

Computers in Mathematics Learning : Training Mental Number Line to Increase Counting Ability

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Abstract. The integers material are often represented in the form of a number line. The magnitude of the numbers represented along the number line is generally represented in mental number line. The level of accuracy of the mental number line will affect the counting ability on the matter of integers. This study aims to determine the effectiveness of the use of instructional media computer-assisted (introduction during the learning process) and manual (board game) to training mental number line that can affect the level of counting ability of mixed operations on the matter of integers. The subject of the study were 15 students of grade 7 that randomly given learning by using computer-assisted learning media then learning by using instructional media manual which is a board game. Computer-assisted learning media is used to increase students' interest in learning mathematics, this step use to supporting instructional media manual shaped board game to train the mental number line. Pre-test and post-test designs are performed. Data analysis was done by comparing the pre-test and post-test results. The result is an increase in the average value between pre-test and post-test. It can be concluded that the learning media is effective to training mental number line to improve the counting ability.

INTRODUCTION

Integers are one of the basic materials in mathematics. Because integers are one of the important and challenging topics in the transition from arithmetic to algebra [1]. There is an indication that difficulties in the matter of integers cause difficulties in learning algebra [2]. The material of integers is often depicted in the representation of the number lines and the magnitudes of numbers are often depicted to be represented along mental number line, so the accuracy of the mental line of numbers will affect on the arithmetic ability [3].

In general, the mental metaphor of the number line is a concept that describes the spatial aspect of the numerical representation of numbers [4]. This is in line with the model of the mental number line proposed by Deheane, which is spatially oriented from left to right and it is compressed in such a way that the space between pairs of numbers becomes smaller with increasing numerical quantities [3,5].

Based on research in 2016, about 83% of 8th graders experienced errors in working on addition and subtraction in integer. After in-depth interviews it was found that most students still had difficulty in comparing the magnitude of numbers in integers [6]. This proves that the mental number line, especially on the ability to compare the magnitude of numbers is needed to support the ability of arithmetic or other numerical tasks [3]. So the training to train the mental number line must be developed. In addition, with the rapidly evolving technological developments, training mental number line with computer-assisted should be enhanced [3]. The use of computer technology in mathematics learning proved to have a positive impact on mathematics learning achievement, a meta-analysis study states that as many as 36,793 students have increased mathematics learning achievement assisted using computer technology [7].

Similar studies have also been conducted in 2011, with dyscalculia students who were given mental training of the mental number line. The results show that students with dyscalculia also get a positive effect with the training of mental number line. In that research, the number-line mental training on computer-based learning media that used called *Calcularis*. Students are required to determine an estimate of a number along a given number line. In general, children with and without DD (Developmental dyscalculia) demonstrate the benefits of training demonstrated by (a) an increase in spatial representation of numbers and (b) the number of arithmetic problems resolved correctly [8].

In accordance with the exposure in this study will be learning with the help of media (computer-assisted and manual) which has the main purpose to determine the effectiveness of the use of learning media in mental train line student numbers that will affect the level of counting ability of mixed operation on integer material. Learning will be done in sequence. Computer-assisted media is used as an introduction during the learning process to increase student interest in integer material. Students' interest in this form is to support students' enthusiasm in subsequent learning using manual media (board games) to train mental number line. The research focus will involve students who are less interacting with computers and coming from low-income families.

RESEARCH METHODS

Participants

As many as 15 students from 7th grade high school, 9 male students, 6 female students, participants aged between 12-13 years, nearly 80% came from low-income families and most were not accustomed to using computers or laptops ($n > 85\%$).

Procedure

This study was conducted for 2 - 3 weeks. In this study consists of two times, namely learning by using computer-assisted learning media (ICT) and subsequent learning using instructional media manual in the form of board game. Students were randomly assigned to work on a pre-test, then provided learning using computer-assisted media to attract students' interest in learning mathematics. After that, given the learning by using a board game to train the mental line student numbers. Then done post-test, the value of pre-test and post-test are analyzed and compared.

