, Laña, & Sasota, 2010).

One possible cause of underachievement in mathematics is the student's negative attitude towards the subject, math anxiety or fear of math. This attitude is attributed to the psychological nature of students and typically to the pedagogical practices of schools. Emenaloa (1984) cited that among the root causes of mathematics phobia in Nigerian schools are lack of effective teaching aids, a shortage of qualified math teachers, lack of adequate in-service training programs and proper incentives for math teachers, and an inherent fear of mathematics. Wong (1999) stated that an over-dependence of the chalk-and-talk method has resulted in unsatisfactory performance in and poor attitude towards school mathematics for many students. Math anxiety may have something to do with the classroom experience. Sousa (2001) said that some children develop a fear of mathematics (or math phobia) because of negative experiences in their previous schooling or a simple lack of self-confidence in dealing with numbers. Yara (2009) mentioned that students' outlook can be directly influenced by the teachers' outlook and teaching approaches.

The negative attitude towards mathematics is also a product of students' inadequate knowledge and skills in basic mathematics. Sousa (2001) recognized that students need to have mastered a certain number of skills before they can understand and apply the principles of more complex mathematical operations. Donoghue (1996) believed that the ability to deal with mathematical problems can easily be performed through mastery of the basic concepts of mathematics. According to Maslow's (1954) Hierarchy of Needs, the lower need in the hierarchy must be satisfied first before trying to satisfy the higher level needs. In learning mathematics, it implies that everything should start from the basic before going to the most complex problems. It is also believed that if a student fell behind,

P-ISSN 2362-8022 | E-ISSN 2362-8030| www.apjeas.apjmr.com

he was unable to catch up because of the sequential nature of mathematics.

But how can a student proceed if he has difficulty in dealing with signed numbers? Gallardo and Hernandez (2002) cited that since the nineteen seventies, several research results have shown that students exhibited extreme difficulties associated with conceptualizing and operating with negative numbers in the pre-algebraic and algebraic scope. Furthermore, Reid (undated) enumerated the four of the more confusing operations: (1) adding two negative numbers; (2) adding a positive integer and a negative integer; (3) subtracting a negative integer from a negative integer; and (4) subtracting a negative integer from a positive integer. These difficulties were also observed by the researchers in their own classrooms.

Children experiencing these difficulties are suspected of possessing certain types of mathematical disorders. Students with mathematical disorders have difficulties solving simple and complex arithmetic problems. Their difficulties stem mainly from deficits in both numerical procedures and working memory. Students with memory disorders have difficulty recalling number facts, have a high error rate when they do retrieve arithmetic facts, and retrieve incorrect facts that are associated with correct facts (Sousa, 2001).

Using mnemonics is a potential approach to address problems related to students' poor retention. Higbee (2001) defines mnemonics as memory aids that assist one in remembering specific information by using a process, strategy, or technique that enables a person to improve memory. There are research reports showing the effectiveness of using mnemonic aids in teaching. To name a few, Scruggs and Mastropieri (1999) conducted a research on mnemonic instruction with world history classes where the analysis of strategy use data revealed that students employed appropriate strategies, and observational data confirmed that student time on task was higher in the mnemonic condition. Survey data revealed general overall satisfaction with mnemonic strategies on the part of teachers and students. They further claimed that mnemonic methods may also be helpful for computation and recommended to teachers the development and use of letter strategies to help students remember lists of information. Also, Delashmutt (2007) discovered that mnemonics worked for some of her students and had become a useful tool in her classroom.

The use of mnemonics,particularly letter strategies, in learning has underlying psychological principles. Primacy Effect theorizes that given a list of information to remember, the human brain will tend to remember the first few data more than those data in the middle. People will also tend to assume that items at the beginning of the list are of greater importance or significance (ChangingMinds.org, undated). Examples of mnemonics used in teaching mathematics are PEMDAS, SOHCAHTOA, and FOIL. PEMDAS reminds the students about the order of mathematical operations, SOHCAHTOA enables the students to recall the trigonometric identities, and FOIL helps the students in performing the steps in multiplying two binomials.

