Research on Geometry Teaching of High School Based on the Software of GeoGebra

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ABSTRACT

In recent years, GeoGebra software has been widely used in high school mathematics teaching, especially in assisting high school mathematics geometry teaching. The software of GeoGebra is complex in function, teachers should use it reasonably according to its characteristics. According to the mathematics curriculum standards and the mathematics teaching theory of the Fan Hiele couple, the author thinks that the use of GeoGebra software in high school geometry teaching should follow the principles of heuristic, interactivity, flexibility and selectivity. In order to improve the efficiency of high school mathematics geometry teaching, in the actual teaching process, teachers should pay attention to setting reasonable geometric questions according to the students' geometric thinking level, minimizing unnecessary operations, combining multiple views to realize the combination of numbers and forms, and handling the relationship between students' software learning and mathematics knowledge learning, organizing and managing the classroom effectively, coordinating the relationship between the software, blackboard and courseware.

Keywords: *The software of GeoGebra, High school mathematics, Geometry teaching, Dynamic presentation, Mathematical experiment, Software operation.*

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Highlights of this paper

- In recent years, GeoGebra software has been widely used in high school mathematics teaching, especially in assisting high school mathematics geometry teaching.
- The software of GeoGebra is complex in function, teachers should use it reasonably according to its characteristics.

1. INTRODUCTION

With the development of multimedia technology, mapping software has emerged in an endless stream, and drawing in geometric teaching has become easier and more accurate. The software of GeoGebra is powerful and easy to be learned, and it performs very well in terms of operating environment, geometry transformation, animation, mapping, and solid geometry (Luo, 2017). Therefore, more and more mathematics teachers of high school are now using GeoGebra software to assist geometry teaching.

However, there have been few researches on the GeGebra software in high school mathematics teaching until now. Can the use of the software of GeoGebra run through the entire process of geometry teaching? What principles should teachers follow when using the software? How should teachers use it for geometry teaching? These are all questions worth pondering.

2. FEATURES AND FUNCTIONS OF THE SOFTWARE OF GEOGEBRA

GeoGebra is a free and cross-platform dynamic software designed by Markus Hohenwarter, a mathematics professor at the University of Atlanta, Florida. It combines geometry, algebra, graphics, tables, statistics, and calculus for all levels of education.

The software of Geogebra has many features and it has its own unique advantages in geometry teaching. (1) The software solves the problem of conic curve mapping better. For example, GeoGebra's "intersection" command can easily draw the intersection of straight line and conic curves, which was not easy to achieve in the past. (2) The software combines geometry and algebra in one, enabling simultaneous changes in the graph and dynamic equations (Zhang and Tang, 2010) thus better revealing the relationship between numbers and shapes. (3) It also has the functions of "drawing process" and "drawing process navigation bar", which can reproduce the teaching process (Li and Pan, 2014) thus reducing the stress of teachers preparing for lesson and teaching in class. In addition, GeoGebra's 3D drawing capabilities provide a good presentation environment for solid geometry. Therefore, when using the software of GeoGebra for geometry teaching, we should give full play to its advantages, shorten the drawing time, simplify the teaching process, and provide students with a more concise and efficient learning environment.

However, the software of GeoGebra is also significantly inadequate. It does not provide paging functionality. In contrast, the document options command under the file menu of the Geometer's Sketchpad can divide a file into pages. The "page" and "link" options of the Geometer's Sketchpad can place different content on different pages of the same courseware, and the pages do not affect each other, forming a complete courseware (Luo, 2017).

3. CHARACTERISTICS OF THE MATHEMATICS GEOMETRY TEACHING OF HIGH SCHOOL

"Ministry of Education of the People's Republic of China (2017)" points out that geometry and algebra are one of the main lines of high school mathematics courses. It is necessary to highlight the fusion between geometric visualization and algebraic operation, that is, through the combination of form and number, to understand the relationship between mathematical knowledge and to strengthen the understanding of mathematical integrity.

With regard to geometry teaching, the curriculum standards also point out the teaching direction. For example, the initial teaching of solid geometry is to help students form a spatial concept. It should follow the principles from whole to local and from concrete to abstract, and provide rich physical models or use computer software to present spatial geometry, to help students understand the structural features of spatial geometry, and to further grasp the methods and skills of representing spatial graphics on the plane (MEPRC, 2017).

