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Graphing Calculator's Impact on Students' Exploration in Senior High School[1]

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In this paper we investigated the influence on school students when they use graphing calculator for exploration, including their experience of exploration, their ability and attitudes. After using graphing calculator based mathematics exploration course, two students were interviewed and 162 students who finished the course in these years were investigated. The results show that graphing calculator is a useful tool to develop students' explorative ability. Most of students had positive attitudes to and were interested in making use of graphing calculator.

Keywords: Graphing calculator; Explorative ability; Attitudes.
ZDM Classification: U74
MSC2000 Classification: 97U70

INTRODUCTION

Mathematics education in China changed greatly in last twenty-five years. Many modern educational theories and new didactic strategies are introduced and influence on mathematics teaching and learning greatly. But the situations in classroom are still traditional, which can be summarized as: Knowledge-centered, teacher-centered and exam-centered. Students' minds are seen as a vessel to be put knowledge created by others. Teachers control everything in classes and students are not given enough opportunities to develop their own thinking ability. Exam-centered means that the aim

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of teaching and learning is only for what will be tested and the skills for exam, oth ers such as students' attitudes, values and creative abilities are not so important. It seems that such traditions may bring many students high scores in routine learning and even in international comparative study (Huang 2004; Li 2004), for a long run, students will lose opportunities to be fostered for their creativity, which is vital for both young generation. Mathematics as one of the most important subjects in school is now a main area to be reformed.

The Second Attached High School of East China Normal University, as one of the best schools with the excellent mathematics education program as it is a tradition in Shanghai and China, has tried to create a new program for students' development in creativity. Teachers in the school have introduced TI graphing calculator in an elective course titled graphing calculator based mathematics exploration. The content and level of the course is not restricted to official curriculum standard. About 20 students registered in the course every semester. They attend a forty-five-minute period every week for 18 weeks. Besides the basic skill for the use of calculator, the teacher mainly introduces about four or five topics, such as mathematics transformation, special curves, number sequences and series, etc., students are required to use what they have learned to explore mathematics concepts or methods with their own interest, and then spend enough time in class for interacting with teachers and peers. A project-based assessment is adopted. Students worked out own project individually or exchange with peers, and have opportunities to present to whole class. So the course is totally different from the traditional way of teaching mentioned above.

For example, one of basic topics of the lesson is the matrix transformation of plane graphs, involving relation between the concept of transforming graph and concept of changing coordinate system; the concept of matrices of rotational transformation, reflection about axis, etc. With TI 83-plus calculator, the whole topic is aimed to solve five questions:

1. How to draw the following graphs?

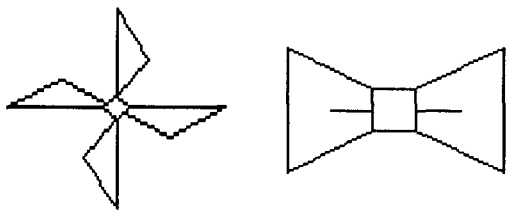

Figure 1

2. If the point $p'(x', y')$ comes from the point $p(x, y)$ by the rotation of an angle θ about the origin, how we represent the coordinates of p' with the coordinates of p.
3. If the point $p(x, y)$ is reflected about the y axis, what is the corresponding transformation matrix ?
4. If point $p(x, y)$ is reflected about the line $y = kx$, what is the corresponding transformation matrix?
5. Exploring after class:
   - What is the transformation matrix if $p(x, y)$ is reflected about the line $y = kx + b$?
   - What happens when the coordinates of a point is transformed by a matrix?

METHODS

This research is mainly focusing on the impact and result of the special course. The research questions are:

- How students engage in mathematics exploration with graphing calculator?
- Is making use of a graphing calculator beneficial for high school students' interests of mathematical exploration?
- Is making use of a graphing calculator helpful for high school students' ability of mathematical exploration?

This research has two parts. The first is a case study. Two students were inter-viewed. Observation was conducted when they had their presentations in class and they were interviewed.

The second part is a survey after a normal mathematics knowledge test with more exploration items. The instrument used in this part to collect data is a questionnaire which consisted of six items, to know students' attitudes and interests when they learn exploration in technological environment. The participants were 162 students; most of them have attended the elective course class.

RESULT OF THE RESEARCH

1. We find from observation and interview that many students were actively engaged in mathematics exploration with the help of graphing calculator and recognize the main steps of mathematics exploration such as observation, experiment, analogy, induction, conjecture, generalization, proving, construction, and evaluation in real and mathematical

situations. In virtue of new technological tools, students were able to experiment problems in many intuitive context.

