

How do students act with Dynamic Mathematics Software in Classroom?

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Abstract: *In this paper, we will present the results of observation of students' action in mathematical modeling class with DMS(Dynamic Mathematics Software). Especially we chose GeoGebra for our research tool, because it is easy-to-use software and has the same grammar of command with school mathematics. In this research, we observed two students' actions with the video which was recorded in the computer and at the back of the classroom. They acted as researchers in the classroom and asked few questions to the teacher. Students modified their works many times and we could observed that students' concept became better. Students also could understood vector addition according to operation in GeoGebra without the mathematical term.*

1. Introduction

Technology has been considered as a tool for giving dynamic experiences of mathematics education to students in secondary school for many years. Especially, we have various kinds of mathematics softwares now; Mathematica, Maple, Geometer's Sketchpad, Cabri(II), GeoGebra, Graphical Calculator etc. Moreover, we also can find various studies using these technologies (see [1], [2], [3], [4], [5] and [6]). These studies were investigated by various aspects with technologies.

However, we still don't know well how students usually act with computer software in mathematics classroom in details. We can only guess that students do experiments about mathematics concepts and eventually find out them. In this study, we researched what students do with technology in the process of mathematical modeling in classroom.

First, we should choose a software for this study. There are many kinds of mathematics software; CAS(Computer Algebra System; Mathematica, Maple), DGS(Dynamic Mathematics Software; Geometer's Sketchpad, Cabri(II)), DHS(Data Handling Software; Spreadsheet) and DMS(Dynamic Mathematics Software; GeoGebra). We decided that GeoGebra was appropriate software for our study, because GeoGebra has functionalities of CAS, DGS and DHS and is easy-

to-use software from very young students to advanced college users. We described students' action with GeoGebra and analyzed them.

2. Introduction of GeoGebra

History of GeoGebra

In 2002, GeoGebra was created by Markus Hohenwarter at University of Salzburg, Austria. He implemented a software that have functionalities of Dynamic Geometry Software(DGS) and Computer Algebra System(CAS). After publishing GeoGebra on the internet in 2002, teachers in Austria and Germany started to use GeoGebra for teaching mathematics (see [7]).

In 2009, Kyeong-Sik Choi who studied in graduate school of Seoul National University had translated GeoGebra 3.2 and its official manual into Korean. In Korea, GeoGebra have been popularized via GeoGebra Korean user community, GeoGebra Naver café (<http://cafe.naver.com/geogebra>) (see [6]).

Functionality of GeoGebra

GeoGebra is an educational software which can manipulate 2-dimensional mathematical objects with algebraic and geometric representation. For example, $y = x$, a linear function, is represented an equation in algebraic view and a line in geometric view.

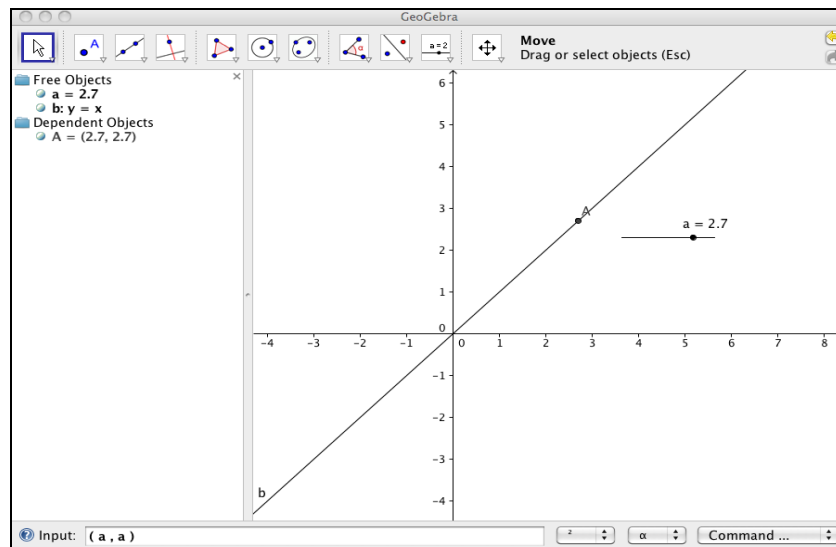


Figure 1. GeoGebra User Interface

GeoGebra also has command and slider. Slider is the visualization of variable in GeoGebra. For example, after making slider 'a', we can type (a, a) in 'Input field' in order to make a point in 'Geometric view' of GeoGebra. GeoGebra command has the same grammar of school mathematics, so that students need not learn another language for handling this software. (see [8])

