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Integrating Hawgent Dynamic Mathematics Software into Cone Volume Geometry Learning in Elementary School

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Abstract

The aim of this research is to integrate Hawgent dynamic mathematics software into geometry learning to help teachers explain concepts and students understand the basic concept of volume of cone in 6th grade of elementary school. The research was conducted at Ningcheng Third Experimental Primary School with the population being all 6th grade students of the 2021/2022 school year. Sampling with a cluster random sampling technique and selected 40 students of 6th grade as the sampling class. In this teaching experiment research, the researcher was using a BOPPPS model based on the APOS theory. The research results showed that 79.49% of the students agree that the integrating Hawgent dynamic mathematics software into cone volume geometry learning process can help them understand the concept of cone volume. Integrating Hawgent dynamic mathematics software improves their interest in learning, the basis of in-depth understanding of knowledge, and the accuracy of the problem. In addition, information, communication and technology is highly integrated with classroom teaching, which can enrich classroom content and improve learning efficiency.

Keywords: *cone volume; geometry learning; Hawgent dynamic; integrating*

1. INTRODUCTION

In recent years, in the reform of the new curriculum standards, China has repeatedly proposed that education should be "people-oriented" and "student-development-oriented". The overall goal of the new curriculum reform is: education should oriented modernization, the world and the future (Binbo, 2019). The modernization and informatization of education cannot be effectively realized if the traditional and old-fashioned teaching methods are still used, that is, teachers are the main teachers and students are passive learners. The constructivism learning puts forward that "education should grow new knowledge from students' original experience", and education should cultivate people with all-around development, develop students' core literacy in mathematics, so as to give full play to students' subjectivity (Binbo, 2019) and change the "passive learning" into "active learning". Education informatization plays a very important role.

"Reasoning is the soul of mathematics" (Burnyeat, 2000), because Mathematics is the science that deals

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with the logic of shape, quantity and arrangement. Mathematics is all around us, in everything we do (Lestari et al., 2019). It is the building block for everything in our daily lives. "Full-time Compulsory Education Mathematics Curriculum Standards" clearly stated in the basic concept: (Chunlian, 2020; Yanping, 2021) "The design and implementation of mathematics courses should pay attention to the use of modern educational technology, especially the influence of calculators and computers on the content and methods of mathematics learning, and vigorously develop And provide students with richer learning resources, use information technology as a powerful tool for students to learn mathematics and solve problems, and are committed to changing the way students learn, so that students are willing and have more energy into realistic, exploratory mathematical activities."

Information, communication and technology (ICT) is very important to mathematics teaching and student learning (Chunlian, 2020). First, for teachers, the application of information, communication and technology（ICT）in teaching can improve the efficiency and efficacy of teaching, train and improve the comprehensive ability of teachers, and promote the comprehensive development of teachers. In the teaching process, it is often said that education should promote the all-around development of student's ability. In fact, the all-around development of teacher's ability is most important. Teachers have comprehensive ability and accomplishment, which can improve teaching efficiency, enrich classroom content, enhance teaching effects and create a classroom with vitality. Second, for students, the information, communication and technology（ICT）into classroom learning can improve students' interest in learning. Interest learning process is the best method or the best teacher. Confucius said, "Those who know are not as good as those who are good as those who enjoy themselves." In addition, it can also improve students' ability of self-inquiry and innovation. Thirdly, for teaching, the dynamic situation created by communication, information and technology is beneficial to reveal the essence of mathematics, promote students' understanding, and make teaching content rich and easy to understand.

In this research, the researcher was Integrated Hawgent Dynamic Mathematics Software to discuss the calculation of the volume of a cone. In the teaching process, based on The APOS theory (Xiaodan, 2020), APOS theory is constructiveness mathematics learning theory proposed by American scholared Dubinsky (1993). it discusses the psychological stage or structure of mathematics learning, namely operation, process, object and scheme and the activity-creating situation and participating in the activity; Process - problem oriented, inquiry process; Object - reveals the essence, generalizes the object; Diagram - Apply practice, form diagram (Gānxiáng, 2018), under the guidance of APOS theory, create the

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teaching model of BOPPPS (Jinjun, 2021; Yanlin, 2021). Boppps is short for Bridge-in, Objective, pre-test, participatory learning, post test and summary. To study the effect of Hawgent dynamic mathematics software on students' learning of cone volume. In his systematic discussion of the APOS theory (Xiaodan, 2020), Dubinsky chose linear algebra, statistics and calculus as specific examples, but this does not mean that the theory is not suitable for the study of geometric knowledge. Different from algebraic knowledge, the learning of geometric knowledge is a process from concrete to abstract, and geometric figures or objects are abstracted from concrete objects in life.

