

The Influence of Graphing Calculator on Students' Mathematical Capability of Self-exploration under the New Curriculum

Ya-pin Tian

tyapin@126.com

Weishanlu Middle School, Tianjin

China

Abstract: *In china, the standard of new mathematical curriculum advocates students' self-exploration, independent study, cooperative discussion, and the experience of the mathematical "re-discovery". This paper intends to discuss the influence of graphing calculator on students' mathematical capability of self-exploration under the new curriculum in three aspects by specific empirical research, mainly reflected in how: (1) graphing calculator expands the space of students' self-exploration; (2) graphing calculator inspires the students' awareness of self-exploration; (3) graphing calculator enriches the ways of students' self-exploration.*

The new mathematical curriculum advocates the study style that students are active and are daring to explore. Chinese educator Tao Xingzhi said: "The vivid teaching does not only instill academic knowledge into students, but should also give students the key to exploring the cultural heritage." It means that teachers should not limit students' mathematical learning activities to receiving, memorizing, imitation and practice, but rather play the role of inspiring students' independence, such as self-exploration, hands-on practice, cooperation, communication, self-learning and other ways of mathematical learning. Teachers should be good at creating an environment for student's creativity and encourage students to participate mathematical activities, to make students become planners, organizers, implementers and evaluators, so that they are brave in exploration and are good at thinking.

With the development of computer science, graphing calculator (GC) becomes a tool for mathematical learning, which is a kind of process-oriented and vest-pocket handheld computer. It has many powerful functions, including calculating, mapping, data processing, programming, even with the infrared transmission and computer connection, promoting students' mathematical communication, data collection, data processing, and mathematics modeling. Also, graphing calculator establishes the relationship between mathematics and other subjects.

As we all know, teaching instruction includes two aspects, teaching and learning. In a dialectically materialistic perspective, teaching and learning are a dialectical unity. Under the new curriculum, how to foster students' capability of self-exploration with graphing calculator? How to unify teaching and learning under the new curriculum reform? And how to take advantage of advanced

information and technology appropriately for training high-quality talents? This paper aims to discuss the influence of graphing calculator on students' mathematical capability of self-exploration under the new curriculum.

1. Background of the practical school with graphing calculator

Military strategists often say: "If you know the enemy as well as yourself, you'll win every battle." Thus, if you want to teach students effectively, you should understand them. So I want to introduce our school and our students firstly. Our lovely school, Weishanlu Middle School, located in Hexi District in Tianjin, is a middle school with 2,000 students who are either junior or senior. Particularly, some of them come from Xinjiang who has composed several classes since the autumn of 2005, in response to with significant strategies of western development, and the spirit of ethnic harmony.

By now, our school has a total number of 457 students from 18 different ethnic groups. The first batch of students have graduated in 2009, some of whom made great achievements in the university entrance examination, such as Wang Chao and other 9 students were admitted to 9 famous universities like Peking University. 54.2% students were up to the standard of famous university (73.3%, arts graduates), while 79.4% undergraduates were up to the standard of normal university (83.3%, arts graduates).

There are 43 students in the experimental class I teach. They are from six different nationalities of the Han, Hui, Mongolian, Kirgiz, Kazak, Uygur, most of who are versatile and are good at singing and dancing. The most commendable is that they can be tough and strict with themselves on aspects both learning and daily life. They cherish the hard-won learning opportunities and environment extremely. When I teach the function and operation of the graphing calculator, they thirst for them and post their particular view about them which play a valuable role in motivating teacher's teaching enthusiasm. Especially, On the occasion of 60th anniversary of National Day, Zhang Gaoli, the mayor of Tianjin, and other leaders came to our school to express their sincere solicitude. They participated in the class meeting at where they cared about students' situation of living, learning and family, and took photos with students of all nationalities.

