Motivating students in learning mathematics with GeoGebra

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ABSTRACT. In this study, I researched three cases of educating mathematics with computer for the gifted students in Korea. The findings show that students were motivated to study math by various reasons (making their beautiful works, searching videos related with math and making materials for others). Students couldn't these activities without GeoGebra and internet connection. Without GeoGebra, students couldn't handle mathematical objects easily. Motivation outside mathematics could also help learning mathematics.

Introduction

In Korea, there were many trials to integrate computer to the classrooms of the secondary schools. Kang and Choi-Koh investigated instructional materials using DGS (Dynamic Geometry Software). They constructed some examples of regular polyhedrons and their development figures using DGS. They argued that the examples would be able to help teacher's instruction in their geometry class of the secondary school [KCK99]. Kim researched the use of GSP in the view of problem-solving [Kim02]. He asserted that GSP materials in Korea were only the introduction for constructing some GSP files. Then he showed GSP examples according to Polya's problem-solving steps.

There has been, however, little study to investigate student's action in student-centered math class using computer software yet. In this study, responses of students in math class of mathematical modeling using computer were investigated. Especially, GeoGebra was used as a computer software in this study. GeoGebra, a Dynamic Mathematics Software for everyone, is easy-to-use and free of charge for education.

1 History of GeoGebra in Korea

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

GeoGebra received the European Academic Software Award, EASA, in 2002. Further development of GeoGebra was funded by a DOC scholarship awarded to Hohenwarter by the Austrian Academy of Science. Since 2006, GeoGebra's development has continued at Florida Atlantic University, USA, where Hohenwarter works in a teacher training project funded by the National Science Foundation's Math and Science Partnership initiative [Pre08].

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. GeoGebra was used for exploring mathematics class for 7th grade students at Institute for gifted students. In Korea, GeoGebra have been popularized via GeoGebra Korean user community, GeoGebra Naver cafe.

2 Methodology

Previous researchers focused how to present mathematical concept to the students well or how to teach math with computer ([KC-K99], [Kim02], [Kim06], [Lee99]). In this study, response of the students was investigated by qualitative method. Teacher only observed student's actions and analyzed student's works and responses.

2.1 Participants

This study was with 40 students who were 7th grade in Gyeonggi province in Korea. They were selected by their excellence of intellectual abilities for mathematics and/or science. The average of their mathematics scores in school was very high as 98.78 and the standard deviation 1.64. Students who responded that they liked mathematics were 35 persons (88 %). The

Questionnaire about preference of math was researched. The result of the questionnaire is the following.