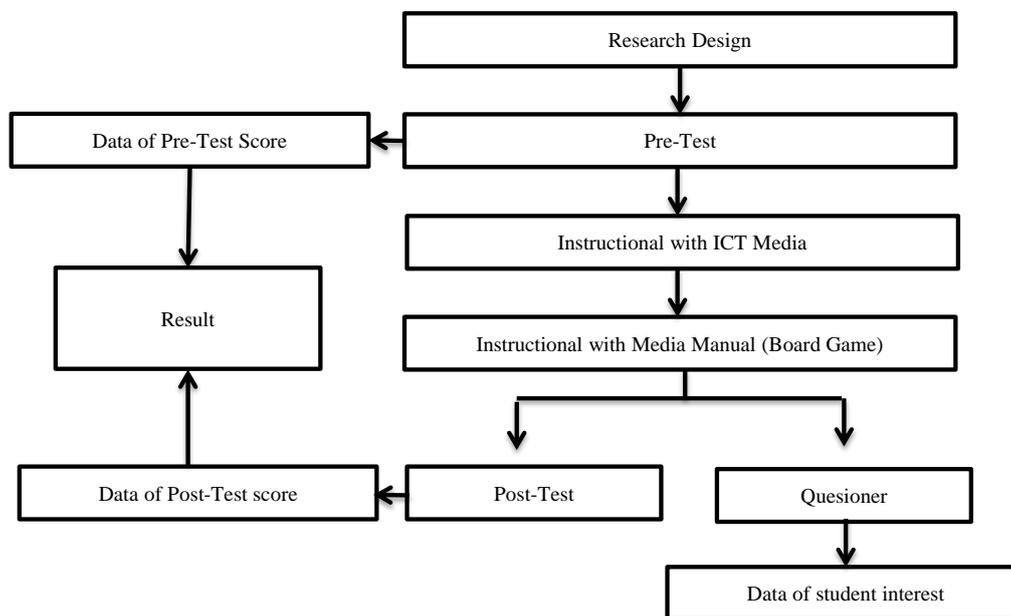


FIGURE 1. Research Design

Materials

Computer Assisted Learning Media (ICT Media)

Computer-assisted learning media is themed quest for the treasure of integers in learning mathematics. Computer-assisted learning media is used to attract students' interest in learning math. As a prelude to the ICT

learning media, there is a splash screen, on this page the title of the ICT media. This page is the view before entering the main menu page. The main menu page contains the menus present in the learning media from the apersepsi stage until the evaluation stage. The main menu and the second on the main menu page is part of apersepsi in learning that contains the Core Competence and Basic Competence of learning and Learning Objectives conducted.

On the next page there is a material page that contains learning content on integer material. On this material page contains material on the definition of integers (including estimates on the number line) and operations on integers (sum, subtraction, multiplication and division). The material page also contains the movement of numbers along the number line, in order to better assist the students to understand the location of a number on the number line. Students are also expected to understand that the more to the left the number is smaller and the right to the bigger the numbers, this is to help the students in understanding the amount of numbers especially in negative numbers.

After the material page, proceed with the evaluation page to find out the level of student understanding. On the evaluation page consists of arithmetic questions on integers. The problem consists of mixed operations and stories that require a deeper understanding of concepts. On this page students are tested on the knowledge and understanding of integer material. The next menu in the learning media is the profile menu that contains the profile of the learning media maker, the reference menu that includes the gratitude to those who have contributed to the making of learning media either directly or indirectly and the last menu is the menu out of the learning media. Some computer-assisted media displays are as follows:



FIGURE 2. (a) Splash screen, (b) main menu page, (c) core competences page, (d) material page and (e) evaluation page in ICT media

Manual Intructional Media

The instructional media is in the form of a board game measuring 30 cm × 30 cm. This manual learning media is given the name of a monopoly of integers, inspired by the monopoly game. In this manual learning media there is a different board containing boxes with estimated number lines, the board of this game is aimed to train the mental number line on the students.

The game board consists of a line of numbers that runs along left to right, also top to bottom. Here, the student is expected to be able to determine the location of a point along the blank line number (without the writing of numbers). In addition to the board game, also needed dice, pawn for game and problem cards made in accordance

with the existing colors on the board game. The color difference on the question card also shows the difficulty level of the problem to be done, starting from the yellow question card (difficulty about low level), the blue question card (problem of medium level) and the red question card (difficulty about high level).



FIGURE 4. Board Game

Learning Procedures Using ICT Media

Initially students were given a matter of pre-test on the matter of integer operations to know the level of prior knowledge to students about the material. In the next meeting the students are given lessons by using ICT (Information Communication Technologies) learning media, this lesson is held twice, at the first meeting explained about the procedure of using the ICT learning media (without using LCD or projector) and explaining a little material about the number round. In the next meeting students independently and individuals try to practice using the ICT learning media, until the evaluation stage. Each student is given a maximum of 20 minutes for the practice.

Learning Procedures Using Manual Media

After finished with ICT learning media, the next meeting students are invited to play by using manual learning media on integer material to train the mental line of student numbers. Randomly the students were divided into two groups, the first and second group assigned one of the students to become group leader. Then students can play with game boards according to predetermined game rules.

The rule of this game is that each group leader makes a suit or hompimpa to decide the turn in rolling the dice. The group that managed to get the first dice roll was entitled to pick pawn (pion) games first. Starting from the starting line, then the game pawn (pion) is placed at the zero point (0), the group member who is playing the throw dice. The dice used is a modified dice containing positive and negative integers on each side, by rolling the dice students are asked to calculate the results of the numbers indicated by the eyes of the dice. Then students walk to the right or to the left in accordance with the results shown by the eyes of the dice. Next, the students take the question card according to the color where the pawn is located. In the question card there is a matter of mixed operation on integers. If the student successfully answers correctly, then the game pawn can advance as much as one step to the next box. However, if the student answers wrongly, then the game pawn remains in its original position. Then the next group got their turn to play.