3. Methodology

This study was a pilot study, because there was not any study for analyzing students' activities with GeoGebra in mathematics classroom. Thus we should observe all actions of students and analyzed them.

Teacher's role

In these lessons, teacher was just a facilitator; giving motivation to the students, asking some questions for making students think and find a proper way. In other words, teacher provided opportunities for the students to consider problems with a proper way.

Students

2 students' activities were observed and analyzed in this study. Although students were all middle school students (8th, 9th grade) in Korea, one of them could even use calculus. Their math knowledge and preference was as follows:

Table 1: Research Participants (score out of 5)

		S1 (Student 1, 9 th grade)	S2 (Students 2, 8 th grade)
Math Knowledge	Trigonometry	O	O
	Calculus	O	X
Math Preference		5 (very good)	5 (very good)

Classroom Environment

Students had a computer each and teacher explained with the main screen in front of them. They all were accustomed with using computer. The procedure and plan of each lesson was as follows:

Table 2: Procedure of Lesson

Lesson	Procedure	Time
Lesson 1 (What is GeoGebra?)	Questionnaire	10 min
	Lesson	20 min
	Activity	50 min
Lesson 2 (Making curves around our life)	Questionnaire	10 min
	Lesson	20 min
	Activity	50 min
Lesson 3 (Making my solar system)	Lesson	10 min
	Activity	50 min
	Questionnaire/Interview	30 min

Table 3: Lesson Plan

Lesson	Program	Content
Lesson 1	What is GeoGebra?	<ul style="list-style-type: none"> • Introduction of GeoGebra's interface
	How to use GeoGebra	<ul style="list-style-type: none"> • How to construct circular movement of a point • Student's activity

Lesson 2	Making Cycloid curve	<ul style="list-style-type: none"> • Watching Youtube video related with example of cycloid (see [9]) • Student's activity
Lesson 3	Making Solar system	<ul style="list-style-type: none"> • Watching Youtube video related with explanation of solar system (see [10]) • Finding materials (see [11]) • Student's activity

The lessons were held in a computer lab located in researcher's school. Video Capture software was installed on each computer to record the students' individual operation with GeoGebra. An additional camcorder also recorded students' and teacher's situation at the back of the classroom. All students were seated together with each computer for discussing about their activities each other easily.

4. Research Findings

We recorded students' actions in each computer as well as captured all the situations with camcorder at the back of the computer lab. In this session, we will describe students' operation with GeoGebra and analyze them one by one.

S1's operation with GeoGebra

Description

In Lesson 1, even though the teacher didn't give any explanation about how to use GeoGebra, S1 tried to use it. After teacher taught how to use 'slider' (visualization of real variable) to S1, he made a point which had the coordinate of (a, b) in Geometry view of GeoGebra. After that, he also entered (a^2, b^2) and (a^b, b^a) in 'Input field' of GeoGebra for making points of coordinates (a^2, b^2) and (a^b, b^a) .

