The effect of CAS calculator usage on the Algebra Achievement of Low Mathematics achievement students

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Abstract: *This paper observed the effect of CAS calculator usage while studying algebra on the achievement of low-achievement students in mathematics, here in referred to as low-achievement students. Participants were composed of 70 low-achievement tenth graders from a high school located in a metropolitan city that had never used a mathematics educational calculator before. Target participants were divided into two groups: an experiment group that studied activity papers with the aid of a CAS calculator, a control group that studied the same activity papers using only paper-an- pencil. The content of the activity papers for the two groups was the same, but the structure differed. Content consisted of numbers and operations, equations and inequalities (character and expressions), and functions. The activity papers of the control group were solved with the use of only paper-and-pencil and solutions were compared to those presented by the teacher. The experiment group first solved problems with paper-and-pencil and then again using a CAS calculator. They were told to compare their two problem-solving processes; compare the paper and pencil procedure with the CAS calculator. The experiment group exhibited matacognition learning using a CAS calculator usage method. The activities were carried out once a day for about one mouth. The two groups completed mathematics achievement tests both before and after the activity papers. The average scores of the experiment and control groups were very different. Therefore, ANCOVA analysis results showed that compared to the pretest, results of the experiment group improved considerably more than the control group.*

1. Introduction

At present, it is technology that is greatly affecting mathematics education. Technology improves students' ability to learn and influences the study areas in mathematics considered essential, that is, teaching and learning areas that need to be dealt with systematically. Many mathematics educators support technology usage in mathematics education. Some of them believe the calculator has a bigger effect than the computer in mathematics education (as, [2]) because the calculator is more portable than the computer and is more economical for students.

TIMSS found that the usage of calculators is connected with mathematics literacy in every country. Indeed, calculator usage has become an important tool for the TIMSS test and the classroom (as, [1]). The calculator is presently being used in the teaching and learning of mathematics in many countries. The purpose of using technology is to improve the conceptual understanding of students via the exploration of other methods to solve problems. That is, rather than restricting the forms of student learning processes, technology, offers an exploratory opportunity to students (as, [2]).

This paper focuses on low-achievement students who are neglected more and more in mathematics classrooms. It observed changes in mathematics achievement after low-achievement students completed 14 classes of experimental learning with the use of a CAS calculator. Accordingly, this study aimed at increasing enjoyment absent in low-achievement students in the class without neglecting actual curriculum study requirements. The use of a CAS calculator while learning allows students to explore new methods to solve problems, which can improve low-achievement students' understanding of concepts. Most importantly, a CAS calculator can help low-achievement students to not only do calculations but also develop mathematics knowledge. Hence, this paper has attempted to develop low-mathematics achievement students' algebraic thinking and overall mathematics achievement.

2. Method

The experiment was carried out in January, 2008. Each day, students participated in study-designed activities, and each class was 50 minutes from 5 p.m. to 5:50 p.m. The subjects were 70 low-achievement high school students－bottom 20% out of 495 tenth graders－from a high school located in a metropolitan city. That had never used a mathematics educational calculator before. The subjects were divided into two groups: an experiment group that studied with aid of a CAS calculator(Classpad 300), and a control group that studied only with paper and pencil. Two teachers per classroom taught the two groups.

To attain initial data, a paper and pencil only pretest was given to both groups in the two classrooms at the same time. A posttest was also given to participants. The pretest-posttest designs were aimed at comparing mathematics achievement improvement, so both allowed only a paper and pencil solving procedure. The two tests were consisted of 25 problems based on curriculum content from middle school grade 8 to high school grade 10. Also, contents contained numbers and operations, equations and inequality, and functions of Algebra.

The experiment group participated in 14 study designed classes; however, there were 3 additional classes: one for the pretest, another for the posttest, and an additional class on CAS calculator usage. There were 16 classes for the control group: 14 were identical to the experiment group except for class method, and two classes were for the pre and posttests. The experiment group first completed a pretest and a class on how to use a CAS calculator then 14 classes using developed activity papers. After the experimental classes, students completed a posttest. During the classes the lecturing teachers explained the mathematics content and solution methods possible with CAS calculators about for 15 minutes. The remaining 35 minutes students concentrated on the activity papers.