The study of the cone volume is guided after learning the area of the circle and the volume of the cylinder. By observing the volume relationship between the cylinder and the cone, the calculation formula of the cone volume is deduced (Liqin, 2021; Zheng, 2021). Learning cone volume can cultivate students' spatial imagination and logical reasoning ability. Spatial imagination has always been the focus and difficulty of students' mathematical geometry knowledge. Cylinder and cone are the contents of unit 3 of the Vol.-2 of 6 grades in the Renjiao Edition. The calculation of cone volume is the key point of this unit, as well as the key point of this textbook, and the key point of space teaching in primary school.

Hawgent dynamic mathematics software is dynamic mathematics with has the characteristics of visualizing or demonstrating mathematical concepts and constructing the essential structure of mathematics (Jihe et al., 2021; Pereira et al. 2021). Hawgent Dynamic mathematics software has the following characteristics (Pereira, Tan, & Li, 2020; Pereira, Wijaya, & Zhou, 2020; Pereira et al. 2020): (1) it provides a supportive and rich problem-solving environment; (2) Reduce the time spent on skills training, so students spend more time and energy on developing conceptual understanding; (3) The wide application of technology; (4) Improve students' learning motivation; (5) It promotes the relationship between declarative knowledge and real world problems.

Based on the above concept background, the fundamental of research problem is how to integrating Hawgent dynamic mathematics software into cone volume geometry learning?, based od the above research problem, the researcher tried to apply Hawgent Dynamic software to the study of cone volume, explore the relationship between cone and cylinder, learn to calculate cone volume (Liu Ruoqing et al 2021), and learn to improving teaching and learning effectiveness.

2. RESEARCH METHODOLOGY

The research was conducted at Ningcheng Third Experimental Primary with the population being all 6th grade students of the 2021/2022 school year. Sampling with a cluster random sampling technique and selected 40 students of 6th grade as the sampling class. In this teaching experiment research, the researcher was using a BOPPPS model based on the APOS theory (Jinglin, 2017;

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Yansong, 2021). The BOPPPS model with six types such as: Bridge-in, Objective/outcome, Pre-test, Participatory-learning, Post-test, and Summary/Closure Module. Below can be seen the BOPPPS research development framework in Figure 1.

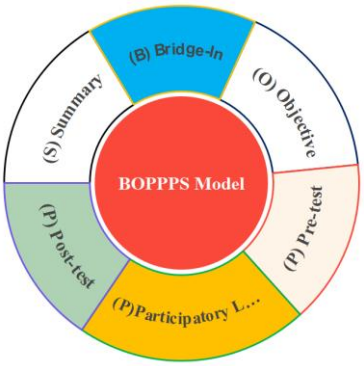

Figure 1. BOPPPS research development framework (Jiangyu, 2021)

Bridge In

The task of entering the teacher is to create a situation to stimulate the students' learning motivation and internal driving force; in this step, the importance of the curriculum should be emphasized. The teacher should pay attention to that the created problem situation should be consistent with the content of the lecture, and the created situation is inspiring situation.

Objective

Teachers must clarify the teaching goals and students' learning goals. Teachers show students the teaching goals and let students clarify the learning goals and standards of classroom learning; in one part, they should pay attention to the clear and pertinent expressions.

Pre-test

The task of the pre-test is to evaluate the students' knowledge and understanding before the class, and to help the teacher adjust the depth and progress of the content; this part can be carried out using the question-and-answer method.

In this step, researchers noticed the results of the students before. it means that to achieve the objectives of this research, the researchers made direct observations of the reality in the field, to teachers and students. and also observe how students use methods that are often used.

Participatory Learning

The task of participatory teaching is to guide students to actively participate in the teaching process, so that students can participate in the teaching process in an all-round way; in this link, based on the APOS theory, through the creation of context, problem orientation, and revealing the essence, a cone volume is finally formed calculation goal. Teachers will use Hawgent Dynamic Mathematics software to design dynamic conical volume mathematics to stimulate students' interest in learning; in addition, they will generally use group discussion, teacher-student interaction, questioning, situational simulation and other methods to guide participation.