Constructivist teaching approaches highlight that it is imperative for the teachers to actively engage learners in creating their knowledge instead of making them passive recipients of information (Jonassen, 1999). To achieve this the role of involving learners in meaningful and enjoyable learning activities is also deemed as vital (Land & Hannafin, 2000). Educational games have social and cognitive purposes and are not designed solely to amuse, but any game may contribute to learning (Ornstein, 1990). Playing games in the classroom is an approach that the teacher can use to provide a source of strong motivation for student engagement in learning and to encourage students' social, emotional and cognitive development (Niecikowski, undated; Kamii & DeVries, 1980). The benefits of transforming classroom activities of ostensibly difficult or tedious subjects into opportunities for learning through playing cannot be underestimated. In fact the use of card games was proven to enrich science teaching (Perlota, Reyes, Rivera, Sato, Solis, & Vega, 2008).

The literature review dealt on problems with mathematics achievement, math anxiety, mathematical disorders, and solutions to address them, such as mastery of basic skills, introduction of mnemonics, and the use of games in instruction. This study combines the potentials of mnemonics and games in improving effectiveness for teaching operation of integers. This leads to the invention of integer operation (INTOP) card game incorporating some novel first-letter mnemonics.

This study tested the effectiveness of mnemonics and INTOP as teaching supports for students learning integer operations. More specifically, the study determined the performance of student-subjects in operating integers before and after undergoing traditional instruction for control group and mnemonic instruction and playing INTOP for experimental group. Testing for effectiveness, the study determined if there were significant differences in the individual performances of the control group as well as the experimental group between pretest and posttest.

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MATERIALS AND METHODS

This study determined the effect of mnemonic instruction and playing INTOP on students' performance in operating integers by comparing it with the performance of students under traditional direct instruction method.

Using the Cabitan National High School (located at Cabitan, Mandaon, Masbate, Philippines) Grade 7 students (SY 2010-2011) as subjects, a study was conducted employing the pretest-posttest, two-groups-two-observations research design, where two groups of 23 students were treated as control and experimental groups. The grouping was done based on ranking of the students' previous grades in mathematics, such that the top rank is paired with the bottom rank, second from the top with second from the bottom, and so on. Each pair is distributed alternately to the two groups.

The control group underwent three-session direct instruction and deductive methods of teaching operations of integers, while the experimental group was exposed to three-session mnemonic instruction and playing INTOP.

Mnemonic devices LAUS and LPUN are used to help students retrieve the rules of integer operations from memory. The letter strategy LAUS helps the student remember that "if two integers have like (L) signs, add (A) their absolute values" and "if two integers have unlike (U) signs, subtract (S) their absolute values." It has extension mnemonics "LACS" which tells about the sign of the result when the two numbers have a common sign, "US SONGAV" (Unlike signs, Subtract; use the Sign Of the Number with Greater Absolute Value) which gives a hint for affixing the sign to the result if two numbers have dissimilar signs. The letter strategy LPUN helps students recall the rule in multiplying and dividing integers that "when two integers have like (L) signs, their product or quotient is positive (P); unlike (U) signs, negative (N)." Another mnemonic device used is CTSOTS which aids students to remember the procedure in subtraction, in which it is advised to "Change the Sign of the Subtrahend" first before performing addition.

These mnemonic devices are used in INTOP. This card game was developed to supplement teaching of integers. It is composed of two sets of cards – integer cards and operation cards. Integer cards contain signed numbers ranging from -10 to 10, each with varying number of copies or distributions. Each operation card contains any of the four fundamental operation symbols. It can be played by at most 4 players in a way similar to playing ordinary card games. The details of the card game will not be discussed in this paper.

RESULTS AND DISCUSSION

Two types of analyses were used in this study. First, the performances of the experimental and control groups were evaluated by computing the mean percentage of their scores in pretest and posttest. Relatively high mean percentage score (MPS) means better performance in a test over another test. Second, the difference between the performances of the two groups was tested for significance. Using *t*-test the means of scores in pretest and posttest and the means of scores in posttest of both groups were analyzed for significant differences.

Table 1. The two groups' mean percentage scores in pretest and posttest

Group	Mean Percentage Score (MPS)	
	Pretest	**Posttest**
Control	43.70	49.80
Experimental	46.10	56.75

Note: Values are computed by dividing the total number of scores in the test by the number of takers, and the quotient is divided by 20 which is the highest possible score.

Table 1 presents the performances of the two groups in pretest and posttest. One can note an increase in MPS of posttest over pretest for both groups.However, the increase in MPS in the experimental group was remarkable, as compared to that in the control group. It implies that the use of mnemonics and INTOP in teaching integers greatly helped increase students' performance in the 20-item multiple-choice teacher-made test on integer operations.