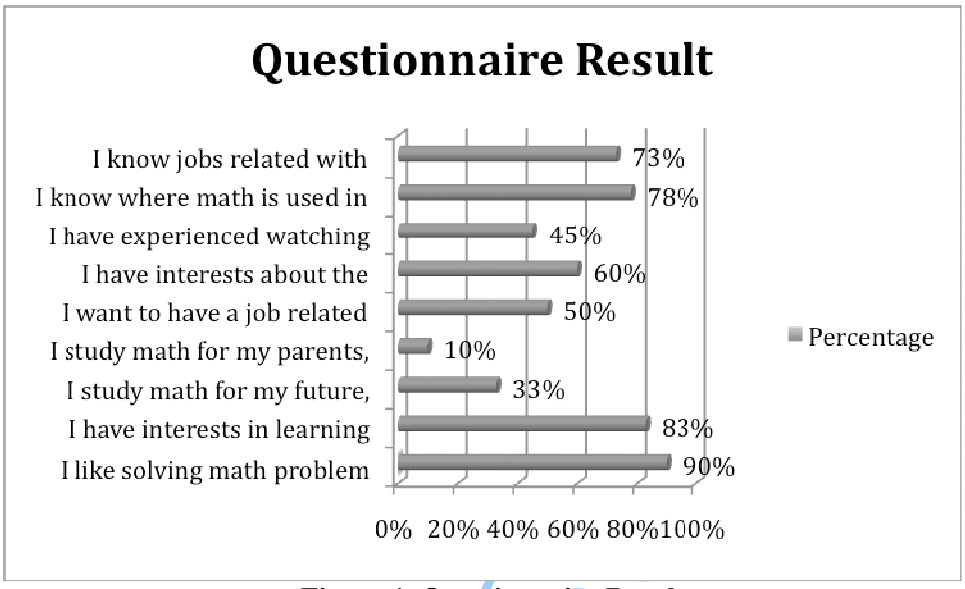

Figure 1. Questionnaire Result

According to the result, these students liked solving math problem and learning new math concept. About half of students knew the informations related with mathematics (job related with math, the story of math genius and movie related math). Many students (about 67%) do not want to study math for their future only.

2.2 Environment of classroom

There were 20 PCs which were connected to teacher's main computer in the classroom. Each computer had two monitor; One was for students, the other for teacher's computer screen. Teacher could show each screen of students to all students.

2.3 Teacher's role in the classroom

According to constructivism, teachers in the classroom should be facilitators. Teacher usually taught many mathematics concepts or how to solve

problems directly in the classroom. However, facilitator only help the learners to understand mathematics concepts or solve problems by themselves. In other words, a teacher tells, a facilitator asks; a teacher lectures, a facilitator supports; a teacher gives answers, a facilitator provides guidelines; a teacher says alone, a facilitator talks with the learners.

In this study, the teacher in the classroom was a facilitator. Teacher only provided goal of the class to the students, explained about goal briefly and answered when there were questions from the students. According to goal provided, students made their works using mathematical concepts with GeoGebra. After submitting their works on the internet, teacher only showed each works to all students. Students assessed other's works, learned from other's works and modified their own works.

3 Research Findings

3.1 Case 1: "Let's make solar system"

3.1.1 Description

In 27 June 2009, there was a class for exploring mathematics using GeoGebra. The Topic was "Let's make solar system". The material for the student was given from the internet. The procedure of class is the following.

1. Visit the website.
2. View the YouTube video about solar system in the website.
3. Search the information for making solar system in the Wikipedia.
4. Make your formula for the situation of problem.
5. Make the model of solar system using GeoGebra.
6. Upload the GeoGebra file on the internet (GeoGebra Naver cafe).
7. Evaluate other's works.

For the first time, students should understand what they would make through watching YouTube video in the website. Next they found the informations for making model of solar system and searched them in the Wikipedia. After making formula for the angle of planet position, they made model using GeoGebra, uploaded their GeoGebra files and evaluated other's works. Students might modify their own GeoGebra model after evaluation of other's works.

Figure 2. Online material provided

3.1.2 Findings

Students made their own solar system well and uploaded their works on the internet. Teacher showed each student's work to all students on the screen. At the moment that the beautiful work was shown, some students concentrated to the work and started to decorate their own works. They seemed to make their own works beautiful, too. They asked how to decorate solar system each other. They made their solar systems over and over. Eventually, they asked how to make a satellite (moon) to the teacher. Teacher explained the relation of planet and satellite. In other words, a satellite goes around a planet with regular velocity. Thus, a satellite rotates the amount of its planet's going around the sun more. After teacher's explanation, students started to make a satellite of the earth. They wanted to change color of a planet (point) variously and to show planet (point)'s trace. This situation was occurred accidentally and was not predicted. Students seemed to be satisfied by their own works.

In this situation, they used the formula for making planets or satellites for their own purposes. The formula was not also given, so they should create their formula by themselves. Students worked for the beauty of their GeoGebra works, not for making mathematical formula. However, they created the formula and applied it to their works well.

