

# Some Mathematics Supplements of Using Graphic Calculator for Vocational High Schools

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**Abstract:** In this paper, we showed some mathematics supplements by using capability of graphic calculator to assist learning mathematics for vocational high schools in Taiwan. In the supplement, graphic calculator is used to study how to solve mathematical application problems. Graphic calculator has never been used as a formal tool for vocational high school mathematics course in Taiwan, one of the reasons is that there is no proper supplement for use in the regular course. As a result, we designed a localized reference, which demonstrates how to use functions of graphic calculator step-by-step to solve mathematics problems. Output in the calculator was also converted into a powerpoint file to guide first-time users how to operate this tool, most importantly, this supplement also covers part of the contents in the regular course to show how calculator as an aid. A localized webpage was given to demonstrate material that we have developed to help and enhance this technology-based learning environment. Some survey was given to show effectiveness of using this tool in learning and teaching mathematics by graphic calculator, if possible, here in Taiwan.

## 1. Introduction

Evidence from literature review and research has showed that calculator is an effective tool for enhancement of mathematical concept, development of mental arithmetic skills, pattern recognition, mathematical investigation, solving real life problem and improving problem solving ability [7]. Scientific calculator has being adapted in some regular courses between elementary and high school at many western developed countries, similar trend also become popular in some Asian countries recently [1, 3, 4]. But, research on this issue seems less popular here in Taiwan. Further more, there are some negative opinions about using this tool in teaching and learning mathematics, people blame calculators for the student's lack of calculation skill. But, statistics shows it is on the contrary to some countries that uses calculator in their regular courses. The statistics shows that student's creativity is even higher than those who were taught by traditional teaching methodology in some Asian countries [1]. In addition, in Singapore, calculator will be adapted into their curriculum of elementary school mathematics. The use of scientific calculators will be first allowed in Singapore Primary School Leaving Examination (PSLE) for all primary level mathematics subjects from the year 2009 onwards. Following the revised mathematics syllabus and curriculum in 2007, not only is the use of calculators is included in the national examination, all Primary 5 and 6 mathematics teachers will be expected to integrate the use calculator into their

mathematics lessons from 2008 onwards [7]. As a result, primary school mathematics teachers are required to be proficient in using the calculator and adept at facilitating pupils' usage of the calculator so as to meet the new assessment requirements. According to this observation, we have carried a study to investigate how to use calculator in teaching and learning for both teachers and students, in order to have a better resolution of whether to use this tool in our educational system in the future. The subject we choose in this research is coming from text books of vocational high schools in Taiwan. The difference between vocational high schools and high schools is that vocational high schools student learn applied sciences or skills and can choose either continue to study in the technical universities or join work force after they graduate. But most high schools students will continue to study in the universities. There is no extra energy to do any experiment outside of regular courses. As a result, using calculator in learning mathematics will not make too much influence for vocational high schools students, in addition, the capability of manipulate calculators easily may be a positive factor for them to join work force.

This paper will mostly focus on how to use graphic calculator on the subject of vocational high school mathematics. We will develop a localized mathematics supplement which demonstrates how to use it in solving mathematics problems and the result will be put in a webpage for future reference. In section 2, we will describe how this calculator-based teaching methodology is related to the constructivism. Section 3 will give the idea of how the localized calculator-based text is developed. A webpage was designed to provide service for first time users. Section 4 will give statistics of a questionnaire to show its effectiveness in implementing calculator in learning mathematics.

## **2. Methodology**

In order to understand if calculator-based teaching can be implemented according to the constructivism which is currently the philosophy of teaching in Taiwan, we will try to investigate the similarity between these two subjects. The following items will be outlined to show calculator-based teaching fits well for the idea of the constructivism.

### **a. Self-Learning**

If the consequence of students' learning in school is not able to do creation by themselves in the future, then their whole life are nothing but imitating and copying. As a result, the learning reform is to make a change of student's learning attitudes. We have to encourage student to find their own solutions, at the same time, their creativity is also established. If student can use calculator in learning, they will learn knowledge through their own operation, it is not any more to learn knowledge from the text book only. It will not only bring up student's interest but also to let them ask and discover how to solve the problem. Teacher will be only a guidance in the classroom

### **b. Process**

By the calculation ability of calculator, student can focus on how to solve, without devoting their energy simply in calculation. It can encourage students to spend more time on thinking, analyzing, collecting data, and managing how to solve. In other words, it can encourage students to establish creativity to solve problems.