Interviewee A is a girl who is fascinated by geometry figure in her study. She chose curve as her topic to explore, and concentrated on the formation of the family of cycloid. In her project report, she used calculator to explore the formation of five kinds of cycloids when the center of the circle moving along a line, along a circle, along a rectangular, along an ellipse, or along a cycloid.

For the case 2, she used the GRAPH function for equations:

$$\begin{cases} x = \frac{r}{k}\cos\ k\theta + r\cos\ \theta \\ y = \frac{r}{k}\sin\ k\theta - r\sin\ \theta \end{cases}$$

and let the circle rotate in clockwise and consider at the same time many cases of the value of k. On calculator she got a series of loci of a point on a circle. Some of them are as follows (Figure 2 - 11):

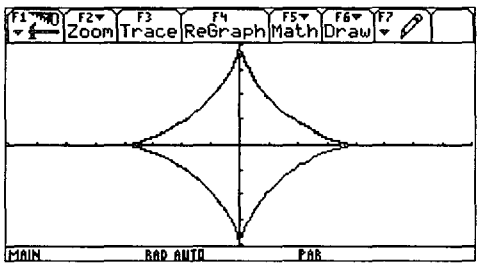

Figure 2. $k=\frac{1}{3}$

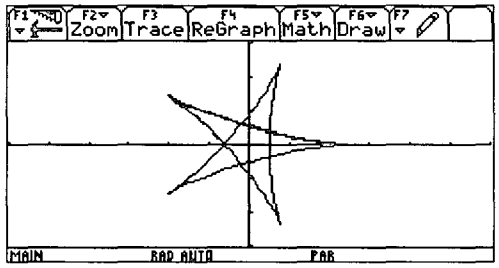

Figure 3. $k=\frac{2}{3}$

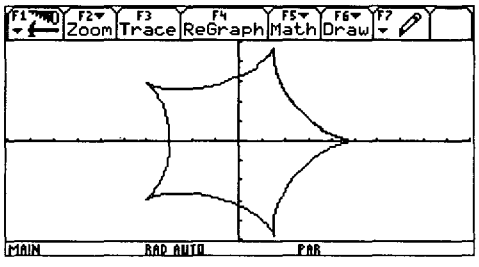

Figure 4. $k=\frac{1}{4}$

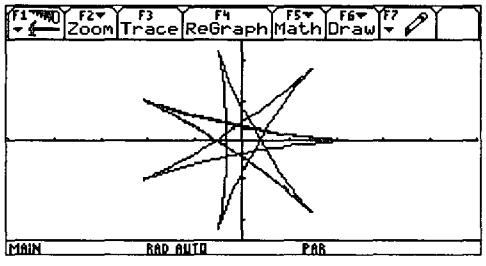

Figure 5. $k=\frac{3}{4}$

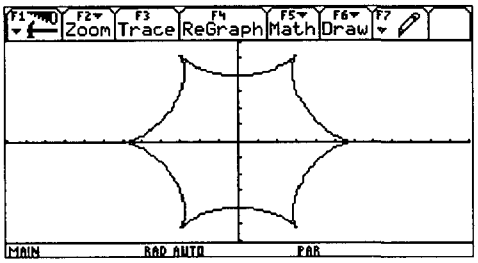

Figure 6. $k=\frac{1}{5}$

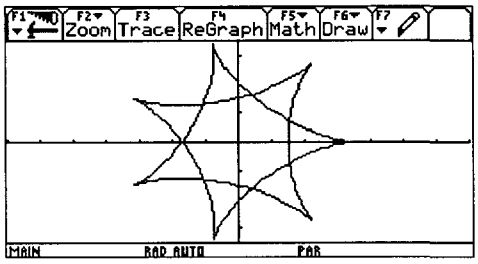

Figure 7. $k=\frac{2}{5}$

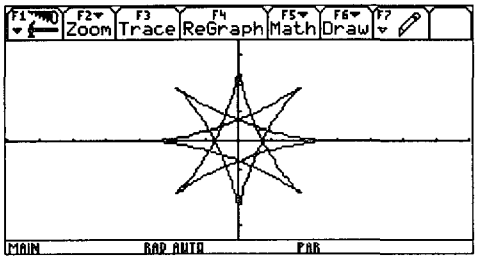

Figure 8. $k=\frac{3}{5}$

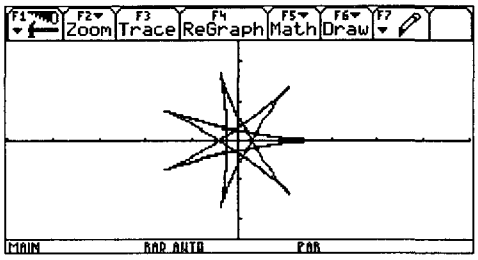

Figure 9. $k=\frac{4}{5}$

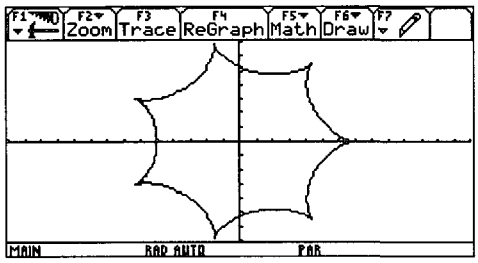

Figure 10. $k=\frac{1}{6}$

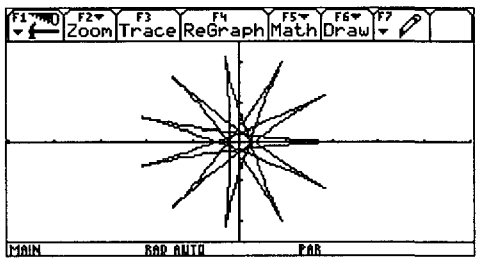

Figure 11. $k=\frac{5}{6}$

Then she had a series of conjectures from her observation for example:

The graph has n+1 vertexes if $k=\frac{1}{n}$ ($n\in Z$) ,

The graph has $n+q$ vertexes and n+q cross points if $k=\frac{q}{n}$ ($(n, q)=1$, $n, q \in Z$) ,

The graph when $k=q$ is similar to the one when $k=\frac{1}{q}$, ...

She described her experience in the interview: When I learn conic section, I am very

