An Application of Educational Programming Language 'Dolittle' in Teaching and Learning of Mathematics

Woo-Hyung Whang & Kyungmi Kim
Department of Mathematics Education, Korea University
Department of Curriculum and Instruction, Graduate school of Korea University
5-ka, Anam-dong, Sungbuk-ku,
Seoul 136-701, Republic of Korea
e-mail: wwhang@korea.ac.kr
kyungmi@korea.ac.kr

Abstract

The purpose of this study is to apply an object-oriented educational programming language(EPL), 'Dolittle' which has developed in Japan, to teaching and learning of mathematics. We have attempted to apply Dolittle in teach mathematics in elementary geometry with Geoboard, a secondary function using coordinates plane and trigonometric plane which had been made by the researcher. Then, we have implemented case studies with secondary school students in order to show the feasibility of programming activities with Dolittle programming. The results indicated that programming activities with Dolittle give students an opportunity to encourage them to explore the concepts of interior angle and exterior angle in learning of geometry, and it was effective in learning the concept of functions.

1. Introduction

Creating a learning environment, where individual students' ideas, interests, and experiences are valued, is important in mathematics education. With the rapid development of computer technology, most educators and researchers agree that computers would continue to influence mathematics education[5]. Zimmermann [9] stated that graphic images serve as an important link between mathematical models and the phenomena of the real world.

Ultimately, the purpose of this study is to reduce the negative dispositions of the students regarding mathematics by offering an environment of mathematics learning through 'Dolittle Microworld' which offers students enjoyable feelings, allows them to explore meaningful learning when they do mathematics, and to provide the environment which can promote cognitive abilities, various mathematical perspectives, meta-cognition and reflective abstraction which are not easy to obtain in practices of a school mathematics in Korea.

In the beginning, we had classified mathematics curriculum domains in which Dolittle can be applied through analysis of Dolittle language and textbooks used in schools. After the analysis of Dolittle, we found that Dolittle can be applied to most parts of elementary and secondary mathematics, especially in areas of geometry and functions. Therefore, we developed Dolittle application materials

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for elementary and secondary geometry and function using coordinates plane and trigonometric plane. Then we have implemented teaching experiments with 6 students to examine the effectiveness of programming activities.

2. Programming and Mathematics education

In recent years, numerous researchers have emphasized the importance of teaching computer science and mathematics with programming language [1]. The few reasons are the complementary relationship between computer science and mathematics and the fact that programming activities enables student to think algorithmically to solve problems[3,7].

Since 1990s, the research of development of various mathematics softwares and new methods of teaching and learning through the Internet in mathematics education have been increased in Korea. By contrast, there have been minimal research on the programming activities focused on the concept of mathematics and how student was affected by programming in learning mathematics[8].

LOGO is an important language in mathematics education. It was found in many studies that LOGO programming activity offers students to promote students' cognitive abilities, various mathematical perspectives, meta-cognition and abilities of problem solving[2].

However, nowadays LOGO is not suitable for school lessons due to its old structure and incompatibility with today's computer. In addition, many students in Korea would find it difficult to write commands in English. Thus, we required Hangul-based (Korean language) educational programming language(EPL) with multiple reserved words that can be easily used even by elementary school students.

2.1 Features of Programming Language for Mathematics Education

Educational programming language (EPL) is defined as a programming language designed for education. Therefore it needs to include the educational features which make it different from other languages[4].

The education programming language needs to:

- be brief and easy to program;
- be algorithmic and expandable;
- allow users to learn basic principles of the computer;
- be compatible and transferable;
- be written in a familiar language that can be easily recognizable; and
- allow users to experience the network.

EPL for mathematics has to include additional features for mathematics education. Furthermore, the purpose of programming activities in mathematics education should be not learning formal aspects of programming, but focusing on important concepts of mathematics.

EPL for teaching and learning of mathematics needs to:

- become Hangul (Korean) educational programming language of text-based type having multiple reserved words supporting

system;

- be easy to represent diverse functions;
- be easy to represent diverse graphics;
- accord with concepts of mathematics;
- allow users to solve problems through various methods; and
- be easy to understand and learn.

Fortunately we had found 'Dolittle', educational programming language, which satisfies the features described above.

