

Experimental Design: Utilizing Microsoft Mathematics in Teaching and Learning Calculus

Rina Oktaviyanthi Yani Supriani
Universitas Serang Raya, Banten, Indonesia

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Abstract

The experimental design was conducted to investigate the use of Microsoft Mathematics, free software made by Microsoft Corporation, in teaching and learning Calculus. This paper reports results from experimental study details on implementation of Microsoft Mathematics in Calculus, students' achievement and the effects of the use of Microsoft Mathematics on students' attitudes in relation to such experience. Two classes of the students from the first year student in Universitas Serang Raya were participated in the study. Control group was taught by using conventional teaching method, whereas experimental group was taught by using Microsoft Mathematics software. Assessment of students' achievement was collected previous to and after experiment by giving the test. At the end of the lecture, both groups completed the questionnaires indicating their attitudes toward and self-confidence in mathematics and computers. In addition, the experimental group was asked to complete a questionnaire about their attitudes toward using Microsoft Mathematics. Interview process was added to complete the data. This study found that students who taught by using Microsoft Mathematics had higher achievement and has a positive effect on students' confidence of mathematics.

Keywords: calculus, educational technology, experimental design, microsoft mathematics, technology application

1. INTRODUCTION

Learning mathematics is closely related to visualization and representation of mathematical objects and procedures. In relation to learning mathematics, technology is identified as a tool and important component to support visualization and interactive media [1] that assist representation, reasoning, calculation construct, exploring, and solving problem. As NCTM asserts that, "*technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning. Teachers' attitudes play an important role in using technology in teaching and learning mathematics* [2]."

The use of technology in education improves learning significantly better than conventional learning. By using technology, students engage in connecting the schools to the wider world, giving the dynamically display linked by multiple representation, interactive models and simulations of learning material [3]. Integrating technology in teaching and learning process is expected to enhance the students' ability to understand the complex idea and able to construct problem solving. There are many studies that have focused on the integration of technology in education purposes from various perspectives. As noted by Churchill (2005), "*technology amplifies our intellectual and physical capacity* [4]", and in this context the technology take part in fundamental role in supporting the complex learning.

One method to integrate the technology in education purposes is applying a computer through multimedia instruction to present and communicate learning materials. Multimedia instruction is presentation involving words and pictures proposed to promote learning [5]. In this way, information processed through both verbal and nonverbal express, in order that the students have the opportunity to optimize the cognitive to take the information given. It is associated with '*the dual coding theory*' that had been developed by Paivio (2006) which emphasizes the concretization of knowledge through images and pictures [6]. An important aspect of multimedia is the principle of multimedia instruction. Connecting with this principle, Mayer (2001) states, "*people learn better from words and pictures than from words alone. When words and pictures are both presented, learners have the opportunity to construct verbal and visual mental models and to build connections between them* [7]."

Calculus is a branch of mathematics that includes limits, derivatives, integration, and infinite series. Calculus which has general applications in science and engineering is used to help solve the complex problems that are not sufficiently solved by basic algebra techniques. Based on the author's experience in the lecture on the first year students in Faculty of Information Technology of Universitas Serang Raya, known that most of the weaknesses of students are only able to perform simple calculations. This problem is a challenge for teacher to find out the alternative solutions in learning Calculus not only to attract and motivate students, but more to provide prospects for students to develop skills in understanding, reasoning, and problem solving. Learning applies the computer used as a solution to these problems. Several computer programs can be used as a tool of interactive and dynamic learning.

Microsoft Mathematics program is free software made by Microsoft Corporation that has a symbolic computing system and work based on mathematical expressions. Microsoft Mathematics as mathematics computing software is appropriate to utilize in assist students to solve the problem of Linear Algebra, Statistics, Calculus, and Trigonometry.

2. LITERATURE REVIEW

One of the main goals in mathematics education is to ensure the success of all students in understanding mathematics. Mathematics is regarded as one of the subjects in the most challenging and problematic aspects of education. However at the same time, mathematics is the most important study in science, considering mathematics as knowledge that is widely used in daily life and applied to many others fields of science. Mathematics is a basic tool in analyzing the concepts of each field in the aspect of human life [8]. For this reason teachers should focus on the development of students' understanding of mathematical concepts and need to provide a quality educational environment. Many students judge complicated to engage with mathematical concepts. Duval (in Curri, 2012) states that, "*there is no understanding of mathematics without visualization* [9]". The visualization is intended to be a concrete tool that facilitates students to explore mathematical concepts.