2. GC benefits the training of students' mathematical abilities of self-exploration.

2.1 Graphing calculator changes the mathematics teaching mode.

The New Curriculum requires that we should consider not only how to teach but also how to learn. By combining teaching with learning, we could create a process of exploration and discovery accomplished by both teachers and students. In the process, teachers should illuminating students way of doing, thinking, learning and practicing. The role of teachers is a coach, not the sport. Teachers should play their roles, no less or more, to motivate students to think, experience, learn and practice. Following this process, students gain more courage and have increased interest on study, as a result of successful practice.

2.2 Graphing calculator enriches the mathematical teaching environment and media

The integration of graphing calculator with new mathematics curriculum promotes the implementation of new mathematics curriculum effectively and enriches researches in terms of teaching methods, learning styles and so on. During the process of students' exploration, graphing calculator conveys the mathematics learning content; enriches the mathematics learning resources; promotes the construction of a diversely associated learning environment by a most effective way; and creates conditions for students' self-learning and self-exploration.

3. The influence of graphing calculator on students' mathematical abilities of self-exploration.

3.1 case analysis

[Case 1] Alimjian, whose learning is very general, often doesn't pay attention to the class and often is criticized by teachers. After the introduction of HP Graphing Calculator, his enthusiasm and interesting were raised immediately. He started to concentrate on what the teachers said and the research problems actively. One day, he gave me a big surprise. When I finished a math class and just wanted to leave, he came up to me and said: "Miss Tian, this is my summary about the 'Nike Function', would you help me examine it? " I was shocked at it! There are full of 11 sextodecimos! Yeah! It's great! I asked: "When did you write it? And why did you choose 'Nike Function' as the topic?" "I have a strong interest in it since you distributed the graphing calculators among us. It is so interesting! One day, I was solving the math problem that 'solve the monotonicity of

$y = x + \frac{2}{x}$, $x \in (0, +\infty)$ ', which inspired me. ", he said.

[Case 2] Mahmut, the math subject representative in my class, is good at mathematics with an excellent performance history. His performance has been the pride of teachers and the great example of students. He is interested in graphing calculator, especially in programming. One day, I asked: "Mahmut, how many programs have you made? " He smiled: " Dozens" he replied. Several programs Mahmut wrote include:

Program 1:

Solve the personal income tax following the nine-grade graduated tax rates

This program uses the judgment statement as follow:

CASE

IF THENEND

IF THENEND

.... .

END:

The program is:

<pre> 30 PROGRAM INPUT A:"30":"A": INPUT YOUR SHOU RU":0:ERASE:DISP 1:"NI YING JIAO:": DISP 3:"YI FA JIAO SHUI SHI":DISP 4:"WO STO SPACE PAGE A..Z BKSP </pre>	<pre> 30 PROGRAM MEN GUANG RONG DE": DISP 5:"YI WU.": CASE IF A-2000<=0 THEN 0>B: END IF A-2000>0 AND A-2500<=0 THEN STO SPACE PAGE A..Z BKSP </pre>
<pre> 30 PROGRAM 0.05(A-2000)>B:END IF A-2500>0 AND A-4000<=0 THEN 0.1(A -2000)-25>B:END IF A-4000>0 AND A-7000<=0 THEN STO SPACE PAGE A..Z BKSP </pre>	<pre> 30 PROGRAM 0.15(A-2000)-125>B:END IF A-7000>0 AND A-22000<=0 THEN 0.2(A-2000)-375>B:END IF A-22000>0 AND A-42000<=0 THEN STO SPACE PAGE A..Z BKSP </pre>
<pre> 30 PROGRAM 0.25(A-2000)-1375>B:EN D IF A-42000>0 AND A-62000<=0 THEN 0.3(A-2000)-3375>B:END IF A-62000>0 AND A- 82000<=0 THEN STO SPACE PAGE A..Z BKSP </pre>	<pre> 30 PROGRAM 0.35(A-2000)-6375>B: END IF A-82000>0 AND A-102000<=0 THEN 0.4(A-2000)-10375>B:EN STO SPACE PAGE A..Z BKSP </pre>
<pre> 30 PROGRAM D IF A-102000>0 THEN (A-2000)0.45-15375>B: END END:DISP 2: B" ¥":FREEZE: STO SPACE PAGE A..Z BKSP </pre>	<pre> NI YING JIAO: 1225 ¥ YI FA JIAO SHUI SHI WO MEN GUANG RONG DE YI WU. </pre>

Program 2: the countdown clock

He uses the statement "DO...UNTIL...END..." as the main body, and then nests 'if' within it.

