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zotero

Home > Archives > **Vol 4, No 1 (2022)**

Vol 4, No 1 (2022)

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Table of Contents

Articles

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Modeling Conic Section Using Hawgent Dynamic Mathematics Software

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Article Info	Abstract
	Teachers should pay attention to the deep integration of information technology and mathematics courses, so as to achieve the effect that traditional teaching methods are difficult to achieve. Conic section in high school is an important carrier for cultivating students' mathematical literacy, but it is highly abstract and comprehensive, making it a "difficult point" in high school mathematics teaching. Hawgent dynamic mathematics software has powerful dynamic and visual functions, which can effectively assist the teaching of ellipse in high school. The questions to be studied in this paper are: (1) describe how teachers use Hawgent dynamic mathematics software to design learning media when teaching the content of conic section and stimulate students' for knowledge; (2) describe how Hawgent dynamic math software be used in class to help students understand the definition of conic section effectively. This research was used the research method combining ADDIE model and teaching experiment to analyze the class using Hawgent dynamic mathematics software to design learning materials and the class using traditional teaching method. Research sample was 130 high school students. Mathematical software design learning materials, can give students an intuitive presentation of the formation process of the conic, so as to help students effectively understand mathematical concepts and stimulate students' curiosity for knowledge.
	Abstrak *Guru harus memperhatikan secara mendalam integrasi antara teknologi informasi dengan matematika, sehingga sulit untuk menemukan pengaruh dari penggunaan metode pengajaran tradisional. Bagian kerucut yang*

berbentuk kerucut	*dipelajari di Sekolah Menengah merupakan pembawa penting untuk menumbuhkan literasi matematika siswa, tetapi sangat abstrak dan komprehensif, sehingga menjadi "sulit" dalam pengajaran matematika di sekolah menengah. Perangkat lunak matematika dinamis Hawgent memiliki fungsi dinamis dan visual yang kuat, yang secara efektif dapat membantu pengajaran elips di Sekolah Menengah. Pertanyaan yang akan dikaji dalam makalah ini adalah: (1) mendeskripsikan bagaimana guru menggunakan perangkat lunak matematika dinamis Hawgent untuk merancang media pembelajaran ketika mengajarkan isi bagian kerucut dan merangsang pengetahuan siswa; (2) mendeskripsikan bagaimana perangkat lunak matematika dinamis Hawgent digunakan dalam kelas untuk membantu siswa memahami definisi bagian kerucut secara efektif. Penelitian ini menggunakan metode penelitian yang menggabungkan model ADDIE dan eksperimen mengajar untuk menganalisis kelas dengan menggunakan software matematika dinamis Hawgent dan merancang bahan ajar dan kelas menggunakan metode pengajaran tradisional. Sampel penelitian adalah 130 siswa SMA. Materi pembelajaran desain perangkat lunak matematika, dapat memberikan siswa presentasi intuitif tentang proses pembentukan kerucut, sehingga membantu siswa memahami konsep matematika secara efektif dan merangsang rasa ingin tahu siswa sebagai pengetahuan.*

INTRODUCTION

Many studies or research result shown that the integration of modern education technology into mathematics teaching in the classroom can effectively improve students' mathematical abilities compared to traditional teaching method, In addition, modern educational technology can stimulate students' curiosity and increase students' interest in learning. That is, when students learn a certain point of knowledge, technology can help students increase their confidence and curiosity (South 2017; Sun 2018). Mean that, the integration of technology in teaching can help students increase their confidence and intellectual curiosity when they learn a new particular knowledge. According (Abdullah, Shireen, and

Nilufa 2014) technology helps teachers to think how to integrate it into daily instruction in the teaching classroom because: 1) technology used as a cognitive tool helps students to understand concepts, develop conceptual models and solve problems; 2) technology used as a communication tool fosters discourse and collaboration between educators, students, parents, and the community; 3) technology used as a management tool increases efficiency for teachers and students; 4) the technology used as an evaluation tool helps teachers reflect on modified instructions and provides feedback on student learning; 5) technology used as a motivational tool to encourage and involve students in learning (Costley 2014; Liu et al. 2003; Pakdaman-Savoji, Nesbit, and Gajdamaschko 2019; Raposo et al. 2020). The results of the study indicate that teaching the integration of modern educational technology can improve students' mathematical abilities. In the process of learning mathematics, mathematics concept very abstract so that students find it difficult to understand. In the learning process, many students feel that mathematical concepts are abstract and difficult to understand, and lose confidence in learning mathematics, so they give-up to learn mathematics (Pekrun et al. 2017).