According to the geometric learning theory put forward by the Dutch scholar Fan Hill in the 1950s, geometric thinking can be divided into five levels: vision, analysis, informal deduction, formal deduction and rigor. In order to adapt the geometry teaching to the level of students' geometric thinking, there are five stages in geometry teaching: interview, guided orientation, explication, free orientation and integration. This requires the teacher to discuss and communicate with students in the consultation stage before the class, to measure the current level of thinking of the students, and the students should understand the subject. In the guiding orientation stage, the teacher should arrange tasks for students according to their answers to the simple questions, so that students can understand the direction and method of learning. In the clarification stage, the teachers should use the correct language to explain the topics to students, and the students should understand and master the knowledge according to their own experience. In the free orientation stage, the students should use different methods to solve problems related to the subject, gain experience in the process of solving problems, and clarify the direction of learning. The main task of the teacher is to arouse students' interest in learning. In the integration phase, students should review and summarize what they have learned, use their own methods to form a certain view, and internalize objects and relationships into a new field of thinking (Zeng and Zhai, 2017).

4. HOW TO APPLY THE SOFTWARE OF GEOGEBRA TO GEOMETRY TEACHING

According to the characteristics of the software of GeoGebra, the requirements of geometric teaching in ordinary high school mathematics curriculum and the analysis of the five-stage theory of geometric teaching, mathematics teachers should apply GeoGebra software to mathematics geometry teaching according to certain principles and requirements.

4.1. Principles of Using the Software of GeoGebra in Geometry Teaching

4.1.1. Heuristic

When using the software of GeoGebra for geometry teaching, students should be prompted at "key points" based on the specific content of the lecture. Teachers can't give all questions and answers, but leave students with the space to think actively, let them observe the formation process of geometric figures, and think about possible questions and answers. If the student has an idea, the teacher can demonstrate the operation for the student and help him get the correct result. If the student does not have an idea, the teacher can prompt the necessary place to help them find the breakthrough point of the problem.

4.1.2. Interactivity

Attention should also be paid to interacting with students in a timely manner, to understand the current level of geometric thinking of students, the problems students are trying to study, their shortcomings and so on. Through the feedback of the students, the teacher can design and adjust the demo of the GeoGebra software to provide ideas and methods for students' geometric learning. For example, when exploring the issue of "estimating π approximately", teachers can ask the following questions in advance. What is π? Do you know the ancient method of calculating π? What decimal places has the π have been calculated so far? and many more. On the one hand, it

provides direction for students to prepare for class. On the other hand, teachers can choose the research methods they are more interested in according to the degree of students' understanding of the π.

4.1.3. Flexibility

During the class, the teacher will also adjust the demonstration of the GeoGebra software at any time according to the student's learning situation. When the students have doubts, the teacher should adjust the teaching content according to the direction of the students' thinking, and strive to generate new knowledge or methods together with students. This requires teachers to be familiar with the use of the software and to provide appropriate assistance based on the needs of the students.

4.1.4. Selectivity

The use of GeoGebra software should be adapted to the student's learning. Teachers must choose the specific method of presentation and demonstration according to the specific content of the class.

The software of GeoGebra is mainly used in the following aspects. (1) Forming the geometric concept. When the concept is generated, teachers can use the software to display the intuitive background of it, visualize the abstract concept, use the rich examples to make the concept get the "prototype" support, form the "model intuitive" of the concept, let the students experience the original process of its formation and understand the concept profoundly. (2) Revealing the connections and differences between different knowledge. Since the algebraic and drawing areas of the software can realize the function of combining and transforming numbers and forms (Zhang, 2018) students can have a deeper understanding of geometric knowledge by means of algebraic knowledge. (3) Solving geometric problems. When solving geometric problems, teachers can use the software of GeoGebra to display the characteristics of the questions in a simple and quick way, and deepen the students' understanding of the meaning of the questions. For example, we can explore the following question. What is the midpoint motion trajectory of a certain point $(4,0)$ outside the circle $x^2+y^2=4$ and a moving point on the circle? Can you find the trajectory equation? After the students' guess, the trajectory of the midpoint can be easily drawn by the GeoGebra's animation and tracking function Figure 1. (4) Conducting mathematical experiments. For example, exploring the motion trajectory of a conic curve. (5) Infiltrating advanced mathematics knowledge. With the software of GeoGebra, it is also possible to penetrate higher mathematics knowledge in middle school and reduce students' strangeness to advanced mathematics.