### **c. Environment**

The graphing capability of calculator is similar to computer online teaching or distance learning. Students can also use the output of graph calculators to analyze how to do next. However, the calculator is a lot more portable than computer.

### **d. Discussion**

Every student has their own calculator, and they may solve the same problem but with different strategies. Teacher can divide students into different groups to show their discovery

and through discussion they may be able to find more interesting results. In addition, students can learn how to express themselves through discussion and questioning.

#### **e. Applications**

If teacher can provide more application problems, through operating calculator, students can establish their capability to solve daily challenge by fully utilizing the equipment. In addition, students can be benefited by the process of data collection, observation of the problems, thinking, equipment utilization, group discussion, and human relationship. From above observation, we find that calculator-based teaching indeed quite fits for the idea of the constructivism.

### **3. Research Method**

We will give a sample instruction material [2] to show how calculator-based texts should be given at the vocational high school. Students are required to understand purpose of the lesson and instructor to understand its purpose of teaching. They are outlined in the following;

**Subject:** Trajectory of a tossing object

#### **【Object of the lesson】**

1. The Knowledge object:  
Learn how to make horizontal component and vertical component of a vector.
2. The Capability object:  
Be able to graph a function by calculators, and to find roots of a function.
3. Related objects:  
Try to make students involved in the solving environment created by calculators, and be able to use functions developed from solving this problem to similar problems. .

#### **【Procedure of teaching this lesson】**

1. Instructor needs to give definitions of these functions in the beginning.
2. Explain how the function should be defined.
3. Get to know the function of the calculator and learn how to operate it.
4. Get to know how to operate calculator and use it to learn mathematics. Demonstrate how to use graphing function of the calculator and let student discuss all kind of possibility.

#### **Use trigonometric functions to calculate the trajectory of a tossing object**

A projectile is launched in the x-y plane at an angle of 30 degree upward from the horizontal (the x-axis), with an initial velocity 40m/sec. Assume the only force is the gravity, how far can this ball reach horizontally? When will it reach the ground? And what is the highest position it will reach?

#### **Solution Method:**

Instructor explains the problem first, and asks if there is any idea to solve this problem from students. Students can go to demonstrate their idea, and eventually instructor will show how to solve this problem by component of vectors.

Assume the initial velocity is  $V_0$ , the angle between horizontal line and tossing direction is  $\theta$ , and assuming the position of the ball is a function of time. In solving this problem, we need the knowledge of differential equations. But, at this exploration problem, authors just want to use the graphing capability of calculators to make students know how to tackle this problem by just viewing its trajectory. We have to omit the solutions of this problem analytically.

Define horizontal and vertical component of the position vector of this object as the followings:

Horizontal component :  $X_1(t) = tv_0 \cos(\theta)$ ,

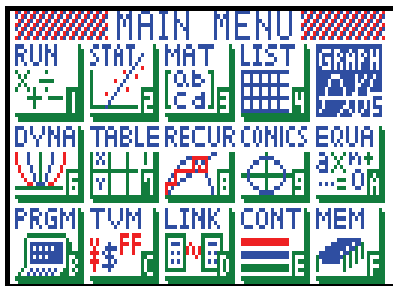
Vertical component :  $Y1(t) = tv_0 \sin(\theta) - \frac{1}{2}gt^2$ , and  $g = 9.8m/sec^2$ .

Now, instructors need to show step by step how calculators can be used and what functions can be chosen to solve this problem. The following outputs from the calculator are given to match the commands given by the instructor. Authors also develop a manual with detail procedures and outputs for first time users to learn step-by-step to manipulate the calculator [2].

Type  $\boxed{AC/on}$  to turn on the machine

Type  $\boxed{MENU}$  to show function manual

Type 5 or move right-left key to the  $\boxed{GRAPH}$  function

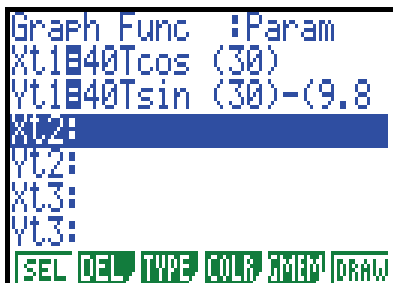


Type  $\boxed{EXE}$  to enter define module, and define the view window,

Type  $\boxed{F3}$ (TYPE) to choose parameter (Parm).