Ellipse shape lesson is closely related to our life, for example: planetary orbits are elliptical, spherical parts are elliptical, etc. These are all examples of life that are familiar to students (Pantazi and Doukakis 2020), but how the ellipse is formed What kind of properties are familiar to students. Therefore, in the teaching process, teachers should take some effective steps to help students understand of mathematical knowledge and develop their mathematics learning abilities. A survey study found that many students still cannot understand the relevant properties of ellipses, and knowledge related to functions and equations is difficult for students (Tong, Uyen, and Quoc 2021). Another study found that when teachers teach elliptical lessons, they can intuitively display the process of forming an elliptical trajectory and accurately display an elliptical image, and students can learn mathematics effectively; educational technology provides a variety of information to help them understand new

mathematical concepts (Pantazi and Doukakis 2020; Solving and Literacy 2012).

Hawgent dynamic mathematics software is a dynamic mathematics software from Guangzhou China which has powerful functions for dealing with basic math problems such as geometry, algebra, and statistics (J. Pereira et al. 2021; Jerito Pereira et al. 2021; Wijaya, Jianlan, and Aditya 2020; Yongxing Huang et al. 2021). Hawgent's dynamic mathematics software has three outstanding characteristics: flexible operation, powerful teaching functions, rich curriculum resources, and replicable mathematical objects and relationships. So that if Hawgent's dynamic mathematics software can be used properly, it will help increase student interest in learning and increase teacher teaching efficiency (Wijaya et al. 2020). Therefore, in this study the researcher was used Hawgent's dynamic mathematics software to design instructional media, teach cone sections, collect student results after class, observe, analyze and interpret the collected data.

Based on the background and research objectives above, the problems of this study are: (1) how teachers use the Hawgent dynamic mathematics software to design learning media when teaching the contents of the cone section and can it stimulate thirst for knowledge and curiosity?; (2) how the Hawgent dynamic mathematics software can be used in the classroom to help students understand the definition or concept of the conic section effectively?

RESEARCH METHOD

This study aims to verify the effect of using Hawgent dynamic mathematics software to design the learning media of conic curve, the author carried out a teaching experiment at Wangli Senior High School 2021/2022 Academic Year with totality of research sample is 130 high school students. It's located at Yulin City, Guangxi, China. The research data was analyzed using WPS Excel and SPSS v25.00 software. Two classes were experiment class used Hawgent software, and the other control class used traditional teaching methods.

This study was used the research and development method with the ADDIE model, namely analysis, design, development, Implementation and evaluation) (Baharuddin 2018; Syukri, Marzal, and Muhaimin 2020). In the analysis stage, the researcher was determined teaching objectives and analyze student learning situations. For example, in the ellipse teaching process, knowledge and skills are numerical knowledge and mathematical skills, processes and methods that students need to acquire after studying this subject. Mathematical processes and mathematical methods used in the content, attitudes and emotional values, namely changes in students' emotions, attitudes and values after studying this lesson, teaching focus and teaching difficulties, as well as analyzing the existing knowledge, experience and condition of students' abilities. At the design stage, according to the analysis of teaching objectives, teaching content and student learning situations, a researcher try to design integrable ware teaching media and material combined with Hawgent dynamic mathematics software. At the development stage, the designed integrable ware design was submitted to two media experts and two material experts for review, along with the teaching content and teaching methods adjusted in a timely manner according to the feedback from experts, and the teaching design was prepared and the appropriate teaching timeline was established. In the implementation stage, the researcher conducted an experiment, comparing the experimental class using Hawgent dynamic mathematics software to modeling learning materials and the control class using traditional teaching methods.