The specific programs are as follows:

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HE PROGRAM
2.75SIN(A*6)+0.8;2.75C
OS(A*6)+0.25:BEEP
493.9;0.05:WAIT 1:
TLINE 0.8;0.25;
2.75SIN(A*6)+0.8;
2.75COS(A*6)+0.25:
STO SPACE PAGE A..Z BKSP

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S2 PROGRAM
+DISPLAY G8:FREEZE:

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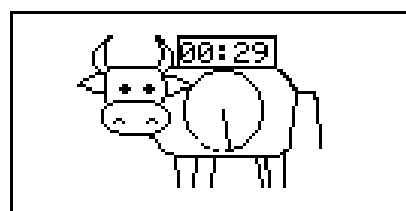
STO SPACE PAGE A..Z BKSP

```

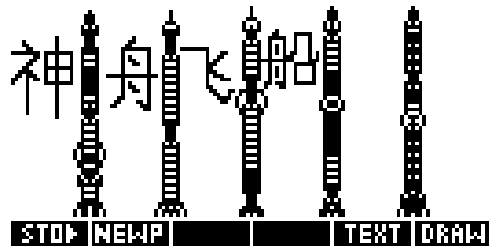
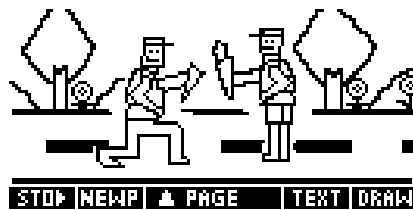
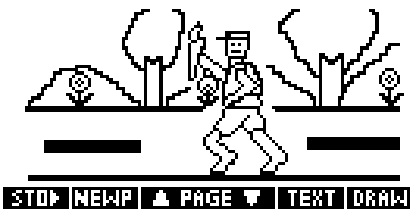
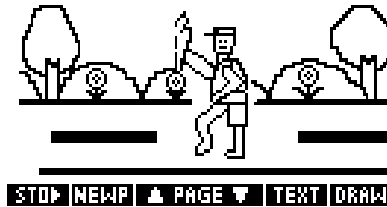
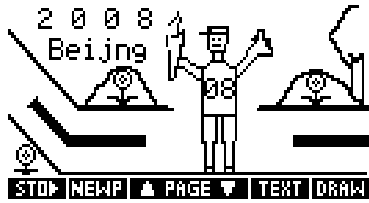
```

HE PROGRAM
UNTIL A==0 AND B==0
END:LINE 0.8;0.25;0.8;
3:
RUN 3:ERASE:WAIT
1:RUN OLYMPICS:
WAIT 1:RUN S2:
STO SPACE PAGE A..Z BKSP

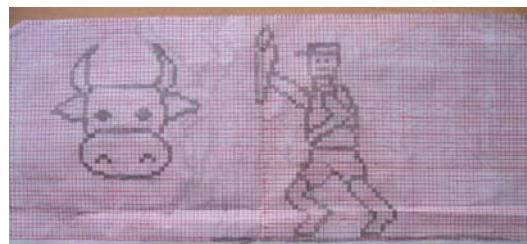
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[Case 3] Xin Lu and Xu Liang are interested in graphics calculator. They designed a program with it, which includes three parts, torch relay with the background music, Welcome to Beijing, a countdown clock and the launch of the Shenzhou Seven. Below are seven pictures captured from the work



The pictures of torch relay originate from the below one. First draw up a table with many small squares, and then paint a picture by painting black in squares, and finally carry the pictures into graphing calculator, stringing the pictures together by program.