much attracted by graphing calculator. Some times a simple equation can introduce me such a pretty curve. How they are formed and what properties they have? Calculator reminds me some direction and also brings me confidence to explore.... Begin with the simplest cycloid, I consider some factors such as relative movement etc, and learn to draw a lot of graphs for observation. If I want to draw such graphs by hand, it will spend my more than one day, I think. ... I try to classify and generalize so many graphs and guess some pattern from the intuitive graphs. Of course, the conjecture should be proved; maybe it is not with calculators. ... This process seems as a game for me to play.

Student B is a boy who was interested in numbers and explored the properties of Fibonacci numbers with the help of calculators. After some steps in his learning process, he turned to makes quotients of consecutive terms and applied some function of calculator to sketch new sequence on the screen (Figure 12, 13). He was surprised through observation that these points of quotient on the screen seems approaching to certain value. The intuitive phenomena stimulated him to check what he guesses. Again he relied on calculator to transform these points to correspondent numerals in a tabular form and saw that they approach value may be 1.618, which was the approximate value of (Figure 14, 15).

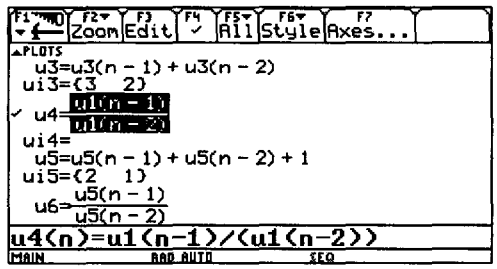

Figure 12

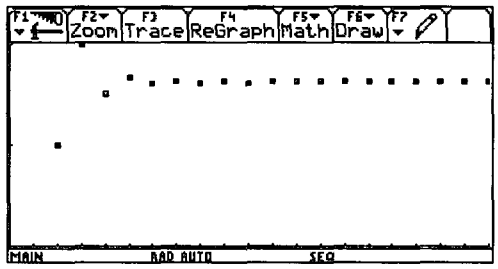

Figure 13

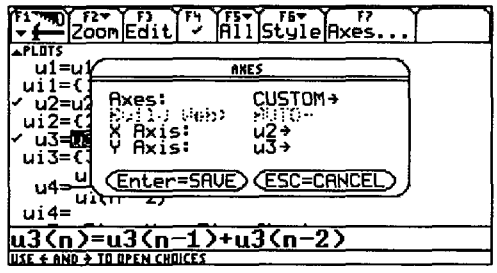

Figure 14

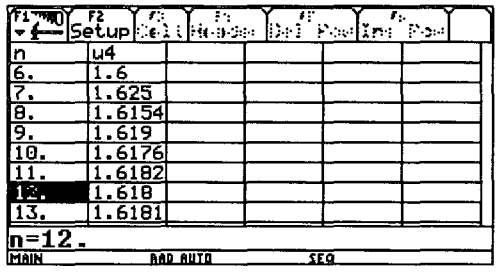

Figure 15

So he naturally wished to confirm it. His experience also illuminated him to collect more information for his explanation and understanding. He even produced a program for

his explore. In his teacher's mind, he was an introvert student and more passive in mathematics learning. But he looked more and more active and "brave" to investigate something when he did his project.