Post-test

The task of the post-test is to detect whether students reach the teaching goals and understand the teaching effect, so as to verify whether the integration of

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Hawgent dynamic math software and math classroom can improve the learning effect and efficiency as well as the students' in-depth understanding of the learning content, so that students' know what it is. And know why."

Summary

The task of summarizing is to summarize, generalize, and reflect on the teaching content of this course. Experts and researchers will summarize from the following aspects: (1) whether the Hawgent Dynamic Mathematics software effectively promotes the efficiency of teachers' teaching, students' learning, and teaching process. (2) In this lesson, whether the design of the conical volume of the integrated ware is colorful, interesting, guiding and enlightening. (3) How can the mathematical integrable ware creating by Hawgent Dynamic Mathematics software be optimized in the future?

3. RESULT AND DISCUSSION

Bridge In

First of all, the teacher first shows students the actual life cone shape case, starting from the students' daily life experience, stimulates the students' internal motivation for learning, so that the students have a preliminary understanding of the cone, understand what kind of cone shape is, and let the students Give examples of what things in life are in the shape of cones. Afterwards, the researchers asked students to observe the pictures of cylinders and cones and think about the relationship between the volumes of cylinders and cones.

Objective

The teacher clearly stated the teaching objectives of this lesson, and directly and clearly told the students that the learning objective of this lesson is to understand the essential relationship between the volume of the cylinder and the cone, get the calculation formula for the volume of the cone, and learn to calculate the volume of the cone.

Participatory Learning

Teachers use Hawgent Dynamic software to draw dynamic teaching integrable ware. Through the experiment of pouring sand or water into cylindrical and conical containers of equal bottom and equal height, the formula of cone volume is obtained. In this study, the teacher used the Hawgent Dynamic software to make a dynamic prototype for the cone container to pour water into the cylindrical container, allowing students to observe the experimental process clearly and intuitively, and explore the volume relationship between the cylinder and the cone.

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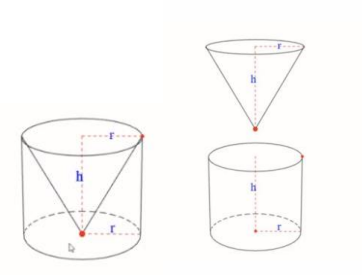
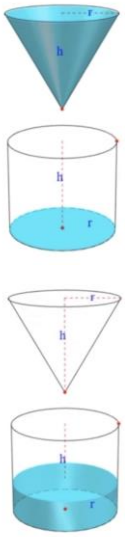
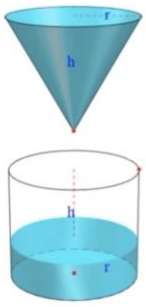
Table 1. Experimental Learning process storyboard

No	Visual Stage	Explanation
1		The first step is to use Hawgent Dynamic Mathematics software to make cylindrical and conical containers of equal bottom and equal height. By observing this picture, students can guess and discuss the relationship between the volume of the cylinder and the volume of the cone.
2		The second step is to use the Hawgent Dynamic Mathematics software to make the dynamic process of pouring the water in the conical container into the cylindrical container. The result of the first pouring is shown in the figure. In this process, it is necessary to mobilize the enthusiasm of students and let students participate closely in this teaching process. And promptly ask the students: After the first pouring, please observe the changes in the water level in the cylindrical container and guess what the relationship between the cylinder and the volume of the cone is. Guide students through observation and guess that the water in the cylinder volume is about one-third of the total volume of the cylinder at this time, and then guide the students to guess that the volume of the cone is one-third of the volume of a cylinder with the same base and equal height.
3		The third step is to use Hawgent Dynamic Mathematics software to continue making the second pouring process, and the result is shown in the figure. As in the previous step, in the teaching process, the dynamic information technology teaching is highly integrated with the student's subjectivity, and the students are continuously guided to reason about the relationship between the volume of the cone and the volume of the cylinder. At this time, the students, by observing the water level in the cylindrical container, guessed that after the second pour, the water in