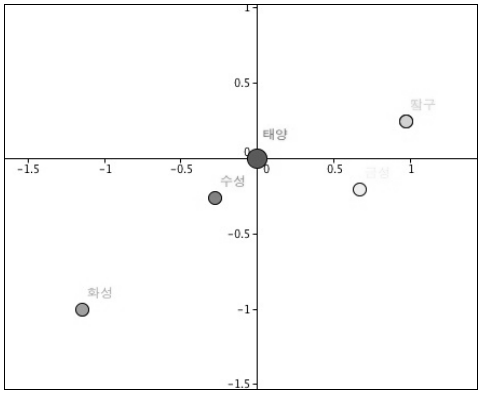

Figure 3. Solar System (with various colors)

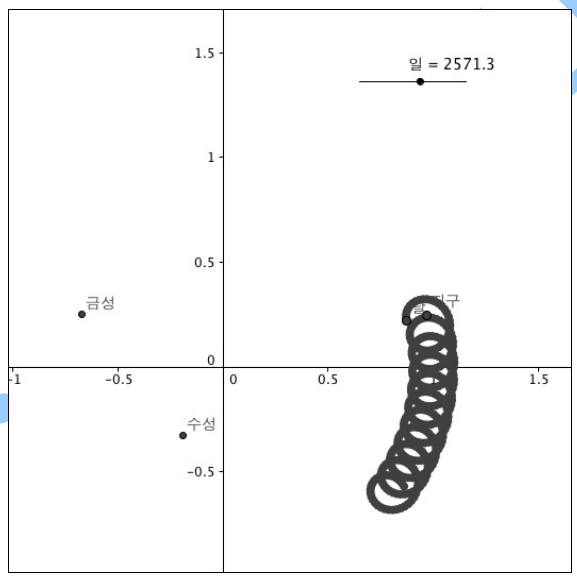

Figure 4. Satellite of the earth

3.2 Case 2: "Let's make GeoGebra work related with our life"

3.2.1 Description

In 12 Aug 2009, there was a class for a project using GeoGebra. The Topic was "Let's make GeoGebra work related with our life". In this time, the

material for the student was not given. Students had to make their GeoGebra work and GeoGebra worksheet. The procedure of class is the following.

1. Design what you will make.
2. Search YouTube video suitable for explaining what you will make.
3. Make GeoGebra work.
4. Make GeoGebra worksheet.
5. Upload the GeoGebra worksheet files on the internet (GeoGebra Naver cafe).
6. Evaluate other's works.

For the first time, students should design what they wanted to make. Next students searched video suitable for explaining GeoGebra work well. After making GeoGebra work, students should make GeoGebra worksheet. In this time, students should insert YouTube video and the description about his/her GeoGebra work. Students uploaded their GeoGebra files and evaluate other's works.

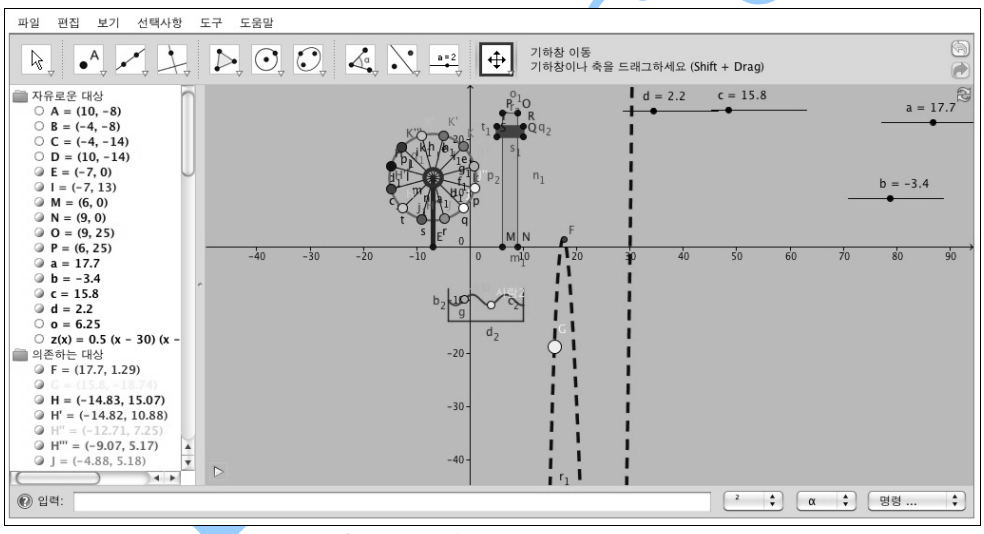

Figure 5. Amusement Park

3.2.2 Findings

Students started to make their works using GeoGebra. They searched YouTube video suitable for explaining what they wanted to make; they should insert video into their worksheet. Teacher only answered when students asked GeoGebra usage. However, students found good examples of

mathematical modeling in real life by themselves. The titles of examples are the followings.