Technology is useful to support students in understanding concepts, reasoning, building and exploring knowledge, solving problems and generating new information. Furthermore, it helps students to better visualize the mathematical concepts. The previous researches have revealed that the activities supported by visualization can improve the learning mathematics [10]. Ashburn and Floden (2006) emphasized the importance of using technology in mathematics learning is to build a graphical representation and symbolic expression of mathematics to assist students in creating the goal of understanding [11]. The approach of technology involves the actions, perceptions, and learning products based on doing, teaching, and seeing [12]. By using multimedia instructions students can communicate information, involve more than one model of presentation, and reminding how a material can be presented. Multimedia instruction is a method for students to represent an abstract object of mathematics. Research showed that using the tools of representation in teaching and learning can support the development of students' mathematics understanding [13]. Being able to connect the different mathematical representations or generate new representations of the same object has proven to be a strong indicator in an effort to increase students' knowledge and understanding.

There are many researchers who concluded that interactive technology especially as visualization tools are an effective media to engage students in the learning and create meaningful learning [14]. It creates interactive visualization is an important aspect in learning process. Connecting different visualization provides different benefits in cognitive development as well. Technology used for the education purposes should be complemented with dynamic animation and flexible so that students can build an understanding in the better way. Hogstad and Brekke (2010) states, "*students need to see things moving to understand and to process information* [15]".

Calculus is part of the mathematics. Calculus plays an important in the curriculum in almost all disciplines, such as engineering, science, business, economics, computer science, and information system. Calculus concepts are arranged in a systematic, logical, and hierarchical from the simplest to the most complex. In other words, understanding and mastery of a concept is a requirement to recognize the further concept. Therefore naturally the mastery of Calculus is essential in learning. However, many students make the Calculus as a trouble in the learning process. Calculus as part of the mathematics has an abstract object that most students are not able to imagine the object.

Microsoft Mathematics is free software made by Microsoft Corporation. This software provides users to perform computational mathematics. Writing, calculating, and manipulating of mathematical expressions and graphical visualization of 2D, 3D and animation can be carried out with simple instructions. Solving problems using Microsoft Mathematics featured step solution of a problem as that obtained when done manually. For example, the function $f(x) = x^2 - 3x + 4$ will be investigated the first derivative of $f(x)$ and its graph in 2D and 3D.