3. Education Programming Language 'Dolittle'

Dolittle adapted many educational ideas of LOGO, turtle graphics, incremental programming, immediate feedback, etc[6]. Dolittle has not only educational advantages of a modern programming language but also advantages of mathematics education of LOGO at the same time. Moreover, Dolittle can attract student's high interest and curiosity since it is possible to make animation games by using various GUI(graphical user interface) functions and Timer object. Dolittle is the programming language that fulfills the requirements of language in mathematics education.

As a result, there have been many studies in Korea investigating Dolittle's possible uses in mathematics education, even though Dolittle is primarily designed for programming education.

4. Application of Dolittle for teaching and learning of Geometry and Function

There are two methods applying Dolittle in teaching and learning of mathematics. One is that students understand the important concepts of mathematics as they are programming. The other is using Dolittle programs written by teacher during the lectures. Both applications have high impact on mathematics education, so we suggest that those kinds of studies should be investigated and applied in school.

We have provided students with a learning environment in which they were able to explore areas of geometry and function. Using a "looks" method within Turtle object, we turned the turtle image which appeared from initial interface of Dolittle program into an image of Geoboard/ coordinates plane.

4.1 Application of Elementary Geometry Using Dolittle Geoboard

Turtle Geometry of LOGO is useful to apply Dolittle in teaching and learning of geometry. We investigated how students from grade 1 through 3 would learn geometry using a "position" method and a file of Geoboard image.

As mentioned before, the environment of teaching and learning by using Dolittle Geoboard could be easily created by creating turtle object and turning it into Geoboard image. However, the lower grade students may find it difficult to use Dolittle. As a solution, we exclude the concept of negative numbers and provide a Geoboard image with only whole numbers for the lower grades.

The following figure shows how elementary school students can draw many figures easily.

The "점으로" method retrieves the

variables of x and y coordinates from the user. This method multiplies two values by 100 and subtracts 500 and 300 from each. As the following figure 1, students can easily create several figures.

```
기하판거북=거북이! 만들고 "기하판_1.gif" 변신.
거북이=거북이! 만들다.
점으로=[ |x y|
! (((x)*100)-500) (((y)*100)-300) 위치한다. ].
거북이! 날다 0 0 점으로 앉는다.
////////밑에 명령어를 입력하세요!!/////////
거북이! 날다 1 1 점으로 앉는다.
거북이! 5 1 점으로 3 3 점으로 닫기
```

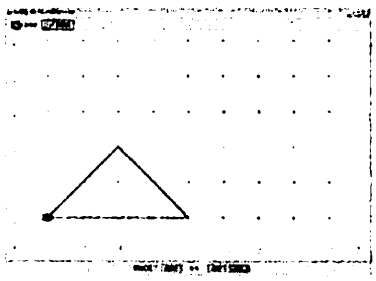

figure1. Dolittle Geoboard.

Mathematics education using Geoboard is helpful in terms of understanding the properties of several figures and the concept of area.

4.2 Application of Secondary Function Using Dolittle Coordinates Plane and Trigonometric Plane

The area of function is considered to be the most important part in mathematics education. In LOGO, many restrictions made it difficult to work with functions. On the other hand, Dolittle allows students to explore various functions with change of an image. Therefore, we modified Dolittle to work with functions much easier and more efficient than before.

Dolittle has built-in exponential, logarithmic, and trigonometric functions. However, due to the lack of magnification feature, these functions do not appear on the screen properly. As a result, we designed new coordinate with 100 pixels as 1 unit, so students can easily see and operate the graphs of functions.

```
좌표거북=거북! 만들고 "좌표_1.gif" 변신.
stx=(0.001).
sty = log(stx). //초기화
로그= 거북! 만들다.
로그! 날다 (stx*100) (sty*100) 위치하고 앉는다.
로그: 함수 =[ |x|
[ y = log(x).
로그! (x*100) (y*100) 위치한다.
x = x +(0.1). ]! 500 반복한다.
].
로그! 0.001 함수
```

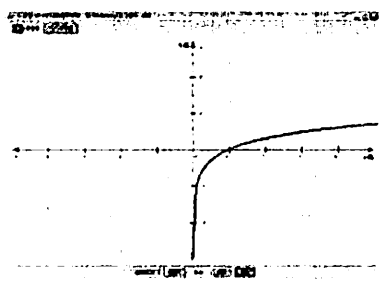

Figure2. Graph of the logarithmic function

Through the process of drawing the above graph, students can experience the properties of the logarithmic function. Not only log-functions but also exp, tri-functions can be explored with similar steps.