> *Amusement park, Marathon, Launching Rockets, Shootings, Pin Ball, Airport, Arrows, Helix(growth of plants), Fountain, Water mill, Black hole, Roller coaster, Voyage, Comet, Typhoon, Accident, Wave, Galaxy, Spear, Clock*

Especially, 'Amusement park' was very impressive work. The students who made 'Amusement park' described how to make it.

> *The video which follows is a YouTube video about Ceder point amusement park, one of the greatest amusement park. I made many rides in the amusement park; Giant wheel, Space spiral, Roller coaster and pools with waves. I made Giant wheel with trigonometric function to represent circular movement, Space spiral with free fall formula and Roller coaster with graph of cubic function. I made people in the pool move up and down; it's the nature of the wave.*

Another impressive work was 'Fountain using quadratic function'. It described traces of a point as water sprinkled up.

In the procedure of searching videos, they seemed to find various topics related with math. These phenomena were not expected; teacher didn't provide any topic or hint. It means that students were accustomed to using GeoGebra and GeoGebra has various possibilities in teaching mathematics in school.

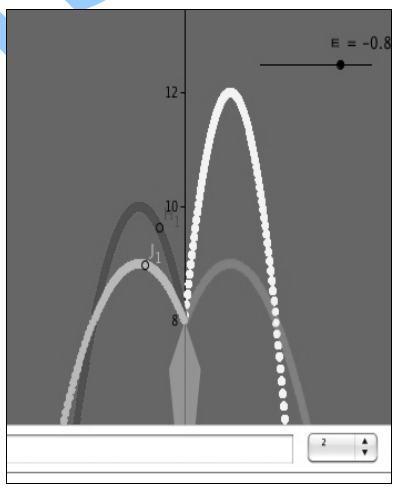

Figure 6. Fountain with quadratic function

3.3 Case 3: "Let's make materials for your friends using GeoGebra"

3.3.1 Description

In 28 Dec 2009, there was a class for a project using GeoGebra. The topic was "Let's make materials for your friends using GeoGebra". In this time, the material for the student was not also given. Students had to make their GeoGebra work and explanation in GeoGebra Naver Cafe, which is the online community for Korean GeoGebra users. The procedure of class is the following.

1. Design what you will make.
2. Make GeoGebra work.
3. Write explanation in GeoGebra Naver Cafe.
4. Upload the GeoGebra worksheet files on the internet (GeoGebra Naver cafe).
5. Evaluate other's works.

For the first time, students should design what they wanted to make. Next students made GeoGebra work according to their plans. After making GeoGebra work, students wrote explanation for their friends, uploaded their GeoGebra files in GeoGebra Naver Cafe and evaluate other's works.

3.3.2 Findings

In this project, many students had difficulties for setting a topic. In school mathematics, students should choose a topic which they would make. They wrote some explanations about their mathematical topics and uploaded GeoGebra files. Suddenly, a student in the classroom made a video (avi file) using a freeware for capturing computer screen. He uploaded the video with his explanation. Especially, he captured GeoGebra's animation. GeoGebra's animation is a functionality which can draw the movements of objects in GeoGebra with sliders. Students could read his explanation with watching video. It was a convenient way for studying with explanation made by others; many community sites provides video uploading function. After his uploading video, many students made their materials like that.

