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A Description of Tenth Grade Algebra Students' Attitudes and Cognitive Development When Learning Algebra Using Symbolic Manipulators (TI-92)

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Introduction

Current trends in technological advancement make it imperative to revolutionise the teaching of mathematics by taking advantage of technology. Demana and Waits (1990) indicate that teachers must start now to implement the many technologies currently available and to prepare for the explosion in technology. The National Council of Teachers Mathematics (NCTM 1991) recommends the appropriate use of technology to enhance mathematics programs at all levels. Present mathematics education research indicates that there might be an increase in both attitudes and achievement in mathematics when students used Graphics Calculators (Carter 1995).

In response to the impact of the technological advance in the educational environment, this study is intended to provide a qualitative description of what happened to tenth grade students' attitudes and cognitive development when learning algebra while using the TI-92 Symbolic Manipulator (SM).

Sample

This study was conducted in a six-week summer program designed to offer high school students the opportunity to enhance their academic knowledge and to foster successful completion of their secondary education requirements.

The sample for this study consisted of six students chosen from the population of twenty-eight tenth grade students enrolled in algebra and advanced algebra classes in a college preparatory program at a Midwestern university during the summer of 1997. An attitude inventory was administered as a pre-test to all students during the first day of classes. Scores were ranked and six students were chosen according to their results: two students with the highest score, two with median scores, and two with the lowest scores. The students chosen in this way were female with very little experience with graphic calculators.

Instruments

The major sources of data were the following: pre-and-post test attitude inventories, interviews of individual students in problem solving settings, interviews of the classroom teacher, observations of the students' final presentations, and researcher's observations of individual and group work.
Every Monday and Wednesday for six weeks, from 5:30p.m. to 8:30p.m, the students worked in problem solving instruction. The Monday's sessions were used to:

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1) Reinforce concepts studied previously in the regular math classroom.
2) Extend concepts studied to greater depth.
3) Prepare students to learn concepts, moving them to a higher level of thinking skills, and
4) Foster students' involvement and creativity.

During Wednesday's sessions, the researcher interviewed the students and asked them to solve three non-routine problems. The students were free to use or not use the SM. The following are examples of the students' work:

Examples of the activities

1) Solve the equation 3x + 6 = 12

All of the students solved this equation by using paper and pencil.

2) What happens to the "x" value if the coefficient of the x is:
   a) Replaced by its opposite

   -3x + 6 = 12. The answer is negative.

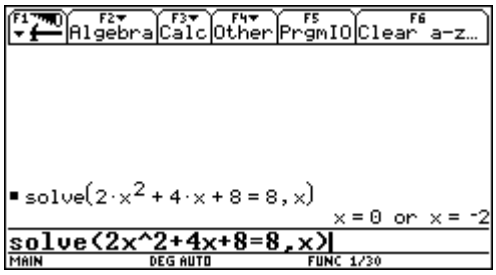
   b) Divided by 2

   (3/2)x +6 = 12 The answer is multiplied by 2

   c) Multiplied by 3

   3(3x) +6 = 12 The answer is divided by 3

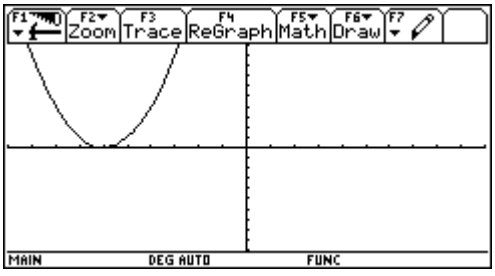
3) Solve $2x^2 - 4x + 3 = 0$.



Four of the students solved the problem by using the SM. The other two did it using paper and pencil.

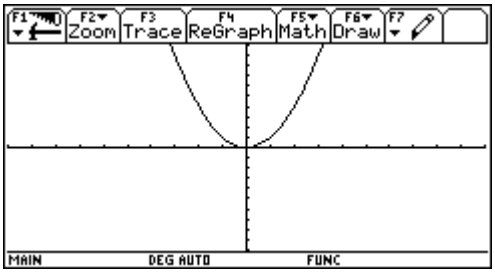
4) Construct the graph of:

a) $Y_1 = (x + 6)^2$



c)

b) $Y_2 = x^2$



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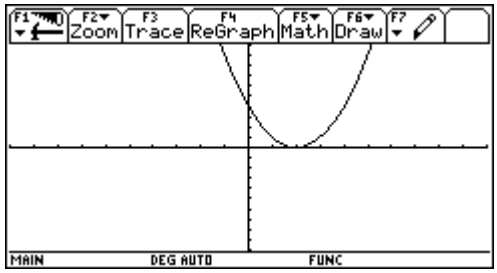
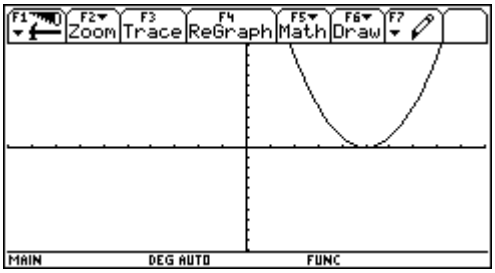
$Y_3 = (x - 2)^2$