The designed activity papers made both groups engage in metacognitive activities while studying, and the papers contained the same content and problems. The only difference was the answer process. The control group was instructed to solve problems for 25 minutes and then compare answers to those presented by the teacher and reflect on their answers. The experiment group was instructed to first solve problems with paper and pencil and then with a CAS calculator. Next, they were to compare and reflect on the two solution processes and resultant answers. For example, to solve x=2x-4 students could not simply use the *solve* command, they had to proceed step by step. In addition, the teacher deliberately did not teach commands like solve to students. Hence, students had to solve these type equations in the following manner using a CAS calculator. Then, students needed to compare and reflect on their two answers and solution processes.

$$x=2x-4$$

$(x=2x-4)-2x$

$-x=-4$

$(-x=-4)*-1$

$x=4$

Data was gathered from student activity papers, the pretests, and the posttests. To analyze mathematics achievement, in particular algebra achievement improvement, marks on the pretests and posttests of the experiment group and the control group were compared and result characteristics analyzed.

3. Results and analysis

Division of participants original placed 32 students in the experiment group and 35 students in the control group. However, final analysis could only be carried out on 26 students in the experiment group and 30 students in the control group. The decrease in student numbers was unrelated to full attendance in the experiment lectures, but absence from either the pretest or posttest or failure to do an activity paper. The students were deliberately excluded as data in this study.

1. Effect on mathematics achievement between groups

Through a comparison, changes in the mathematics achievements of the two groups were investigated. The mean score of the 26 students in the experiment group was 41.94, and the mean score of the 30 students in the control group was 53.46 for the pretest. The means suggest that at the onset, the two groups were equally separated by their mathematics achievement scores according to two midterm examinations, two final examinations, and several tests in 2007. However, the main focus of this paper is algebra achievement, and the pretest results for algebra differed between the two groups.

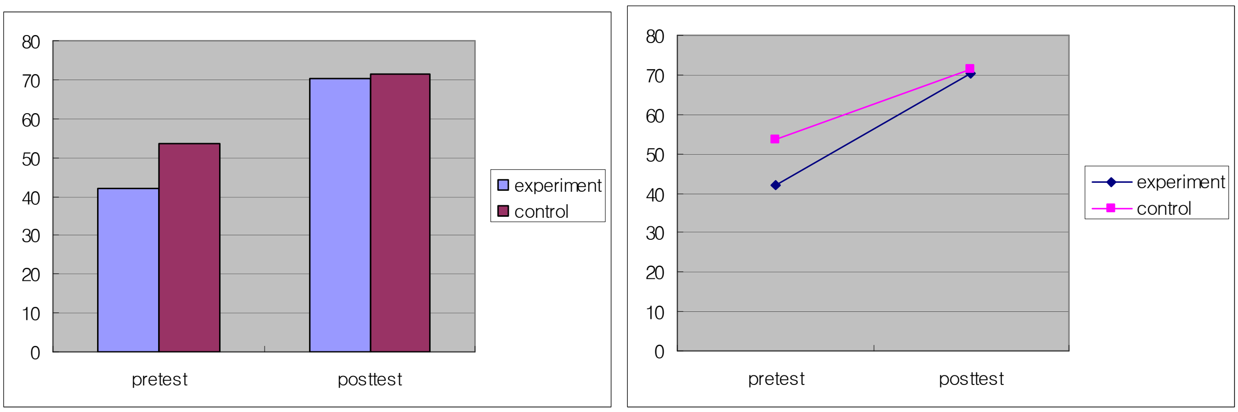

Figure 3.1 Changes in mathematics achievement mean scores of the experiment and control group

Before engaging in about one mouth of experimental classes using activity-designed papers, the mean score of the experiment group was 70.47 and the mean score of the control group was

71.29. On the posttest, the mean score of the experiment group increased to 28.53 or 68.03%, and the mean score of the control group increased to 17.83 or 33.35%. This implies that the experiment group improved more than the control group. Table 3.1 shows the results of the pre- and posttests for the two groups. As aforementioned, both groups improved as shown by mean scores and changed standard deviations.

Table 3.1 Pretest and Posttest mathematics achievement results

Group	Participants	Pretest		Posttest	
		Mean	Standard Deviation	Mean	Standard Deviation
Experiment	26	41.9423	22.11566	70.4654	13.70133
Control	30	53.4633	25.12392	71.2933	22.10264
Total	56	48.1143	24.26426	70.9089	18.52271

To determine statistically any significant difference between the two groups on mathematics achievement, an analysis of covariance (ANCOVA) was performed by taking the mathematics achievements on the pretest as a covariate and having the mathematics achievements on the posttest as a dependent variable.

Table 3.2 ANCOVA Results

Variation	Sum of Squares	Degree of Freedom	Mean Square	F
Covariate (pretest)	12373.956	1	12373.956	101.106*
Group	20139.845	2	10069.922	82.280*
Error	6486.481	53	122.386	

* : $p < .001$

By Table 3.2, statistically there is significant difference in results according to ANCOVA analysis when the mathematics achievements on the pretest are used as the covariate and the mathematics achievements on the posttest are used as the dependent variable ($F=82.280$, $p< .001$). Hence, the experiment group that used CAS calculators appears to have improved more than the control group on overall mathematics achievement.