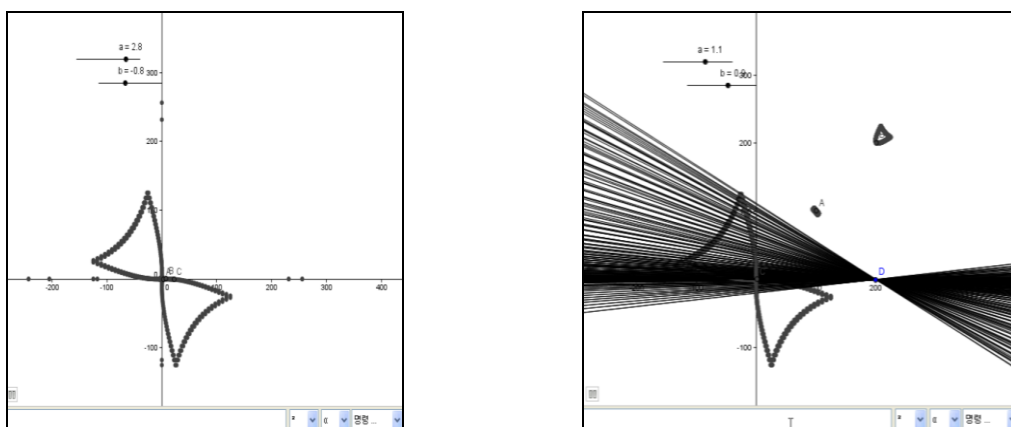


Figure 2. S1's activities in Lesson 1 (S1 made his works according to his own will.)

In Lesson 2, S1 watched a Youtube video related with circular movement of a point. After that, although he had some difficulties in using command of GeoGebra, he entered $(\sin(a),$

$\cos(a)$) in 'Input field'. He also could construct the similar curve which he had seen in Youtube video using two sliders by entering ($\sin(a)+b$, $\cos(a)$). Moreover, he changed his formula as ($\sin(a)+a$, $\cos(a)+1$) for making the same curve in the Youtube video.

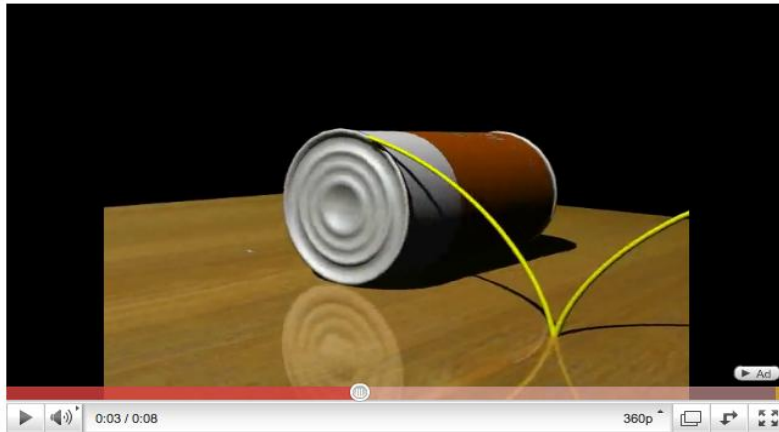


Figure 3. Youtube video related with circular movement of a point

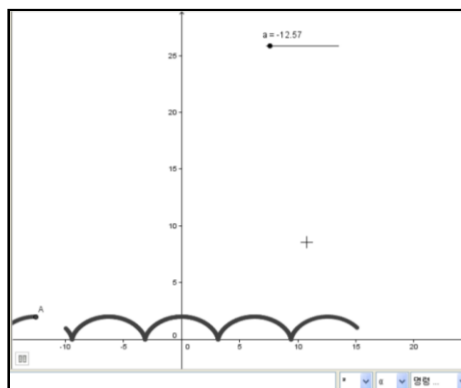


Figure 4. Trace of a point of ($\sin(a)+a$, $\cos(a)+1$)

In lesson 3, S1 made a 'slider' for making planets(points) moving around the sun(the origin). S1 entered ($1.16 \sin(a)$, $1.16 \cos(a)$) in 'Input field' for making the Mercury and observed the point's movement in Geometry view. After that, he changed the point's coordinate as ($1.16 \sin(88 a / 365)$, $1.16 \cos(88 a / 365)$) and found that the movement was different from the video. Lastly, he changed the coordinate as ($1.16 \sin(365 a / 88)$, $1.16 \cos(365 a / 88)$). S1 asked only a few questions to make his works to the teacher.