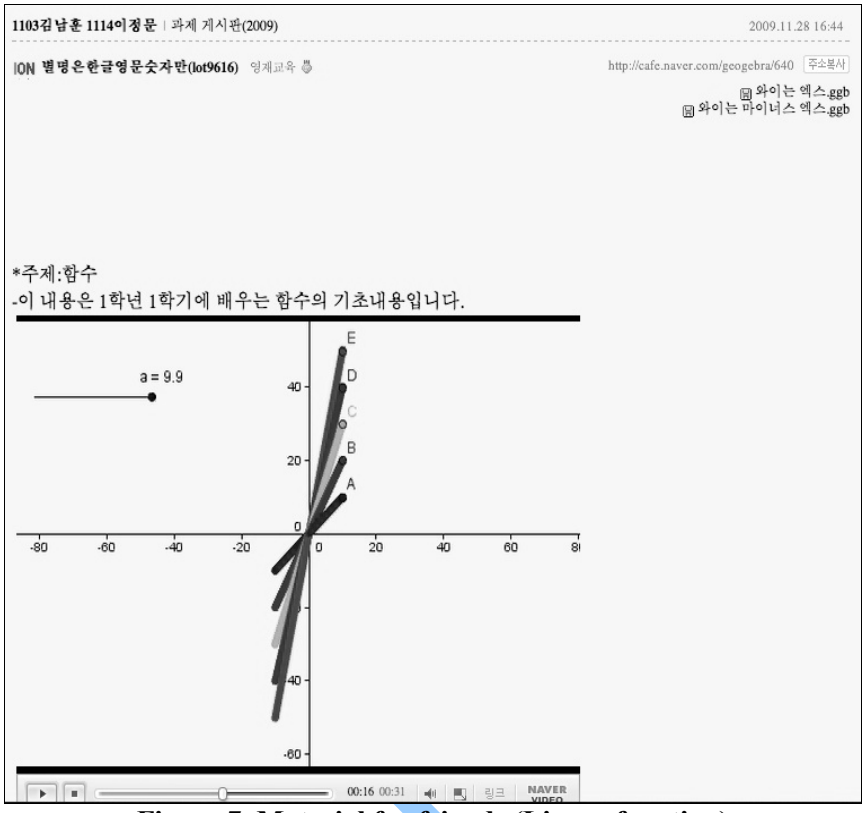

Figure 7. Material for friends (Linear function)

After the class, students wrote the followings.

I made math materials for others for 4 hours. I didn't know what I would made or how I could explain using GeoGebra. But, I could find the way through many trials with GeoGebra and explain some mathematical topic using materials from the internet. I am not good at GeoGebra, but I was proud of making the work by myself, although sometimes I was disappointed about not working of my work. But I could study much, I think that this class was meaningful to me... (From GeoGebra Naver cafe)

Um...
First, the material should be in detail for the person who didn't know anything about the knowledge. I wanted to explain the knowledge more deeper, so that I searched knowledge related with the knowledge more. So I have more knowledge about that.

While many people explain by writing, I drew(made) pictures using GeoGebra and explained. It's very interesting to me! (From GeoGebra Naver cafe)

First student had difficulties in first step of the project. Especially, he didn't use GeoGebra well. He was occurred many trials and was able to learn many things. He was also proud of making the work. Second student could get more knowledge through the process of making materials for others. She was interested in it.

Conclusion

This study shows the investigation of responses and works of the students in class of exploring mathematics in Institute of gifted students, Korea. In the class on 27 June 2009, students created their own formula and learned GeoGebra usages for making their GeoGebra works beautiful. In the class on 12 Aug 2009, students found many situations with mathematics in YouTube videos; they could get many ideas in searching videos suitable for their topics. Thus, for mathematical modeling using computer by students, teacher should provide materials, i.e., books, videos or internet materials. In the class on 28 Dec 2009, students learned many things for making materials for others. According to on student's writing, students studied more; they couldn't make anything before they knew the informations well.

In these three classes, computer and internet connection played important role. Without computer and internet connection, students couldn't search informations, videos, upload their own works and make materials for others easily. Especially, students could also handle mathematical objects easily using GeoGebra, which is an easy-to-use software based on mathematical and educational knowledges. Students could learn knowledge for making their beautiful works and materials for others. Motivation outside mathematics can help students in learning mathematics well.

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