After learning by using game boards, students are asked to fill out a questionnaire about ICT learning media and manuals. Post-test is done at the end of the research.

Data Collection

To know the level of effectiveness of learning by using media to increase the ability of counting operation of integer mix of data collection is done through pre-test and post-test. Meanwhile, to know the level of student interest in learning mathematics by using learning media collected through questionnaire of student interest.

RESULT

The main purpose of this study was to determine the effectiveness of the use of learning media in mental train the student's line of numbers that will affect the level of calculation ability of mixed operation on the matter of integers. Data analysis was performed using quantitative statistics SPSS 16.0 by comparing the mean values obtained at the time of pre-test and the mean score of the students at post-test. The result is as follows.

TABLE 1. Comparison of Pre-Test and Post Test values

		Mean	N
Pair 1	Pre-Test	40.6667	15
	Post-Test	63.3333	15

In the table shows that, there is an increase in the average score of students before (pre-test) and after being given learning by using learning media (post-test). From this result, it can be concluded that students' learning outcomes on integer material have improved after using media in learning.

To answer the proposed research hypothesis, the following statistics are calculated. Research Hypothesis H_0 = Learning Media is not effective in improving the ability of integer matter and H_1 = Learning media is effective in improving learning ability in integer matter.

Before proving the research hypothesis, it will first be proven that the data already obtained is normally distributed using the Kolmogorov-Smirnov test.

TABLE 2. Result of Normality Test

Kolmogorov-Smirnov			
	Statistic	df	Sig.
PreTest-PostTest	0.171	15	0.200'

From these results it is known that the sig value in Kolmogorov-Smirnov $> \alpha$. So it can be concluded that the data has been distributed normally.

Next will be proven hypothesis of research. Statistically can be written as follows. $H_0: \mu_{PRE} = \mu_{POST}$ and $H_1: \mu_{PRE} < \mu_{POST} (*)$. The research hypothesis exists in H_1 . Using Left-hand Test. From SPSS obtained the following results. $t_{count} = -4,908$, $\alpha = 0,05$, $\frac{1}{2}$ sig (2-tailed) $< \alpha$. Because it uses the left-handed test, the value of $t_{count} < 0$ and the value of $\frac{1}{2}$ sig (2-tailed) $< \alpha$, then H_0 is rejected. So H_1 is accepted. Thus, it is proven that the learning media is effective in improving the mixed count operating ability on integer matter.

TABLE 3. Results of Hypothesis Testing

Paired Differences								
	Mean	Std.Deviation	Std.Error Mean	Lower	Upper	t	df	Sig.
PreTest- PostTest	-2.566E1	20.25434	5.22965	-36.88314	-14.45019	-4.908	15	0.000

Thus, the use of learning media in mathematics can provide significant results and effective enough to improve students' counting abilities on counting operations of mixed matter of integers. To find out whether ICT learning media enough to interest students in learning mathematics, the data in the analysis of student questionnaire answers. A total of 93.3% of students stated that ICT learning media attracted their interest in learning mathematics, 86.7% of students stated that the display of ICT learning media attracted and increased interest in learning mathematics.

From the results obtained there is a significant increase in the value of pre-test and post-test. Students better understand the location of numbers on the number lines presented in the form of board game media. This is evidenced by the more students knowing that the more to the left the numbers on the number line are smaller and the right to the number on the larger number lines (although on the blank lines given on the board game the students can still determine the location of positive and negative numbers, left of the center of the zero point is the set of negative numbers and the right of the center of the zero is the positive number).

Students are familiar with the spatial representation proposed by Deheane about the mental number line, where “This representation may be likened to a mental number line, because it bears a natural and seemingly irrepressible correspondence with the left-right coordinates of external space” [9].

Improvements in the stages of comparing the magnitude of the numbers give a good impact on the ability to calculate. Can be seen from the results of pre-test and post-test. Coupled with an increased interest in learning, there is a deeper motivation in learning mathematics with media usage.

According to the study Kucian (2011), states that “The results obtained are promising and demonstrate an improvement in various aspects of spatial number representation and mathematical reasoning in children with and without developmental dyscalculia. Moreover, brain imaging results depict a general decrease in brain activation immediately after training in both groups and point to a partial restoration of normal activation in number processing after a consolidation phase in dyscalculic children.” The result of mental training of the number lines does have a positive impact both on the spatial abilities of numerical quantities and mathematical reasoning [8].

CONCLUSION

From the results of data analysis can be concluded that the effective learning media in improving the ability to count the operation of the mixture on the matter of integers. This increase is the result of an increase in the spatial representation of the magnitude of the numbers presented in the learning media so that students better understand about the location of a number on the number line where the more to the left of the number will be smaller and the more to the right number will be greater that can help in the problem of comparing the magnitude numbers. This result indirectly implies that the learning media can train the mental line of numbers on the students, so that students can experience an increase in the ability to calculate the mixed operation of the matter of integers.

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