Enter the horizontal component as function :  $X1(t) = tv_0 \cos(\theta)$  and vertical component t as

function:  $Y1(t) = tv_0 \sin(\theta) - \frac{1}{2}gt^2$ .



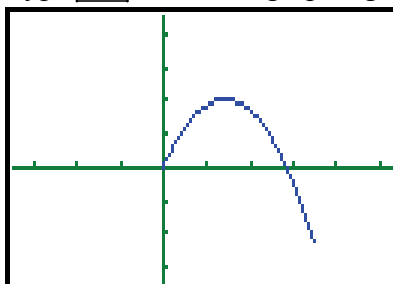
Remember to enter  $\boxed{SHIFT}$  →  $\boxed{MENU}$ (SET UP) to set up.

Make Angle be Deg (degree module).

**Discussion:**

Students can use radian instead of degree. To let them redefine these functions and discuss the different between these two setting.

Type  $\boxed{F6}$  to use the graphing function,



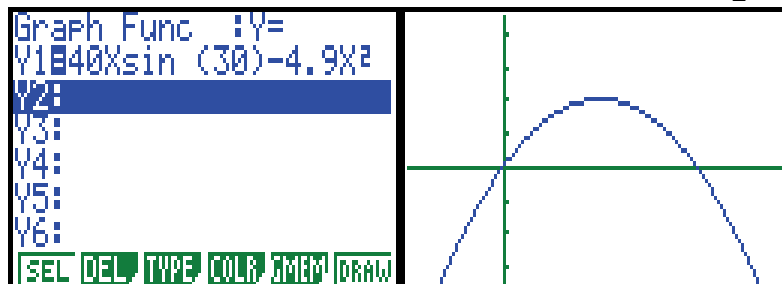
From the output, we can see the trajectory of the tossing ball.

### Discussion:

To find the highest location of the ball, we need to use the vertical component function instead of the horizontal component function.

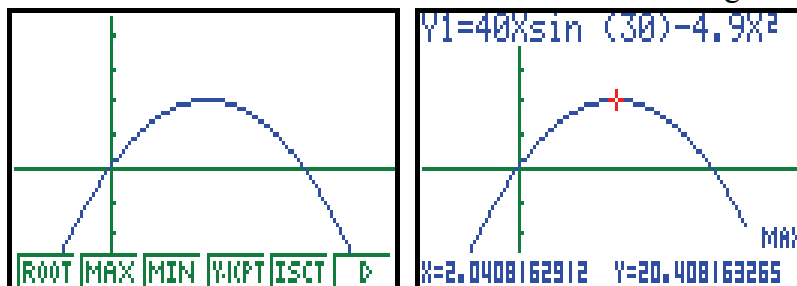
Back to manual, type  $\boxed{F3}$ (TYPE) and change function as  $\boxed{Y=}$ .

Enter the vertical component function:  $Y1(t) = tv_0 \sin(\theta) - \frac{1}{2}gt^2$ , use x as time t.



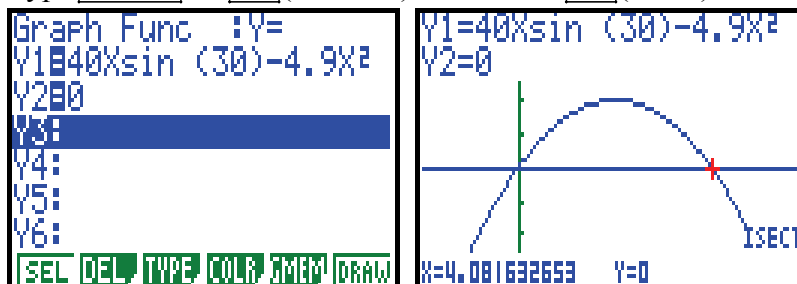
Type  $\boxed{SHIFT}$   $\rightarrow$   $\boxed{F5}$ (G-Solv).

Use the function of CASIO 9850 to find maximum of a given function as  $\boxed{F2}$ (MAX),



From the graph, when t equal 2.04, the ball will reach the highest position and the height is about 20.4. In order to find out when the ball will hit the ground, we need to define a new function  $Y2=0$  and find the intersection of the vertical component function and the new function.