During the evaluation stage, analyze student feedback information data and organize student feedback suggestions, try to interpret the data and making a conclusions.This study used a questionnaire survey and content analysis to collect data from material experts and media experts. Second, product validation carried out by two material experts and two media experts. Finally, the mean scores were classified according to the criteria, and the media and material expert data were interpreted with the average score of the material expert and media expert. The evaluations were classified using a Likert scale shown in Table 1.

Table 1. Assessment criteria for material and media experts

Rating Score	Criteria	Description
$\overline{x} \geq 4.2$	Excellent	Without revision
$3.4 < \overline{x} \leq 4.2$	Good	Small part needs to revision
$2.6 < \overline{x} \leq 3.4$	Sufficient	Need to revision
$1.8 < \overline{x} \leq 2.6$	Poor	Major revision
$\overline{x} \leq 1.8$	Very Poor	Useless

RESULT AND DISCUSSION

Analysis Stage

According to China's 2019-2021 national examination results data for regular college admissions (Figure 1), it can be seen that the results in the analytic geometry section are not ideal. In 2019, students' mastery of analytic geometry was only 45.2%, and in 2020 it increased by 1.89%, or 47.09%. However, students' mastery of analytic geometry in 2021 is down 2.29% from 2020 and down 1 percentage point from 2019. It can be seen that the students' mastery of analytic geometry has not improved significantly during these three years.
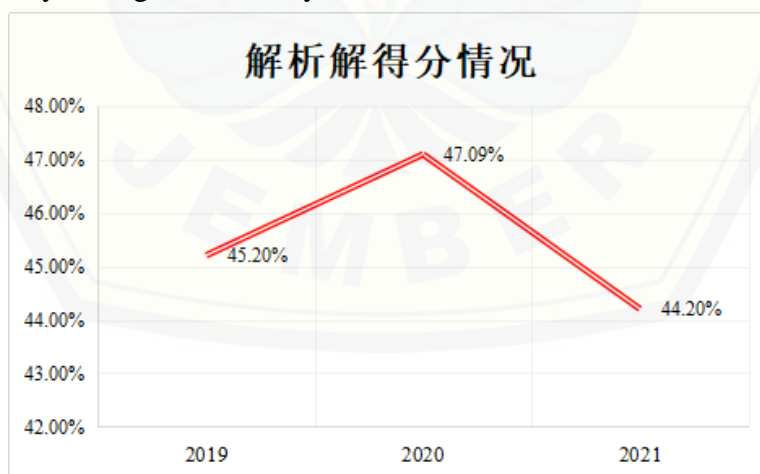

Figure 1. China's 2019-2021 National Examination Results Data for Enrollment in Ordinary Colleges and Universities

Through the data of the national unified examination results for the enrollment of ordinary colleges and universities in China, the researcher analyzed the difficulties that students was encountered in mastering the content of conic sections, and randomly selected 25 students in a class to conduct in-depth interviews. Students mastering the content of conic sections will face the difficulty may be as shown in Table 2.

Table 2. The difficult faced by students in mastering the content of conic sections

Aspect	Students Feedback	Students	%
Knowledge and Skills	High school students cannot understand the basic definition of a conic curve	22	88
Process and Method	In specific problem situations, students cannot calculate the results	19	75
	When solving problems, students cannot clearly explain each step	20	80
	When solving problems, students cannot grasp the key points of solving problems	15	60
Emotional Attitude	In the calculation process, the students are careless, but final result is wrong	8	31
	Students are not interested in this part of the conic curve	6	25

Table 2 show that, in terms of knowledge and skills, 88% of high school students could not understand the basic definition of conic section, 75% of students could not calculate the results in specific problem situations; in terms of process and method, 80% of students When solving problems, they cannot explain each step clearly, 60% of students fail to grasp the key points of solving problems when they encounter problems. In the dimension of emotional attitude and value, 31% of students are careless in the calculation process. The final result was wrong, 25% of the students were not interested in this part of the conic section.