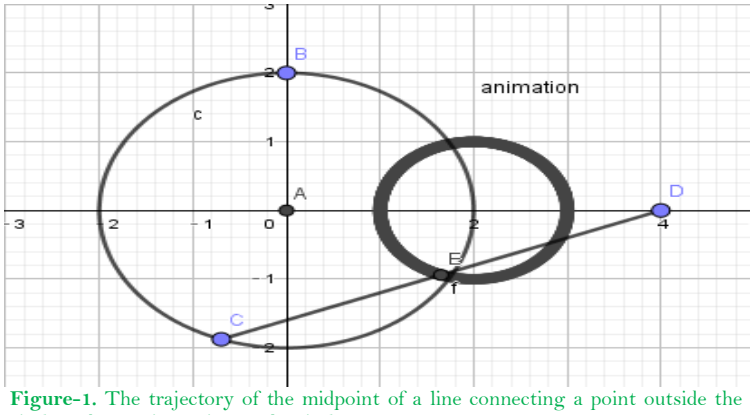

Figure-1. The trajectory of the midpoint of a line connecting a point outside the circle and a moving point on the circle.
Source: Created by the author based on the question above.

4.2. Requirements of Using the Software of GeoGebra Reasonably in Geometry Teaching

4.2.1. Knowing the Geometric Level of the Students in Advance and Setting up Appropriate Demonstration Questions

According to the "five stages of geometry teaching" theory of the Fan Hill couple, teachers should first consider the level of geometric thinking that students are currently in when teaching geometry. Therefore, teachers should not only consider the knowledge provided by the existing textbooks, but also set appropriate demonstration questions according to students' current level. The specific steps are as follows. (1) The teacher communicates with the students before the class to understand the students' preliminary knowledge and questions about the class. (2) The course is designed into multiple questions according to the teaching objectives and teaching materials, and the level is deepened step by step. (3) The teacher selects the problem that requires computer demonstration, use the the software of GeoGebra to operate, and use the "drawing process" option to record.

For example, in the section "The decision theorem that a line is parallel to a plane", the teacher first should communicate with the students during the preparation stage to understand the general knowledge background and the geometric thinking level of the students, and to judge their understanding of this lesson. For example, what are the positional relationships between lines and planes? What is the definition of parallelism? Can you give examples of parallelism between lines and planes in the real world? and so on. According to the current situation of the students, the teachers will study the teaching materials again and connect this lesson with questions. For example, how to ensure that there is no common point between the line and the plane? What are the common characteristics of the following examples of parallelism? If a straight line b in the plane α is parallel to the known straight line a, what is the positional relationship between the straight line a and the plane α? Can the above conditions be met to indicate that the line and the plane are parallel? and many more. Finally, the teacher should demote the questions prepared in advance with the software of GeoGebra.

4.2.2. Grasping the Timing of the Presentation and Minimizing Unnecessary Operations

Since the GeoGebra software does not have a paging function, the interface tends to be cluttered when there are too many images. In this case, a new interface is needed, which wastes valuable time. Therefore, teachers should try to reduce unnecessary operations when drawing, but choose problems with higher abstraction and difficult for students to understand. For example, when learning the definition of "ellipse", the teacher does not have to display various types of ellipse one by one, but can guide the students to explore how to make the elliptical trajectory with the software according to the definition of it.

4.2.3. Trying to Let Students Experience the Process from Concrete Things to Abstract Graphics

Complex digital and graphical relationships and variable geometric positional relationships are major difficulties in mathematics learning. Therefore, it is necessary to construct visual contexts with dynamic connections, so that students can find patterns in dynamic demonstrations (Zhang and Tang, 2010). While the software of GeoGebra speeds up the drawing speed of teachers, it is also easy for teachers to ignore students' understanding of the drawing process. Therefore, in the actual teaching, teachers should pay attention to let students experience the process of graphic abstraction, let students explore the ideas of solving problems in dynamic changes. (1) The teacher should explain the purpose of the figure and the purpose of each step to students in time when drawing. (2) Before using GeoGebra software to demonstrate, teachers should introduce appropriate physical models or examples to students, which will help students to reduce the strangeness of the images and help students understand the images.