Type  $\boxed{SHIFT}$   $\rightarrow$   $\boxed{F5}$ (G-Solv) and choose  $\boxed{F5}$ (ISCT) to find the intersection.



### Discussion:

Instructor can ask if there is any other way to find the solution. Can we use the root of the vertical component function as the solution? Eventually, when  $x = 4.08$  or time  $T = 4.08$ , the ball will hit the ground. Substitute it back to the function  $X1(t) = tv_0 \cos(\theta)$ , and we know the longest distance is about 141.34.

### Practice:

#### Discuss the following questions:

When the ball will reach the highest position? What is the velocity of the ball at that position?

A webpage [5] is designed and provided as a media for the first time users to learn how to operate this tool when they try to solve mathematics problems. Powerpoint files are created to

demonstrate step-by-step procedures given in the calculator to show how to operate certain functions; worked problems are given with outputs to let users know if they have used correct functions. Some contents in the webpage are outlined in Figures 1-3.

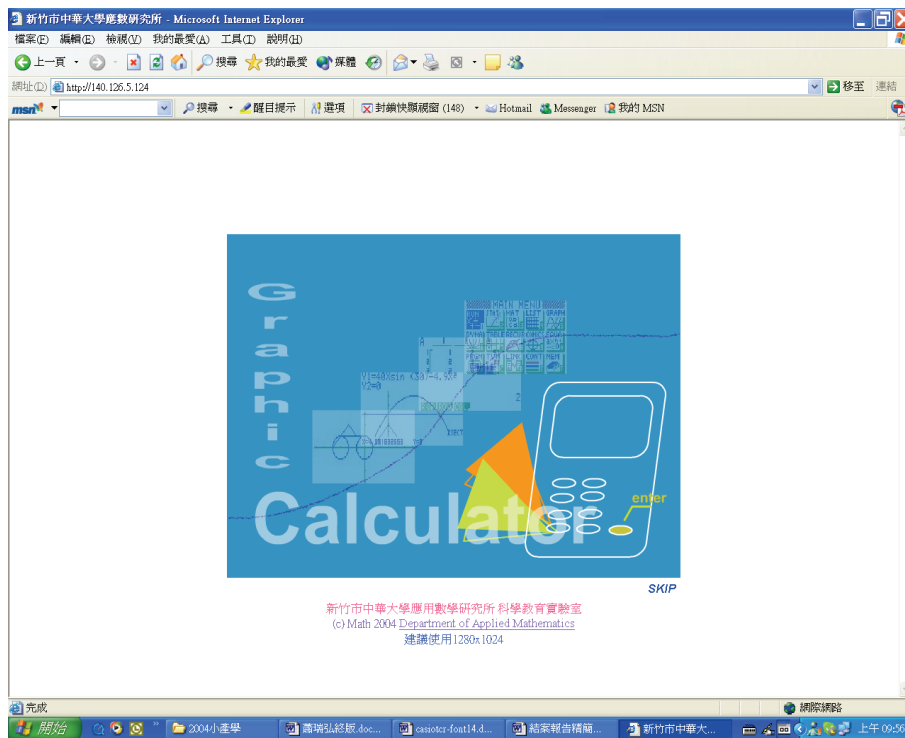


Figure 1: The front page of webpage Calculator Studio

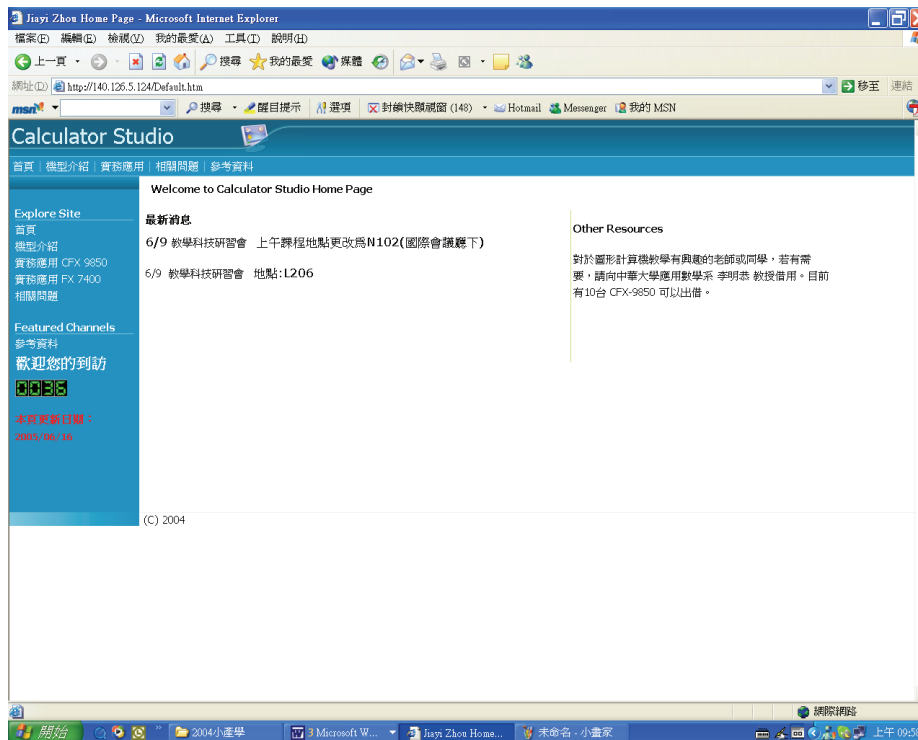


Figure 2: Contents of the Calculator Studio

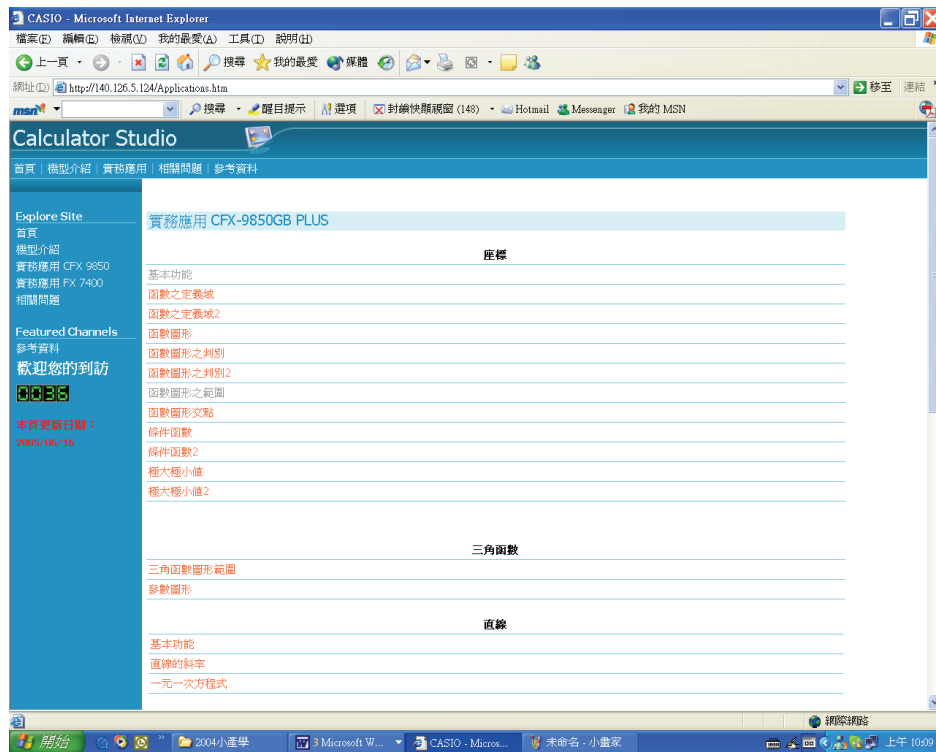
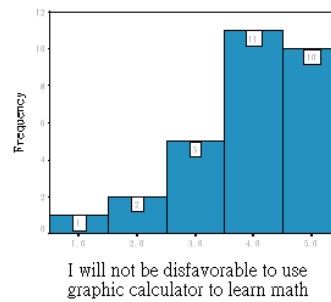
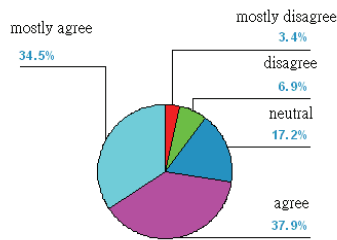