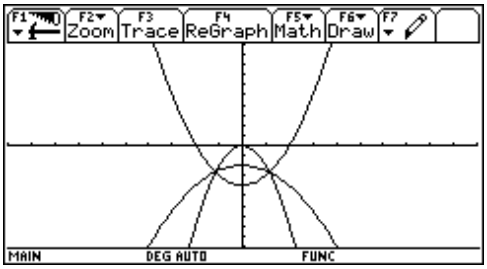


d) $Y_1 = (x- 5)^2$



All of the students used the SM to construct the graphs. In addition two of them used the split screen feature to check the table of values.

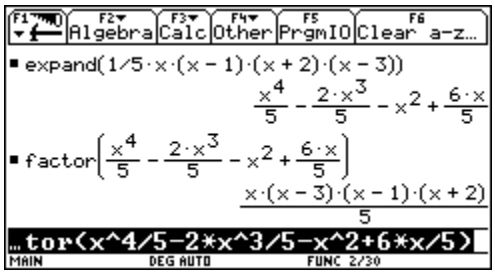
5) Match the function with its graph.
   a) $f(x) = x^2 - 4$
   b) $f(x) = -2x^2$
   c) $f(x) = -(1/2)\, x^2 - 2$



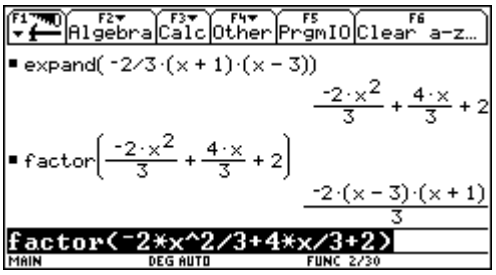
6) Find all the real values of x that satisfy $(2x^2 + 8x + 5)^{(x - 9x + 20)^2} = 1$.

7) What is the resulting amount if $1000 is invested for 10 years at 11% compounded annually?

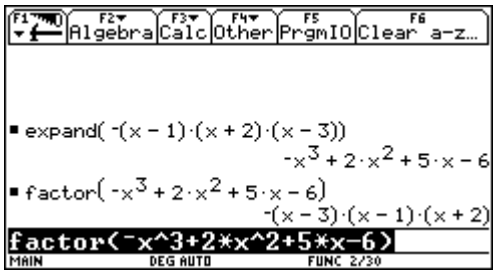
8) Tell how many linear factors are there and find the zeros of the function from its graph. Multiply the factors to expand each polynomial.
   a) $f(x) = (1/5)x\,(x - 1)(x + 2)(x - 3)$



b) f(x) = -(x – 1) (x – 2) (x + 3)



c) f(x) = - 2/3(x + 1) (x – 3)

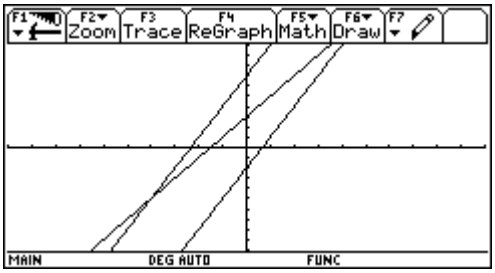


Results of the study

During the first week students participating in the study were not excited about it or about the SM. They were afraid to solve any kind of problem using the SM. They had problems learning how to use the SM and dealing with the mathematics concepts that the classroom teacher and the investigator were trying to cover. When the investigator tried to promote a discussion about the specific problem, they were unable to express an idea or to talk about it. This first week was very frustrating for everybody. During the last session, at the end of the first week, students were working on homework problems from their regular mathematics class, some students were trying to use the SM, but their frustration was evident.