Findings

We could find that S1 did various experiments for making his works. He made these actions according to his own will without teacher's any directions. In Lesson 1, although his aim in the class was to just observe the functionality of 'slider', he made various examples with 'sliders' and observed them. In Lesson 2, he used GeoGebra command such as ($\sin(a)$, $\cos(a)$). Sometimes, he added some numbers or variables each coordinate; ($\sin(a)+b$, $\cos(a)$)

and $(\sin(a)+a, \cos(a)+1)$. In Lesson 3, he changed some numbers for making proper model of each planet.

After some experiments with GeoGebra, he could get knowledge about his aim and find how to make a proper model with GeoGebra.



Figure 5. Youtube movie (Solar system)

S2's operation with GeoGebra

Description

In Lesson 1, S2 had many questions to the teacher. However, his questions were related how to use GeoGebra, so we don't describe his questions.

In Lesson 2, S2 watched the video related with circular movement and analyzed circular movement. He made a 'slider' named 'a' and a point $(a, 1)$ in Geometry view. He couldn't find what to do next and asked to teacher.

Teacher: Let's make a point around the origin first. $(\cos(a), \sin(a))$. And we should make the point go forward. How can we do that?

S2: (No reply)

Teacher: It should move while it also rotate. What should we do? What should we do to center B and point A?

S2: (Entering $A + B$ in the 'Input field') Adding them together. It makes sense. Ah, it's just adding.

S2 constructed a curve which had seen in the movie by using a single variable (slider). In addition, he was able to create his own equation by using the variable (slider). (Figure 5)

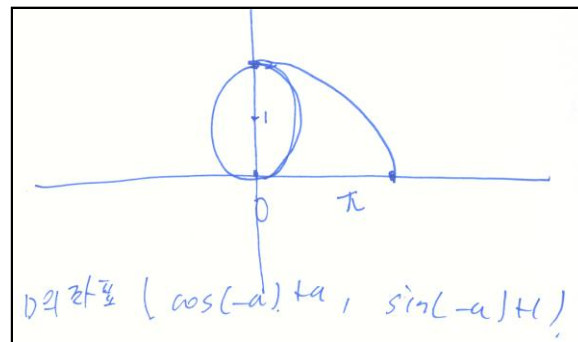


Figure 6. S2's equation of his curve in Lesson 2

In Lesson 3, S2 analyzed the movements of the planets and started searching data about solar system from the internet and asked to teacher.

S2: Only one slider?

Teacher: Yes. Just one. People usually think that many sliders should be needed, but we need just one.

S2 made the planets(points) in a similar way with S1, but he entered $(0.58 \sin(a/88), 0.58 \cos(a/88))$, $(1.5 \sin(a/365), 1.5 \cos(a/365))$ in the 'Input field'. For making a proper model of solar system, he used only the ratio to represent the angles.

Although the meaning of variables(sliders) were different, they were essentially the same concept and had differences only in units.

Findings

S2 wanted to have communication with teachers. He asked some questions and teacher gave only clues for the problem, not the answer. However, he could find the concept of vector addition (e.g. $A + B$) in the discussion with the teacher. He could find connect the movements of point A and B in observing their movements. He also could write the equation of the curve very easily using only vector addition. (Absolutely, he didn't know the term, vector addition, but he already knew the concept.)

5. Conclusion

In this study, we observed the actions of students who operated GeoGebra for making mathematical models of a curve(cycloid) and the solar system. We could find some facts as follows:

- S1 made his works with many trials and modifications.
- Sometimes S1 didn't do according to teacher's directions and made another things with GeoGebra.
- S2 could understand the concept of vector addition without mathematical term.
- S1 and S2 could write their formula using slider's name and the operations.

The students made errors at first time, because they were not accustomed with GeoGebra. However, they gradually became aware of the relationship between ‘slider’ and variable with many modifications. Finally, they could make their own mathematical models and express their formula with symbolic representations.

Therefore, we can conclude that we should observe and analyze students’ common errors and modification steps more. After that, we can construct an assumption for the pattern of students’ actions with DMS(Dynamic Mathematics Software) and it will help us make a new educational program(curriculum) of mathematics with technology.

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