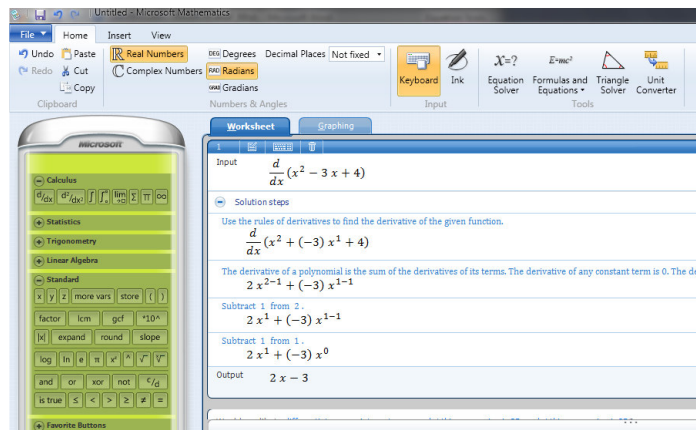


Figure1. Tutorial of differentiation method in Microsoft Mathematics

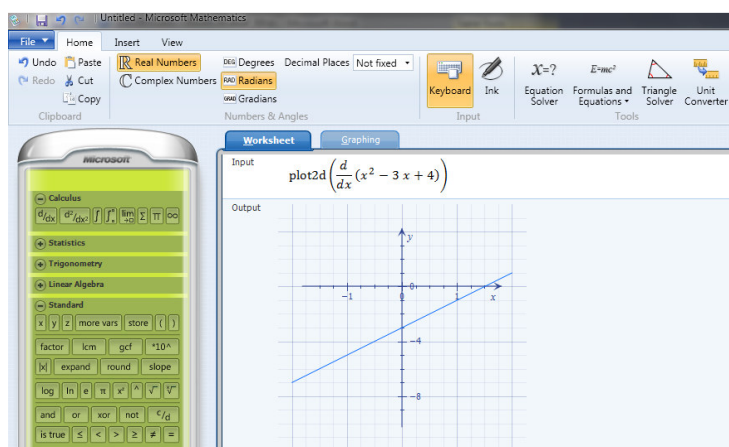


Figure2. Plot graph in 2D

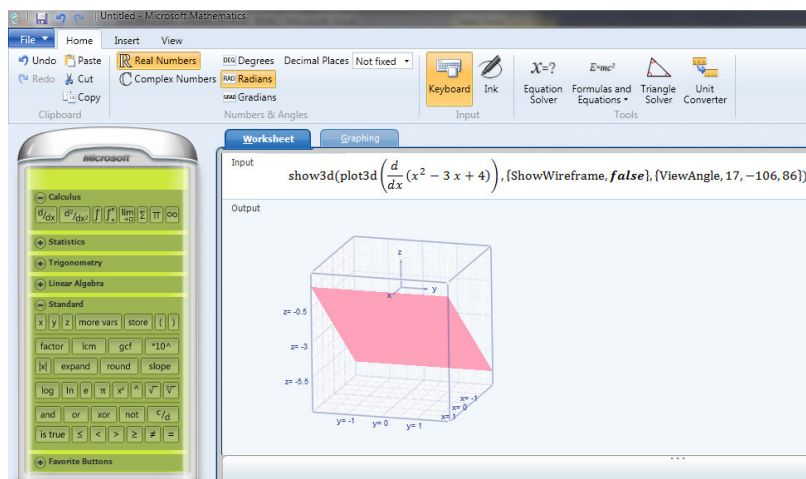


Figure3. Plot graph in 3D

3. METHODOLOGY

The main aim of this study was conducted to answer the following research questions:

- What is the role of Microsoft Mathematics in the teaching, learning, and understanding of Calculus?
- What are the effects of the use of Microsoft Mathematics on students' attitudes towards mathematics in the classroom?

The first aim of this study is to find out descriptive information the use of Microsoft Mathematics by students to build their knowledge and construct their understanding related to mathematical content. This data was obtained from the pre-test and post-test of mathematical test both experimental group and control group. Then the data was analyzed quantitatively comparing the group that had experimental teaching using Microsoft

Mathematics with the one that had conventional teaching. Quantitative and qualitative analysis of data collected by earnings of questionnaire about students attitudes toward using Microsoft Mathematics to answer the second research question.

A mixed method research design that integrated both quantitative and qualitative research methods has been used in this study. The quantitative approach assisted to evaluate students' understanding and learning of Calculus concepts using Microsoft Mathematics according to the scores earned. The subjects that participated in this study were 22 students. The students were divided randomly in two groups: control and experimental group. The experimental group was students who taught by using Microsoft Mathematics and the control group was students who taught by conventional teaching. At the end of the lecture the experimental group completed a questionnaire about their attitudes toward using Microsoft Mathematics. The questionnaire was used in experiment study was taken from an article written by Fogarty, Cretchley, Harman, Ellerton and Konki (2001) [16]. In the article clarified that the questionnaire is validated and used to measure attitudes toward using technology in learning mathematics.

4. FINDING AND DISCUSSION

As the experimental work according to the use of Microsoft Mathematics in learning mathematics started by illustrating a review of activities developed to indicate how Microsoft Mathematics has been used in learning Calculus. The results of the mathematical tests, comparing the performance for each student in the pre and the post test between the experimental and the control group were shown.

Experimental teaching using Microsoft Mathematics

This study worked the design experiment methodology that engages in stating the aims, planning to accomplish the aims, collecting and analyzing data (MacDonald, 2008) [17]. This study organized the activities for the use Microsoft Mathematics during the lecture based on three main purposes of using a tool in teaching and learning process (Wilson, 2008) [18]. These activities are shown in the following table with appropriate modification of the research.