In fact, the use of graphing calculators is one of the avenues that can inject new excitement and enthusiasm into the mathematics teaching and learning process (Idris 2005; Nor 2005).

2. The data showed that most of students who experienced the use of calculator hold positive attitudes to the way of learning and exploration.

The data collected from a questionnaire showed that about 68% students often use calculator to solve problems (Figure 16), and those who never us it is 15%. But only 8% students always use graphing calculator and 43% use less. But most of students believe that graphing calculator is useful in both traditional and explorative study (Figure 17), and even useful for exploration (69 %).

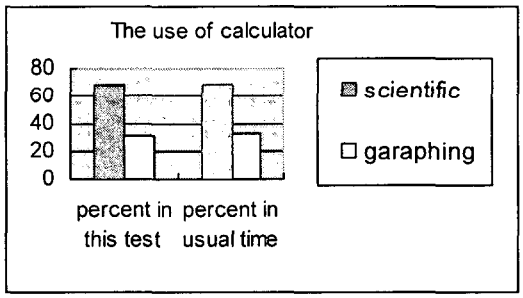

Figure 16

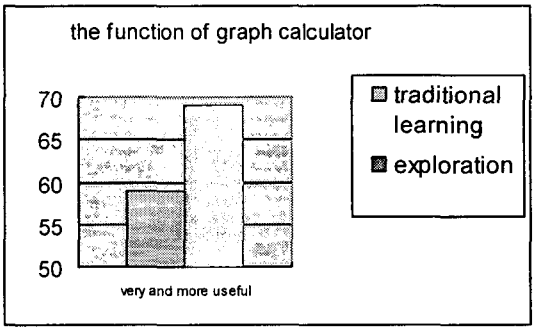

Figure 17

We found that the students who think graphing calculator is not useful for exploration were those who never learned to use. But the students who used it in this test think it was

very or more useful for exploration (46% and 54%). It implied that students can experience the powerful function of graphing calculator when they use it. The result shows us that students believed graphing calculator gave strong support for students' mathematics exploration and stimulated their interests for mathematics learning and exploration.

A special item of the questionnaire is to see students believe what kind abilities can be supported by graphing calculator. The data is in Figure 18:

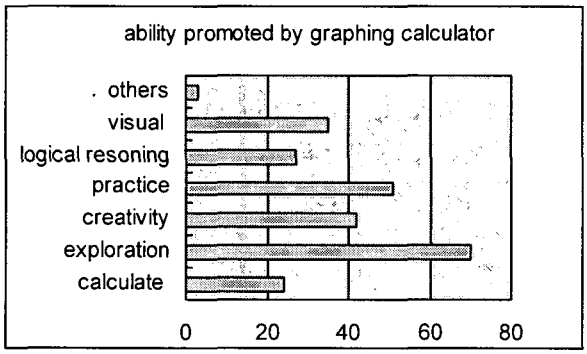

Figure 18

The exploration ability was chosen by seventy per cent of students and the next two--practice and creativity, were also relevant to it.

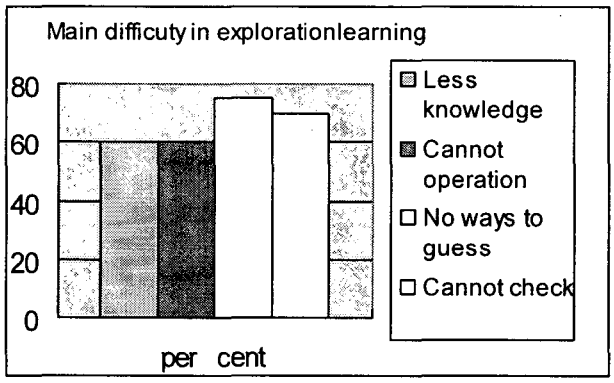

Figure 19

It is worth to note that there were about eighty per sent students had experience of autonomous exploration when they learned the courses, only ten percent of them finished their project report well. In the analysis of the answers of related question in questionnaire, there were four important factors attributed by students: students have less

knowledge (60%), the operation cannot be continued (60%), no way to guess (about 75%), cannot check the conjecture (about 70%).

This research has been investigating the impacts of using the graphing calculator on develop students' exploration ability at the senior high school level. The use of graphing calculator in teaching and learning of mathematics had provided students more opportunities to experience exploration activities and they are really interested in it. Some of them have done better. But this is only a starting stage. Though these findings will encourage policy makers and schoolteachers to continue such trial and inject more and more interesting and important mathematics topics for more students in future, we are also face with some problems such as relative curriculum, teachers' ability and strategies in using technology for teaching, and students' preparation for learning.

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