2. Effect on mathematics achievement among groups

1) Effect on mathematics achievement among experiment group students

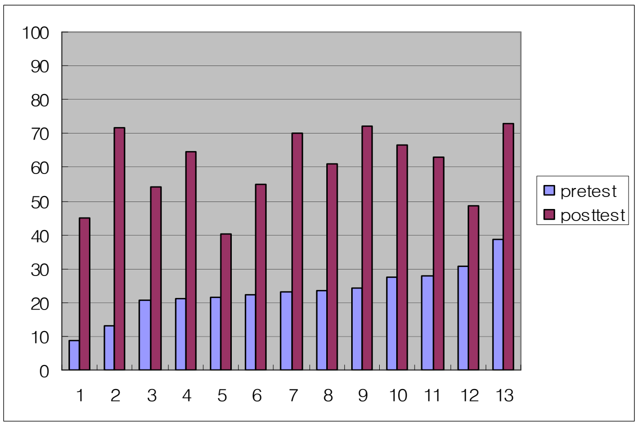

Figure 3.2 Mathematics achievements of the bottom 13 students in the experiment group

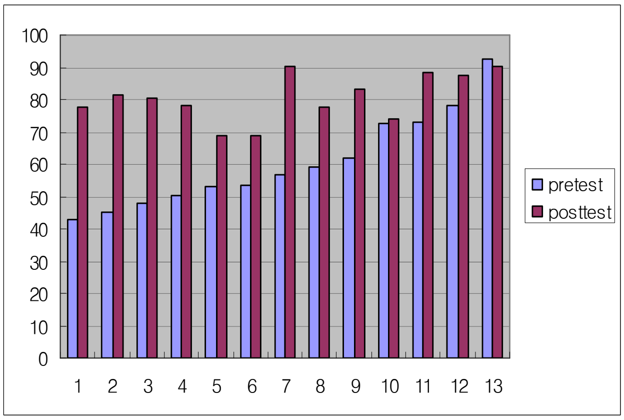

Figure 3.3 Mathematics achievements of the top 13 students in the experiment group

Figure 3.2 and Figure 3.3 show the achievement results of the experiment group on the pretest and posttest. The pretest was used to separate the 26 students of the experiment group into two groups (bottom group: 13 students; and top group: 13 students). Figure 3.2 compares the pretest and posttest results for the bottom 13 students, and Figure 3.3 compares the pretest and posttest results for the top 13 students. In Figure 3.2, all 13 students improved a minimum of 18 points over pretest results, and the most impressive improvement was 58.7. In Figure 3.3, almost all students improved from 1.6 to 36.4 points. One student dropped from a mark of 92.7 on the pretest to 90.3 on the posttest. Hence, generally, initially lower students, academically, improved significantly more then students initially found to never higher mathematical achievements (see Table 3.3). Moreover, difference between the top group and bottom group in the experiment group decreased from 37.1 points on the pretest to 20.1 points on the posttest.

Table 3.3 Effect on the mathematics achievements of the two groups in the experiment group

	Mean of Pretest	Mean of Posttest	increased scores
Bottom Group (13 students)	23.4	60.4	37
Top Group (13 students)	60.5	80.5	20

2) Effect on the mathematics achievements among students in the control group

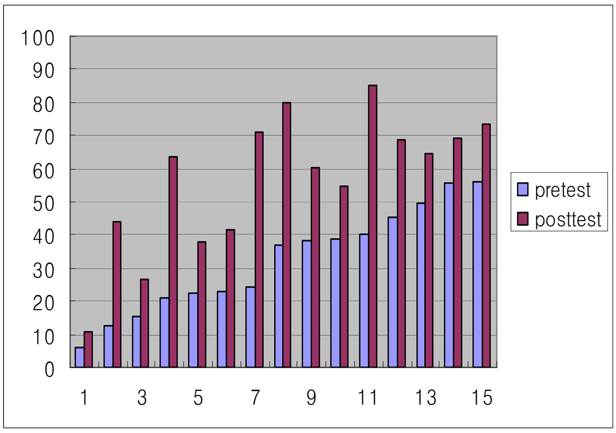

Figure 3.4 Mathematics achievements of the bottom 15 students (pre-determined by pretest results) in the control group