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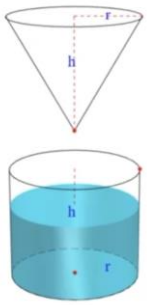
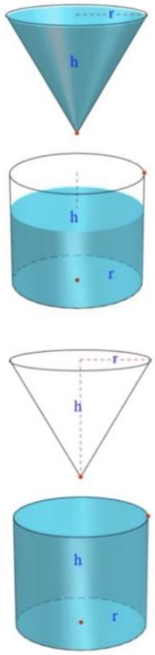
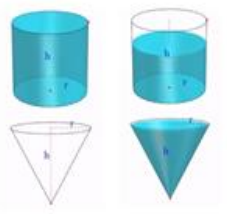
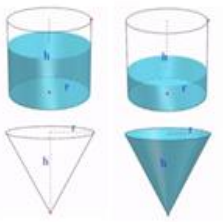
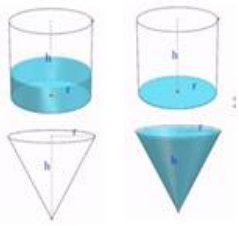
		the cylindrical container accounted for two-thirds of the total volume.
4		The fourth step, this step is the most critical link. By pouring the water in the cone into the cylinder for the third time, it can be found that the cylindrical container has been filled with water. At this time, guide the students to take the initiative to say "Pour the water in the cone container into the cylindrical container, and fill it up exactly three times." At this time, the teacher should actively encourage students: "The performance of the students is awesome, and the guesses of the students are very correct. The volume of a cone of equal base and equal height is one-third of the volume of a cylinder. We have learned the formula for calculating the volume of a cylinder. V=Sh, then the calculation formula for cone volume $V=\frac{1}{3}Sh$, with V represent of volume, S is bottom area and h is height respectively.
		
After the formula for calculating the volume of the cone is derived, the water in the cylindrical container is poured into the cone container to verify the conclusion. It can be found that all the water in the cylindrical container should be poured into the conical container, just filling three conical containers. The conclusion that the volume of a cone with a constant base and a height is one-third of the volume of a cylinder is still valid.		

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Post-test

Post test results are student interviews. The results of the student interviews can be seen in the following Figure 2.

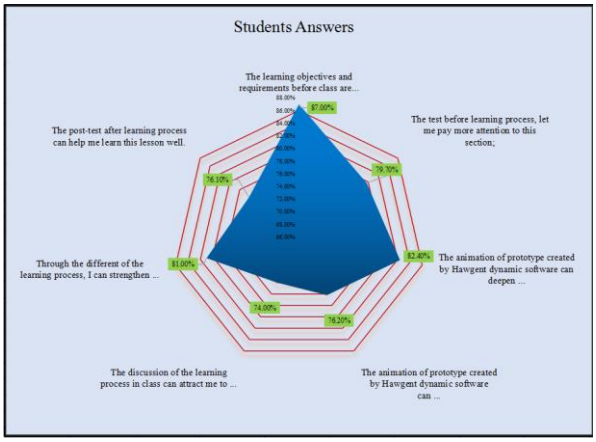

Figure 2. Student's answers

Based on the Figure 2 concluded that, the 87% agree with the learning objectives and requirements before class are clear and provided me with direction and goals, a 79.7% of students agree with the test before learning process, let me pay more attention to this section, a 82.40% students agree with the animation of prototype created by Hawgent dynamic software can deepen my understanding of knowledge about cone volume geometry, 76.20% students agree with the animation of prototype created by Hawgent dynamic software can stimulate my interest in learning, 74% students agree with the discussion of the learning process in class can attract me to actively participate in learning process, 81% of students agree with through the different of the learning process, I can strengthen communication and cooperation with others, 76.10% agree with the post-test after learning process can help me learn this lesson well.

Summary

After the experiment learning process, the researcher used a questionnaire survey to accumulate opinion of students or students' answers to the following questions and finally analyzed the effectiveness of integrate Hawgent Dynamic software into the teaching process based on the BOPPPS model. The majority of students agree with the average 79.49% from 7 indicators.

4. CONCLUSION

According to the research result show that, using Hawgent dynamic mathematics software to integrate in teaching and learning process can stimulate students' learning interest and motivation, deepen students' understanding of the cone volume, can let students understand the nature of the cone volume calculation, students on the basis of in-depth understanding of knowledge, to improve the accuracy of the problem. In addition, information, communication and technology (ICT) is highly integrated with classroom teaching, which can enrich classroom content, improve learning efficiency and promote the overall development of teachers and student's ability. The average of student's answers is 79.49%.

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