For example, when learning "the determination that the line is parallel to the plane", the teacher can first introduce the actual problems prepared in advance. What is the positional relationship between the edge of the door leaf and the door frame? What is the positional relationship between the edge of the book and the cover? Students observe the real thing and guess that the two are parallel. Then the teacher guides the students to translate the above questions into mathematics questions. The student asks: Is the straight line EF parallel to the plane ABCD Figure 2? In this process, the students can experience the process from the physical object to the image, which is inevitably helpful to understand the theorem.

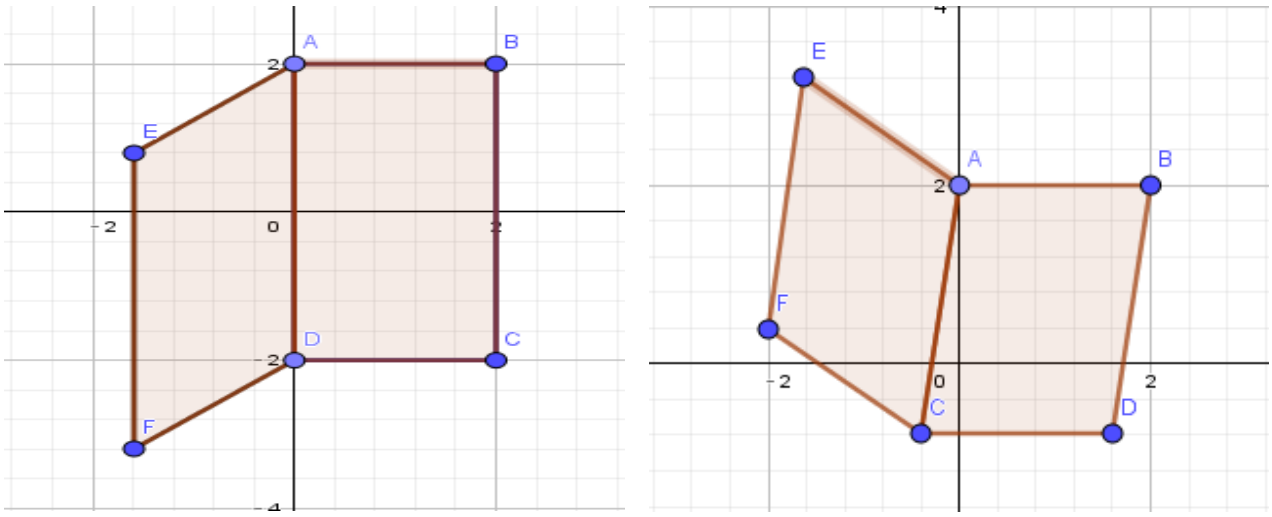

Figure-2. Examples of a straight line EF parallel to the plane ABCD.

Source: Created by the author based on the question above.

4.2.4. Letting Multiple Views Work Together for Digital and Graphic Integration

Simple visual presentation has not been able to reduce cognitive load very well, and it must work in conjunction with other characterizations. In the content design of visual teaching, combined with the analysis of specific content, visual representation must be rationally blended, and integrated into other meaningful "information blocks" (Zhang and Tang, 2010). Geometry learning is closely related to algebra learning. Therefore, teachers should make full use of other functional areas such as algebraic area and table area when performing geometric teaching, so that each function can cooperate with each other to truly realize the combination of values and shapes. Teachers should pay attention to the following points. (1) First of all, be familiar with the various input commands in order to quickly get the desired image. (2) When the value changes, you can first let the student guess how the image will change. (3) And then students should carefully observe the relationship between image changes and numerical changes, so that they can understand the relationship between algebra and geometry and reduce the cognitive load.