Table1. Presentation of activities utilizing Microsoft Mathematics

No	Purpose of using the tool		Description	Pedagogical benefits
1	Promoting drill and practice	As a problem solving	Students used Microsoft Mathematics to try different approaches to solve a given Calculus problem. For example, in solving problems students may start looking for a solution with the graphical, numerical, or algebraic approach.	<ul style="list-style-type: none"> - Reduction time required to practice basic skills - All students involved in teaching and learning process
		As a calculation	Students applied Microsoft Mathematics to determine of the values of the function or to estimate Calculus multiple expressions.	
2	Variation of parameters	As a visualization	Students utilized Microsoft Mathematics to facilitate the better visualization of a function, the concept that is taught or problem situation. For example, students changing parameters of the Calculus function and looking at the changes in the graphical characteristics.	<ul style="list-style-type: none"> - Direct feedback is helpful to make the relation between the parameters in Calculus functions and assist to construct a variable effect the graphical representation
		As a graphing	Students used Microsoft Mathematics to graph function and to solve problems related to area under a curve or area of intersection of the two curves.	
3	Conceptual understanding	As an exploratory	Microsoft Mathematics applied to investigate and recognize concepts of integration. For illustration, students explored and presented integration of one or more function using Microsoft Mathematics in the algebraic and graphical representation.	<ul style="list-style-type: none"> - Emphasis on recognizing of learning the algorithm for solving function equations
		As a confirmatory	Students applied Microsoft Mathematics to validate their answers in problem solving tasks.	

Accessibility of Microsoft Mathematics recommends students not only in discovering the concepts of Calculus, but also in communicating the concepts mathematically. By using Microsoft Mathematics students were able to present their solutions and provide feedback to the teacher during the lecture.

Pre and post test result

In the following tables show the results of the pre and post test and the mean of the result both experimental group and control group.

Table2. Pre test and post test scores of students in the experimental group

No	Experimental Group	Pre test	Post test	Difference of result
1	S1	90	95	5
2	S2	87.5	90	2.5
3	S3	82.5	90	7.5
4	S4	66	73	7
5	S5	61	70	9
6	S6	68.5	75	6.5
7	S7	75	70	-5
8	S8	90	90	0
9	S9	49.5	63	13.5
10	S10	77.5	75	-2.5
11	S11	70	83	13
Mean		74.32	79.45	5.14

Table3. Pre test and post test scores of students in the control group

No	Control Group	Pre test	Post test	Difference of result
1	S12	73	58	-15
2	S13	82	78	-4
3	S14	64.5	75	10.5
4	S15	76.5	75	-1.5
5	S16	93	95	2
6	S17	71.5	75	3.5
7	S18	66.5	75	8.5
8	S19	69	58	-11
9	S20	62	73	11
10	S21	90	75	-15
11	S22	50	70	20
Mean		72.55	73.36	0.82

Generally by comparing to the pre test results, both groups had higher performance in the pre test. In the experimental group can note that the average of the difference between pre test and post test is 5.14 that are significantly higher than in the control group, which is 0.82. This shows that the students in the experimental group advanced more in the post test than students in the control group. There are two students in the experimental group and four students in the control group which had lower performance in the post test. In Table4 and Table5 are shown the descriptive statistics calculated with SPSS of both groups.

Table4. Normality of the data pre test

Tests of Normality

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
ExperimentalGroup	.209	11	.197	.919	11	.311
ControlGroup	.253	11	.048	.839	11	.301

a. Lilliefors Significance Correction

The respondent of this study is less than or equal to 50, then the normality of the data using The Shapiro-Wilk. The data will have a normal distribution if p is greater than or equal to 0.05. From the Table4 obtained sig. for both experimental and control group is > 0.05 . It indicates normality of the distribution pre test scores.

Table5. Descriptive statistics of pre test scores in both groups

Group	N	Mean	Std. Deviation	Std. Error of Mean
Pre Test 1. Experimental Group	11	74.3182	12.87686	3.88252
2. Control Group	11	72.5455	12.50091	3.76917

According to Table5 above, there are no significant differences from two groups in pre test results. It means that the level of students in two groups generally is the equal. This information is important for the analysis of post test results, as compared the control group that had conventional teaching with the experimental group that participated in experimental teaching using Microsoft Mathematics. The knowledge level of students in both groups based on the mathematical content can be defined as a good level as their average scores are 72-74 (the maximum of scores was 100).

Figure4 shows the graphical representation regarding to the frequency of scores gained by the students for each group.