Figure 3: Application Problems from Vocational High Schools Mathematics

#### 4. Results and Discussion

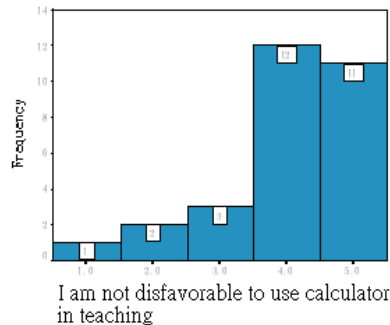
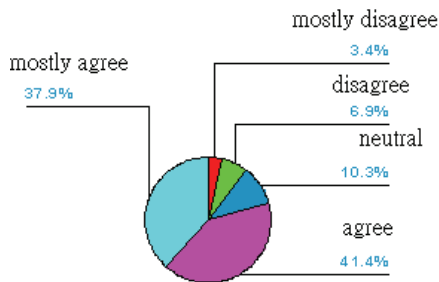
In this section, we will outline some of the results and the statistics of using this material in a workshop to show its potential. A localized text book which combines CASIO CFX-9850 GB Plus as a tool in teaching is developed. It consists of mathematics materials in the regular course and some application problems which are incorporated with functions of the calculator. To study the effect of implementing this text in a regular course is difficult to proceed in any school, since they have regular schedule to follow up. In addition, they are not familiar with this tool. Fortunately, we use part of the contents in a one-day workshop to demonstrate how it can be used in teaching. The attendees are mostly major in education, who will be teachers of Junior high schools in the future. In that section, there are 29 attendants, and 29 questionnaires are collected. The questionnaire is designed based on the idea given at [6]. There are 10 questions in this questionnaire. Some of the questions are outlined for reference, there are: 1. I like the way by using calculator to learn mathematics; 3. I do not against using calculator to learn mathematics; 8. I will not against to use calculator in teaching; 10. I will encourage my colleagues or students to use calculator to learn mathematics. The following are part of the result of the statistics. (The ratings of the questions are divided into 5 levels, 5.0 means mostly agree, 4.0 means agree, 3.0 means neutral, 2.0 means disagree, and 1.0 means mostly disagree.)

**Item 3.** I do not against using calculator to learn mathematics.



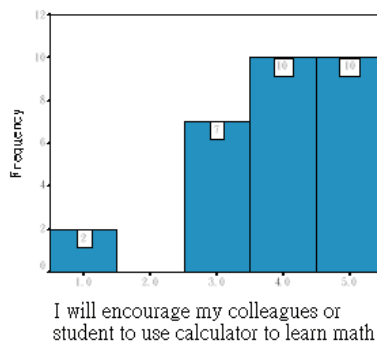
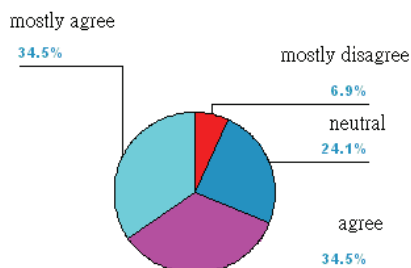
From the pie chart it shows that there are 37.9% agree, and 34.5% mostly agree. There are almost 70% of the whole attendants who accept to use calculator to learn mathematics. There are only 3 persons do not favor using calculator. Basically they do not have more time to do practice, it will be better if they can learn more about this technology from more seminars of this kind.

**Item 8.** I will not against to use calculator in teaching



From the pie chart, it shows that there are 41.4% agree, and 37.9% mostly agree. There are almost 80% of the whole attendants who will tend to use calculator in their teaching if they know more about this technology. It takes more time to prepare in order to use it in teaching and perhaps it also has more challenge too. Time consuming problem makes some attendants feel hesitate about using this technology. But, if they can have more training sessions, this situation should be better.

**Item 10.** I will encourage my colleagues or students to use calculator to learn mathematics



From the pie chart, it shows that there are 34.5% agree, and 34.5% mostly agree. There are almost 70% of the whole attendants who will encourage their colleagues or students to accept



this new technology at their schools. Specially, there are 2 persons do not favor, it shows that technology is still not 100% accepted in the current teaching environment. Over all, it shows that there is a great potential to promote this technology to learn mathematics in Taiwan education system.

The rest results will not be given here, but most of them are positive about implementing calculator to help learning or teaching mathematics. Nevertheless, research in using technology to assist learning should be done more in the future.

## 5. Acknowledgement

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