4.2.5. Dealing with the Relationship between Students' Software Learning and Mathematics Knowledge Learning in Mathematics Inquiry Experiment

Under the condition of sufficient teaching resources, proper mathematics inquiry experiment is not only conducive to students' understanding of geometric problems, but also can improve students' practical ability and increase their interest in learning geometric knowledge. However, because students are unfamiliar with this software, teachers should pay attention to balancing the relationship between students' software learning and mathematics knowledge learning when conducting mathematical inquiry experiments. In conducting the inquiry

experiment, the teacher should pay attention to the following points. (1) Before the experiment class, the students should be given appropriate guidance on how to use the software to map to avoid wasting unnecessary time during the experiment. We should train them in advance to avoid excessive trouble about software usage during class. (2) In the experimental class, the focus should be on the exploration of the experimental tasks. Each group can choose a classmate who is interested in computer as the team leader. When there are problems related to the operation of the software in this group, the team leader is responsible for solving problems or seeking help, so as to avoid confusion caused by students' discussion.

4.2.6. Paying Attention to the Effective Organization and Management of the Classroom

In geometry teaching, using the software of Geogebra to carry out mathematical inquiry experiments is very meaningful for students to understand geometric knowledge, but in addition to dealing with the relationship between software learning and mathematics knowledge, teachers should also pay attention to the organization and management of the classroom. Teachers can follow the steps below. (1) Exploring tasks and precautions at the beginning of the experiment. For example, you can only use two types of tools, such as straight line and circle. Does this task require students to complete independently or in groups? and so on. (2) Appropriate guidance and evaluation should be given during the experiment. (3) After the experiment is over, the students are instructed to establish a personalized experimental report as the experimental result. They can use the record function of the software of GeoGebra to record the experimental process and create an report for display.

4.2.7. Coordinating the Relationship between Software Operation, Blackboard and Courseware Demonstration Reasonably

In traditional geometry teaching, writing on the blackboard and using courseware demonstrations play an important role. Together with the use of GeoGebra software in the classroom, teachers need to switch back and forth, which not only takes a lot of time but also brings a lot of useless interference to students. Then the teacher needs to coordinate the relationship between the use of the software of GeoGebra, the blackboard and the courseware. Teachers should pay attention to the following points when teaching. (1) For some simple questions, let the students help teachers to operate the GeoGebra software. It can not only exercise the students' practical ability, but also reduce the burden for the teachers. But students must be given proper preparation time before class. (2) Abandon the traditional courseware demonstration when it is not necessary, create a "no courseware class", and use the software of GeoGebra to realize the functions that the blackboard cannot achieve. (3) Connect the demos of one lesson as learning materials for students to review. In short, teachers should pay attention to the rationalization of the teaching process when using GeoGebra software for teaching, and can not add extra burden to the classroom.

5. CONCLUSION

In summary, the proper use of GeogGebra platform in geometry teaching can effectively help students form geometric concepts, establish connections between different knowledge, solve geometric problems, and so on. Therefore, in the teaching of geometry, teachers should follow the principles of inspiration, interactivity, flexibility and selectivity. Teachers should also pay attention to setting reasonable geometric questions according to the students' geometric thinking level, minimizing unnecessary operations, combining multiple views to realize the combination of numbers and forms, and handling the relationship between students' software learning and mathematics knowledge learning, organizing and managing the classroom effectively, and coordinating the relationship between the software, blackboard and courseware.

However, how to coordinate students' learning of the software and mathematics knowledge, and how to organize and manage classrooms more effectively are worthy of further consideration.

REFERENCES

Li, D. and W. Pan, 2014. Several advantages of geoGebra in high school Mathematics teaching and learning. Fujian Middle School Mathematics, 35(3): 10-13.

Luo, S.P., 2017. The similarities and differences between geometric sketchpad and geo gebra. Academic Weekly, 11(35): 37-38.

Ministry of Education of the People's Republic of China, 2017. Ordinary high school mathematics curriculum standards. Beijing: Beijing Normal University Press. pp: 25-27.

Zeng, Y.L. and C.D. Zhai, 2017. A summary and enlightenment of the research on the geometric thinking level of fan hill theory. Contemporary Education Theory and Practice, 9(5): 12-16.

Zhang, W.Z. and H.R. Tang, 2010. Research on the whole process optimization of Mathematics teaching based on geoGebra. Journal of Mathematics Education, 19(1): 99-102.

Zhang, W.Z. and H.R. Tang, 2010. The five principles of visual teaching content design. Eeducation Research, 31(10): 99-102.

Zhang, Z.Y., 2018. High school Mathematics visualization teaching: Principles, approaches and strategies-based on geoGebra platform. Mathematics Bulletin, 57(7): 21-31.