5. Example of Geometry and Function Lessons

Eight teaching experiments had been implemented by two teachers, teacher A from a middle school and teacher B from a high school. Each teacher chose 3 students

from bottom(G1; F1), middle(G2, F2), and top(G3, F3) group. Teacher A gave students geometry lecture with Dolittle, and teacher B taught function using Dolittle. At the same time, they observed the influence of programming activities on the students. Two teachers were interviewed after each lesson and interviews were videotaped and transcribed. The results have been analyzed through activity sheets, interview transcripts, and programming codes made by students.

The result of the experiment implemented by teacher A clearly shows the improvement of understanding the concepts of figures including study of interior and exterior angle. This is because Dolittle requires students to put not only lengths of sides, but also interior or exterior angles as well. Even though there was the difference of time taken to understand the concept depending on the level of the students, all three students successfully completed their assignments.

The following figures are examples programmed by students.

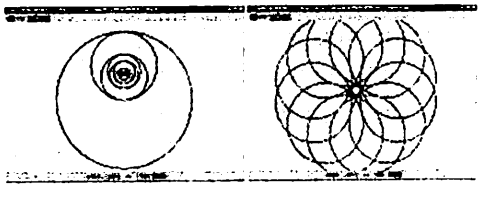

Figure3. Students' examples in Geometry lesson

The left one is created by student G1. He used two turtles that draw circles touching two points.

The other one is drawn by student G3. During the interview, she stated that "I wanted to draws circles with a star in it." Both works are creative and include mathematical features.

The teaching experiment of teacher B was beneficial to understand the concepts and properties of functions. Unexpectedly, the effect of the activities was not proportional to students' achievement level; instead, it depended on the students' ability to use the computer and their interest in mathematics.

The following conversation shows how student F1 figured out the concepts of a linear function through several trials and errors.

Teacher B : How did you find the pattern?

Student F1 : When I first drew y=4x and y=5x and found (-100, -400) and (-100, -500) as first position (of the turtle), I thought the difference of 4 and 5 changes only y values. But, I found later that the first coordinate of y=x graph is (-300, 300); y=2x is (-200, -400), y=3x is (-100, -300) and meaning the number in front of x(it means a coefficient) decides the ratio of x and y.

The following graphs are programmed by students of teacher B.

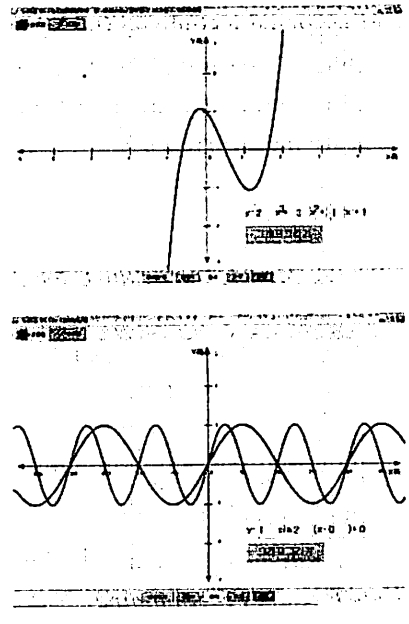

Figure4. Students' examples in Function lesson

Both students used Button object to show the graph. They were proud of the fact that they made a program.

6. Conclusion

Throughout this study, we found that Dolittle can be applied in a wide range of mathematics education including geometry, algebra, and concepts of functions. The teaching experiments provide students to experience the concepts of interior and exterior angles and functions. Especially, we could find another meaning of the study in that Dolittle provides the environment for students to enjoy studying mathematics.

Since the original purpose of Dolittle is not for mathematics education, there are still limitations and problems to overcome. Therefore, future developments and studies of Dolittle have to be implemented.

Furthermore, future studies on practical application of Dolittle and constant systematic study on the principle and method of teaching and learning of mathematics with Dolittle programming activities are necessary.

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