Graphical Representation of Pre Test

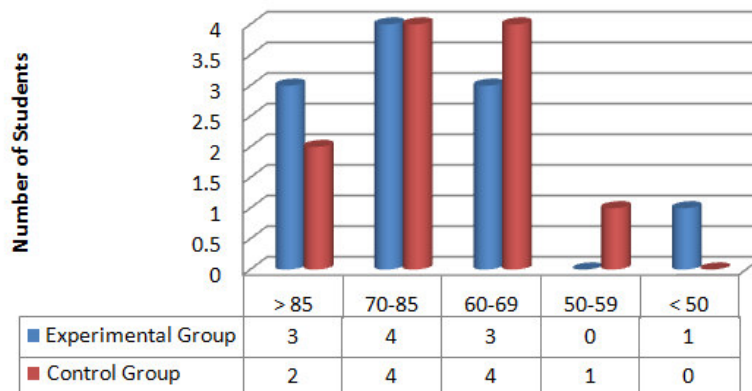


Figure4. Graphical representation of pre test in both groups

From the Figure4 noted that the frequency of scores for both groups is approximately the same, particularly in the interval of scores 70-85. The other intervals are compensated, for illustration in the intervals 50-59 there are no students from the experimental group, but in the interval > 85, there are many students from the experimental group.

Next here below is presented the descriptive statistics of the post test scores of two groups (Table6 and Table7).

Table6. Normality of the data post test

Tests of Normality

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
ExperimentalGroup	.120	11	.200*	.950	11	.640
ControlGroup	.122	11	.200*	.975	11	.931

a. Lilliefors Significance Correction

*. This is a lower bound of the true significance.

From the Table6 gained sig. for both experimental and control group is > 0.05. It indicates normality of the distribution post test scores.

Table7. Descriptive statistics of post test scores in both groups

Group	N	Mean	Std. Deviation	Std. Error of Mean
Post Test 1. Experimental Group	11	79.4545	10.57699	3.18908
2. Control Group	11	73.3636	9.93250	2.99476

In Table7 noted that the higher mean is earned by the experimental group with a difference is 6.09. This illustrates a significant result for the study that the experimental group had better performance than the control group in the post test. Here below shows the graphical representation of the post test result based on frequency of scores gained by the students in both experimental and control group.

Graphical Representation of Post Test

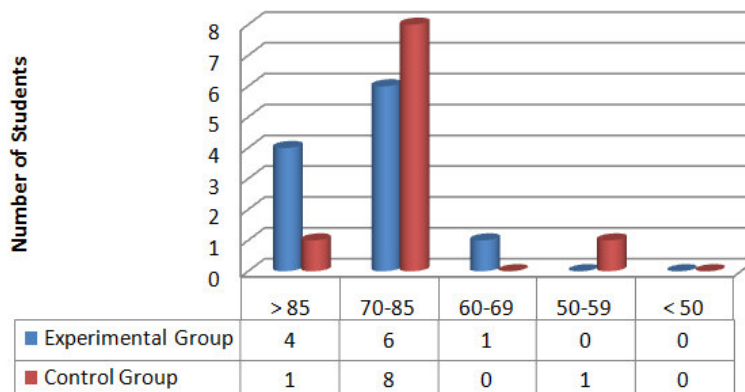


Figure5. Graphical representation of post test in both groups

In Figure5 above describes that the frequency of scores > 85 is greater in experimental group, and the frequency of scores 70-85 is greater in the control group. The data clearly specify that the performance of students in the experimental group was better than in the control group.

Students’ attitudes toward using Microsoft Mathematics

Cronbach’s Alpha reliability pre and post both groups, as shown in Table8, are high and accordingly describe that the mathematics attitude investigation could be accepted as a reliable instrument for the purpose of the study.

Table8. Cronbach’s Alpha reliability coefficients for the pre and post both groups

Method	Item	Cronbach’s Alpha
Experiment Group	Overall	.863
	Mathematics Confident	.836
	Computer Confident	.909
Control Group	Overall	.950
	Mathematics Confident	.810
	Computer Confident	.728

Both control and experimental group have given the questionnaire 1 and 2. The questionnaire 1 is about mathematics confidence attitudes and the questionnaire 2 is about computer confidence attitudes. Here below are the following details of the results.