[Case 4] Zhang bing is also a mathematics lover. He wrote an article about how to make a periodic table of elements by hp39gs. He said: "I decide to make a periodic table of elements because I saw a work of Mine sweeper. I thought it was funny and I spent two weeks pondering over it. Then, I thought it could be helpful in our study. For example, using it in making a periodic table of elements, because we can't learn all the mass of elements by heart. "

Of course, this is not the only four cases, there are still a lot of students show their interest in graphic calculator, not listed here. These students, who come from remoter Tianshan, study how to use graphing calculator and take part in activity of Winter Camp about HP graphing calculator. The activity developed their ideas, improved their study score and gave them more courage.

3.2 case study

Changpei Wang, the professor in Beijing Education Institute, visited our school in May, 2010. He interviewed 6 of our students.

Pro. Wang: "Do you have some impressive researches with graphing calculator?"

Xin Lu: "When we discussed the 'Nike Function' in Grade One of Senior High School, I found it's difficult to draw various graphs of function along with the parameter variation by hand, and also it's difficult to remember the monotonicity of it. However, it is much easier with the graphing calculator. We can understand the nature of the 'Nike Function' by classifying, comparing and discussing with it with the graphing calculator."

Zhang bing: "In the university entrance examination, there are some complicated composite functions to calculate, which require us to study how a certain parameter influences the graph of the function. One time, I tried to equate the variety and then tested it by using the GC. I found my conclusion wasn't completion. I got many interesting things by using graphing calculator, for example, the graph of function with logarithmic and trigonometric function is similar to that of logarithmic function. It's helpful to further study the graph. "

Mahmut: "When I studied the trigonometric function $y = A \sin(\omega x + \varphi)$ in Grade One of Junior School, I found there are many parameters in a function which influence the graph of the function. For example, a certain parameter A controls the height, and the other one ω , may control the cycle and so on. This means that the graph can move like a flash along with the variety of parameters, as well as the wave in physics. The graphing calculator can make these varieties visible and also can be used in physics class."

Pro. Wang: "What's the foundation of making program to math? Was your intelligence deepened by accomplishing a program? "

Xin Lu: "Yes. I think programming embodies a view that mathematics comes from true life and also allows to apply this. Typically, we can't make a perfect program immediately. We should edit it many times, and we must know the characters, parameters of the function well."

Pro. Wang: "Let's have a discussion. In your opinion, how good is this work? Which do you like better? "

Xin Lu: "I think wonderful work should embody the feature of both GC and mathematic. The work of a periodic table of elements, which links math with chemistry, is better. "

Zhang Bing: "I think Mahmut's is better. The main idea which I never thought, nesting loop within another one, is new. The algorithm, calculating approximate progression by GC, is simple. "

Pro. Wang: "In your opinion, what's the way of using graphing calculator effectively? Are you worried about the negative influence on exam that could be produced by the graphing calculator? "

Xin Lu: "No, I don't think so because the questions in the exam could be done without the GC. The purpose is to encourage us to use the GC in developing our capability and enlightening us instead of just dealing with a question. The process of doing a question with the GC is creative. The students get to think more than that just about solving the question. "

Pro. Wang: "What's your feeling about using a graphing calculator? "

Tannur: "In my knowledge of senior mathematics, the trigonometric function is abstractive. It was difficult for me to understand. The numeric-picture connection is how I began to learn it. But after using the GC in study, I understand it better than others who don't use the GC. For instance a certain parameter controls the feature in Sine function... (be interrupted) "

Pro. Wang: "It's wonderful! 'a certain parameter controls the feature of a function...' It's significant. You said that you have more achievements than students who are without the graphing calculator. Why do you think that? "

Tannur: "The GC is helpful especially when it was combined with investigations. For example, many students, except those in my class, think trigonometric functions are difficult to learn. Because we have made use of the GC to study, however other classes haven't. "

Pro. Wang: "it's just a special story. Very wonderful! What's your feeling about it? "