Table 2. The results of *t*-test for the pretest and posttest of the individual groups and for the posttest scores of the two groups

t-test Samples	*t*-value	Tabular value	df	Decision
Control Group's Pretest-Posttest	2.426*	1.717	22	Reject H_o
Experimental Group's Pretest-Posttest	3.450*	1.717	22	Reject H_o
Both Groups' Posttests	1.9*	1.68	44	Reject H_o

**Significant at 0.05*

Note: The *t*-test for dependent samples was used to calculate the significant difference in the pretest-posttest scores of the individual groups, while the *t*-test for independent samples was used to determine the significant difference in the posttest scores of the two groups.

P-ISSN 2362-8022 | E-ISSN 2362-8030| www.apjeas.apjmr.com

Table 2 presents the result of tests for significance between pretests and posttests of the two groups and between the posttests of both groups, at the same margin of error of 5 percent. It can be noted that the computed *t*-value for the control group was greater than the critical value at the given degree of freedom. It means that the performance of the control group over its pretest was significant. Therefore, traditional instruction was effective in transferring knowledge of integer operations to students. Similarly, it is noticeable that in the experimental group the computed *t*-value is also greater than the critical value at the same degree of freedom, which implies that there was a significant difference in their performance in posttest over pretest.

Comparing the posttest scores of the two groups, however, using *t*-test for independent samples, the computed *t*-value is greater than the critical value at degree of freedom twice that of the individual groups'. This means that there is a significant difference between the performances of the two groups. Implication was made that the experimental group outperformed the control group in terms of operating integers correctly.

Students under the experimental conditions were exposed to mnemonic strategies and gameplay. Undoubtedly, they learned effectively from these strategies on how to correctly apply the facts, concepts, and principles governing integer operations, so they performed well in the post test. The letter strategies LAUS and LPUN helped the participants to easily retrieve from memory the rules and facts about adding, subtracting, multiplying, and dividing signed numbers. This finding is consistent with that of Scruggs and Mastropieri (1999) and Delashmutt (2007) who found mnemonic instruction useful and effective in teaching a wide range of school subjects.

Playing INTOP engaged Grade 7 students in activities where they can actively construct their own knowledge. It gave them an opportunity for meaningful and motivating classroom experiences (Land & Hannafin, 2000) and for social and cognitive development (Niecikowski, undated; Kamii & DeVries, 1980) through collaborative practice, which contributed much to their learning of essential mathematical ideas associated with manipulating integers. This is why they performed well in posttest, an indication that playing INTOP card game effectively supported students' learning of integers. It also confirms the result of the study conducted on the effectiveness of games in enhancing science teaching (Perlota, Reyes, Rivera, Sato, Solis, & Vega, 2008).

CONCLUSION AND RECOMMENDATION

The significant difference in the performance of group in pretest-posttest suggests that both the traditional method of teaching and the use of mnemonics and INTOP in instruction increase the performance levels of students in operating integers. However, those students who participated in mnemonic instruction and INTOP performed better in operating integers than did students who were taught under traditional instruction. Hence, the use of mnemonics and INTOP is an effective strategy for supporting students with difficulties in understanding integers and their operations.

Based on the results of this study, it is recommended that teachers use mnemonic devices LAUS and LPUN in teaching operations of integers and develop other mnemonic devices to facilitate retention and retrieval of important mathematical facts and rules by students (esp. those with learning disability). Since it was also found out that playing INTOP improved students' procedural skills in and conceptual knowledge of integer operations, it is recommended that INTOP be used as a supplementary tool in teaching integers to help students develop proficiency and confidence with signed numbers. Furthermore, electronic game developers are encouraged to program a software version of INTOP for educational and recreational purposes. Finally, local schools should include and promote INTOP in math contests in the local, district, division, or regional levels.

The overall aim of INTOP card game is to provide a supplemental practice tool in learning integers and their operations and to develop computational automaticity among students. It is most effective when the game activities are carefully planned and properly implemented. However, it should not be used as a sole teaching approach that deprives students of more meaningful experiences in applying integers to solving real-life problems. To ensure effective and efficient learning of integers, INTOP card game should be used complementarily with other constructivist teaching approaches. Furthermore, other studies on the use of INTOP in instruction should be carried out in a wider scope, including its effect on the behaviors of students playing the game, to evaluate its effectiveness in raising students' overall achievement in mathematics and in developing positive attitude towards the subject. Other related studies may be conducted to test the effect of varying durations of playing INTOP on students' performance in mathematics.

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