The students were asked to construct the graphs of the following functions and to determine which ones corresponded to the graph of parallel lines,

1. y = 3x – 2
2. y = 2x + 3
3. y = 3x + 7



One of the students saw the graphs on the screen of the SM and for the first time she asked a question "How can you relate the graph with the equations?" This was the first signal to the researcher that the students were interested and they were paying attention to her explanations. After that, three of the students gave her an explanation about slope and point of intersection. The students expressed that, for the first time, these words made sense to them.

The students' attitudes started to change during the second week and they continued to change through the following weeks. At the end of the third week, the students were confident in solving exercises and finding the answers using the SM as well as using paper and pencil. They used several problem-solving strategies to accomplish the goal, like constructing a table, solving a similar problem, constructing a graph, etc.

They were always ready for the tutoring sessions and they began to act as a group and were willing to help each other. They improved their communication skills and their mathematics vocabulary. They started talking to each other and by comparing the results they were able to understand the problem. They made estimates and they laughed when their estimates went beyond the common sense. Students' motivation and determination to find and discuss the answer when they solved problems were the most common indicators of attitude changes during the tutoring sessions. Also, they were able to solve the same problems by using paper and pencil.

Students' cognitive development of algebraic concepts improved during the six-week period. They realised that they could solve a problem in different ways, and they were able not only to solve it but also to talk about it, and to understand it. For example, the students were asked to solve the following linear system of equations:

$$\begin{cases} 3x + 7 = y \\ 9x + 4y = 14 \end{cases}$$

Two of them did it by using the graph feature of the SM. Another did it by using paper and pencil, and three of them did it by simplifying the equations using the SM.

Students' self-confidence improved during this period and the levels of frustration and anxiety dropped. Students expressed that the SM helped them to understand how to solve a given problem while allowing them to do some explorations. They reported that the SM provided them with a visualisation of the problems. For example, one of the students stated, "The SM helped me to visualise what is being taught in my regular math class; now I know how the zeros of a polynomial function and the roots of a quadratic equation are related, it is like opening a window in your mind."

By using technology as a tool, students recognised the power and usefulness of mathematics to describe and confirm assumptions while understanding connections. The SM empowered these students to learn in-depth mathematics concepts that otherwise they would not be able to learn until they take mathematics classes at the college level. One of the students expressed that she spent hours during the night to learn how to use the SM.

She covered topics beyond the ones her regular mathematics class teacher covered in the summer program. For example, she was interested in the 3-D mode of the SM and she learned how to graph functions like $(x^3 y - y^3 x)/ 390$ using this feature. She also was the first one to learn how to use the zoom feature to get better approximation of the functions' values. This technology motivated the students to become independent learners.

Students gave a presentation to the whole class at the end of the six weeks. Even though they were using an overhead projector and a TI 92 (SM), the presenters were confident and secure about their knowledge and the topics to be presented. One student expressed that she had never dreamed that she was capable of doing a presentation in mathematics.

The classroom teacher reported that it was clear that the students involved in the study stimulated in a positive way the other students in the regular classroom. They asked her questions related to the SM and they wanted to learn how to use it.

By the end of the six weeks, all of the students agreed that they had experienced a positive change in their attitudes towards mathematics. They said that before they were always scared in a mathematics classroom because they did not know what was going on. They mentioned that now they felt smarter and had no fear when they tried to solve a problem.

Table 1 below displays the students' change from the pre- to the post-test.

TABLE 1

Comparison Between Students' Pre-and Post-Attitude Inventories			
Student Number	Pre-Test	Post-Test	Gain
1	-17	25	42
2	-11	30	41
3	20	37	17
4	21	30	9
5	39	42	3
6	40	44	4

Conclusion

There was an overall improvement in students' cognitive development when they learned algebra using the SM and on students' attitude towards mathematics. The students were able to communicate with each other using appropriate math vocabulary. They were able to make several attempts to answer a question without getting frustrated or discouraged. By using the SM students had free time to talk and to make conjectures. They could do troublesome computations in minutes, and they could use all their energy in the process of thinking on how to solve the problem. Also, the participating students developed problem-solving strategies that helped them to look for answers even when they struggled with the solution to a problem. Students' self-esteem improved and they were confident in their own knowledge about algebra an their skills to use the SM.

References

Carter, H. H. (1995). A visual approach to understanding the function concept using graphic calculators (doctoral dissertation, Georgia State University, 1995). Dissertation Abstract International, 56 3869A.

Demana, F. & Waits, B. K. (1990). The role of technology in teaching mathematics. Mathematics Teacher, 82(7), 546-550.

National Council of Teachers of Mathematics (1991). Professional Standards for Teaching Mathematics. Reston, VA: National Council of Teachers of Mathematics.