Ke Tian: "The advantages are showed especially when I study functions. It's easy to just study a certain function. But it becomes difficult when all the conceptions, graphs and features of different functions have to be learnt. For example, the parameters in different functions may be expressed in the same letter; however they control the different aspects of a graph. If I want to see the parameters well, the best way is drawing pictures, and, therefore, I have to draw many graphs. However, it will much easier with the GC as the graph can be shown on the screen by just imputing a figure. "

Pro. Wang: "All your words are attractive! You said that you can make a induction from the systematic summary. Can you give me a specific example? "

Ke Tian: "For instance, $y = \frac{k}{x}$, controls the gradient of the line in the graph, but if we want to know how the graph varies along with the coefficient, we have to draw many pictures. (Draw picture as well as interpreting). Another example, there are four kinds of equation in a parabola equation. I don't understand them well. But it becomes easier if shown on the screen of the GC by imputing figures. "

From what has been discussed above, we may draw the conclusion that in terms of concept, students can understand the functions of graphing calculator in mathematical learning correctly. They know it clearly that the function of graphing calculator is the enlightenment of interview and the extension of thinking instead of a simple device just for calculating. In terms of recognition, graphing calculator offers a visible way for solving abstractive mathematics questions. At the same time, graphing calculator provides with multiple representations for math question which benefits students' math's intelligence and question solving. Moreover, the appliance of graphing calculator promotes the universal connection with mathematics, for example, other subjects or practice with mathematics. The usage of the graphing calculator allows students to understand how mathematics is integrated in our lives.

3.3 The Influence of Graphing Calculator on Students' Mathematical Capability of Self-exploration

The promotion of graphing calculator in our school in recent two years not only arouses the interest in mathematic of the students, but also cultivates their capability in self-learning and self-exploration, so their mathematical attainments can be improved.

The influence of graphing calculator is embodied below:

(1) Graphing calculator expands the space of students' self-exploration

Students can create a small-scale science laboratory by connecting the graphing calculator with the experimental probes of physics, chemistry, biology etc. They can apply what they have learned in practice, such as a mathematic model to promote the connecting between different subjects. The model takes the skill of the data streamer as catalysts to study how density and temperature influence liquidity. Some students compose a piece of music and learn from the harmonies between mathematic and music using the graphing calculator and progression. Such activities embody the strong relationship between mathematics and practice, between mathematics and other subjects.

(2) Graphing calculator inspires student's awareness of self-exploration

The graphing calculator, with its powerful functionality, benefits students' self-exploration by arousing their favorites and activities in mathematics. "Interest is the best teacher. "Students can form the sense of satisfaction, be happy, proud and motivated with the graphing calculator increasing their awareness of self-exploration. Thus, students open their eyes and expand their learning space, so they can gain more knowledge and achievement.

(3) Graphing calculator enriches the ways of students' self-exploration.

The ways of students' exploration are limited without the graphing calculator. For instance, so many experiments are needed to estimate probability experimentally by hand. The graphing calculator reduces the difficulty. Students can conduct simulating experiments by writing programs and experiencing the process of how the frequency approaches probability. Moreover, in previous exploration, data is usually offered by the teacher or text book directly. However, with the help of the graphing calculator, especially the skill of data streamer, students can collect data about frequency, temperature, force, PH value and pressure etc. What they gain conveniently by several

small probes, so that they can experience the whole process of posing a question, collecting data, processing data and finding a result. The development of the exploration method inspires students' enthusiasm for mathematical research, enhances the quality and depth of research and expands their capabilities of mathematical exploration.

Under the new curriculum, the graphing calculator arouses students' fervor for self-exploration, expands the space of self-exploration, enhances the capability of research and promotes the implementation of new mathematical curriculum reform. As a teacher, we should understand the new technologies and position ourselves to create an environment for students' exploration and become the inspirer for students' research. Friedrich Adolf Wilhelm Diesterweg (Germany) said that: "The essential of teaching art lies in inspiring, stimulating and encouraging instead of imparting knowledge. "Moreover, the teacher should grasp firmly the principles of "everybody having, using appropriately, and using frequently" making the graphing calculator into a reliable assistant which is helpful for students in the application of mathematics".

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