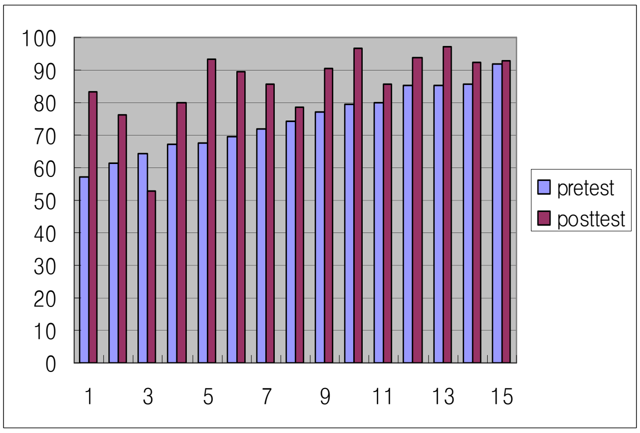

Figure 3.5 Mathematics achievements of the top 15 student (pre-determined by pretest results) in the control group

Figure 3.4 and Figure 3.5 show the achievement results of the control group on the pretest and posttest. The pretest was used to separate the 30 students of the control group into two groups (bottom group: 15 students; and top group: 15 students). Figure 3.4 illustrates the pretest and posttest results of the bottom group, and Figure 3.5 shows the pretest and posttest results of the top group. In Figure 3.4, all students in the bottom group of the improved. The increased marks ranged from 4.8 points to 46.8 points. Figure 3.5 shows that most top group students improved their test grades in the range: 0.7 to 26.1, from pretest to posttest. Only one student fell to 52.8 points on the posttest from 64.1 points on the pretest. Hence, similar to the experiment group results, the bottom group students showed greater improvement on the posttest than the top group students (see Table 3.4). Moreover, the difference between the top group and bottom group for the control group decreased from 42.2 points on the pretest to 29.2 points on the posttest.

Table 3.4 Effect on the mathematics achievements of the two groups in the control group

	Mean of Pretest	Mean of Posttest	increased scores
Bottom Group (15 students)	32.4	56.7	24.4
Top Group (15 students)	74.6	85.9	11.3

3) Effect on the mathematics achievement of students in the experiment and control groups

From sections 1 and 2 investigation results show that the posttest mean score of the bottom group of the experiment group is significantly similar to the pretest mean score of the top group of the experiment group. However, the posttest mean score of the bottom group of the control group does not reach the pretest mean score of the top group of the control group. Investigation of the bottom groups of the experiment and control groups in Figure 3.2 and Figure 3.4 found the posttest score of the bottom group of the experiment group to have improved evenly among all students from 40 points to 70 points, an average of 50 points. In addition, the posttest score of the bottom group of the control group improved from 10 points to 80 points, so there does not appear to be any distinct pattern. Also, the posttest score (60.4 points) of the bottom group of the experiment group was higher than the posttest score (56.7 points) of the bottom group of the control group.

Investigation of the top group of the experiment and control groups in Figure 3.3 and Figure 3.5 found the posttest scores of the top group of the experiment group to have improved evenly among all students from 68.8 points to 90.3 points. Similar, the posttest scores of the bottom group of the control group improved from 70 points to 80 points, except for one student who showed a decrease in mark. The increased achievements between the bottom groups of the two main groups were 37 points and 24.4 points. The bottom group of the control group was 9 points higher than the bottom group of the experiment group on the pretest, but the bottom group of the experiment group was 3.7 points higher than the bottom group of the control group on the posttest. Additionally, the posttest score (60.4 points) of the bottom group of the experiment group was higher than the posttest score (56.7 points) of the bottom group of the control group. The top group of the control group was 14.1 points higher than the top group of the experiment group on the pretest, but the top group of the control group was 5.4 points higher than the top group of the experiment group on the posttest.

4. Conclusion

Results of the study found that the experiment group attained statistically higher mathematics achievement than the control group. That is, low mathematics achievement students were positively affected by learning with a CAS calculator than with just paper and pencil. Furthermore, if general students used CAS calculators, they would show more improved achievement than learning solely through the paper and pencil procedure.

Second, the bottom group of the experiment group showed greater improvement than the control group's lower achievement students in overall mathematics achievement. A comparison between the top group and bottom group of the experiment group and between the bottom groups of the experiment and control groups showed the bottom group of the experiment group to have greater improvement than the other groups. Hence, this study shows that CAS calculator usage has greater positively affect on students of lower mathematics achievement than other students.

References

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[2] Stewart, S. (2005). *Concerns Relating to the CAS Use at University Level.* Proceedings of the Annual Conference of the Mathematics Education Research Group of Australasia. Held at RMIT, Melbourne, 7-9 July, 2005.