Categories of Attitudes The Questionnaire 1

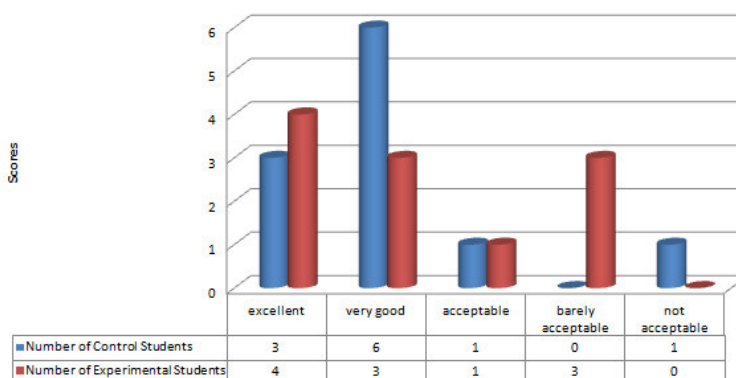


Figure6. Categories of attitudes both groups on the responses from the mathematics confidence questionnaire

According to the Figure6 mostly students in the control group had “very good” attitudes related to mathematics confident and generally students in the experimental group had “excellent” attitudes.

Categories of Attitudes The Questionnaire 2

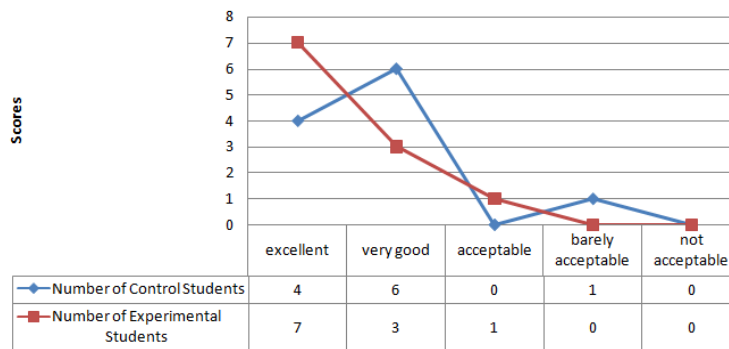


Figure7. Categories of attitudes both groups on the responses from the computer confidence questionnaire

Associating with computer confident, from the Figure7 can be noticed that commonly students in the control group had “very good” attitudes and in the main students of the experimental group had “excellent” attitudes.

5. CONCLUSION

The main aim of the research is to investigate the roles of Microsoft Mathematics in teaching and learning Calculus. Here below presented the answers of the research question, according to the results of the research.

a. What is the role of Microsoft Mathematics in the teaching, learning, and understanding of Calculus?

From this study along with previous researches on the use of computer for education goals demonstrated that applying program computer, in this study is Microsoft Mathematics, in classroom is important to improve students’ learning. Interactive visualization which is a branch of graphic visualization in computer science is essential components offered by Microsoft Mathematics. It facilitates students to better understand in mathematical content and involve studying how students interact with computer to improve representation that is not obtained with conventional teaching. As shown by the students’ achievement in the experimental group in the post test compared to the students’ achievement in the control group. The qualitative analysis of this study is according to on the model below (Curri, 2012) [19].

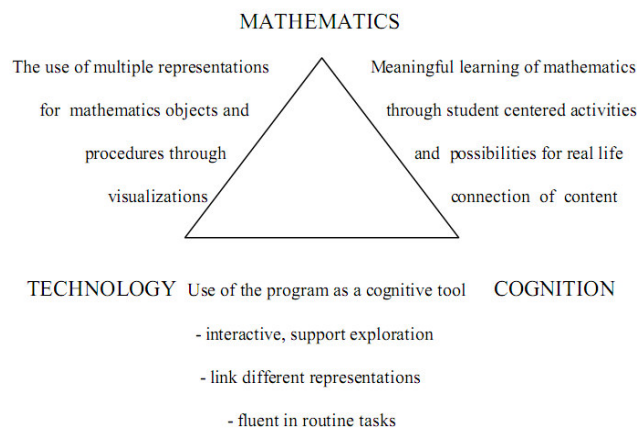


Figure8. Qualitative analysis model by Curri (2012)

b. What are the effects of the use of Microsoft Mathematics on students’ attitudes towards mathematics in the classroom?

Generally this study informs the positive attitudes toward the use of Microsoft Mathematics. It assists students to gain the better understanding, enrich students’ mathematics learning, and increase students’ motivation to get more involved in learning activities. As illustrated by students’ response through completing the questionnaires.

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