Design Stage

In the stage of learning media design, the learning media is designed, combined with the functional characteristics of Hawgent and the requirements of the national mathematics curriculum standards, and consistent with the content of the teaching materials. This dynamic and interesting feature of learning media can well stimulate students 'interest in learning and conform to the students' cognitive law. A schematic representation of the learning media using Hawgent is shown in Figure 2.
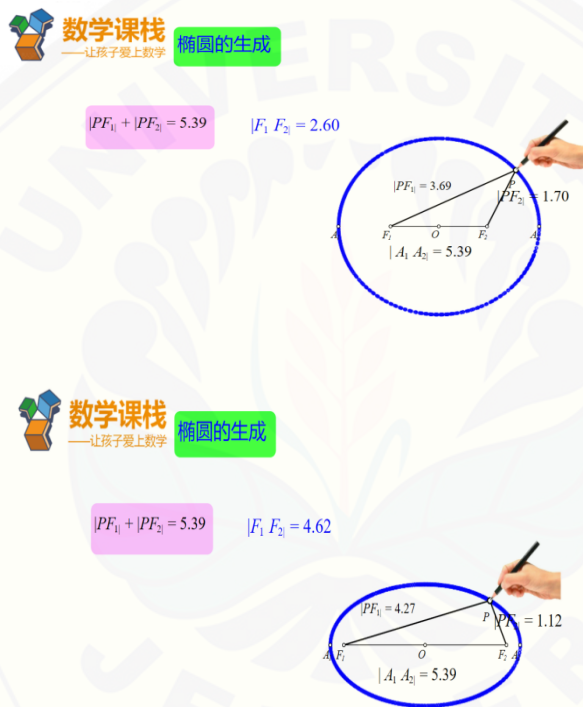
Figure 2. The elliptical trajectory when the long axis is constant and the focal length is changed

In Figure 2., the learning media with the Hawgent design can dynamically display the generation process of the elliptic trajectory, i. e., the moving trajectory of point P is an elliptic, while the sum of the lengths of PF_1 and PF_2 is kept constant. Hawgent can show students that when the sum of PF_1 and PF_2 are unchanged, change the position of

points F_1 and F_2, the movement trajectory of point P is still elliptical, helping students to understand in dynamic changes that with the sum of PF_1 and PF_2, the farther the distance of points F_1 and F_2, the more "flat" the shape of the ellipse.
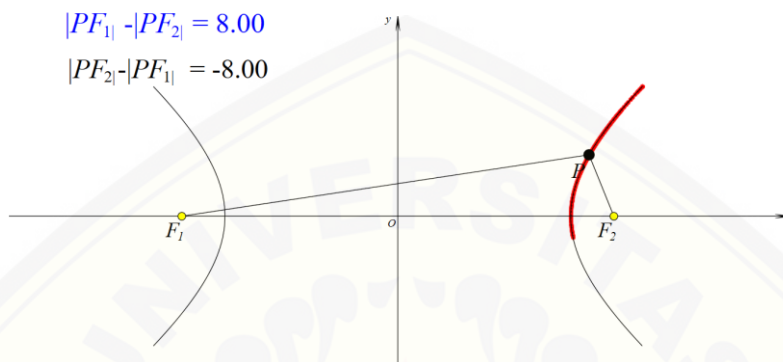
Figure 3. Trajectory of hyperbola

After the teacher explained to the students the ellipse is the plane to the F_1 and F_2 distance sum equal to constant (greater than $| F_1F_2 |$) of the moving point P trajectory, the student has obtained the experience to explore the plane coordinate system, then the teacher to guide the students to explore the hyper plane is the difference between fixed point F_1, F_2 moving point P of constant trajectory, in figure 3, the teacher can arbitrary drag point F_1, F_2 position in the x axis to change the pitch, students can experience when the distance difference between PF_1 and PF_2, point P track trace. In addition, Hawgent can also be used to explore the unified definition of the conical curve, which refers to the distance to the fixed point F and the distance to the fixed line l (F is not on l) of the ratio e is a constant point track, students can experience the diverse representation of the conical curve in the operation.
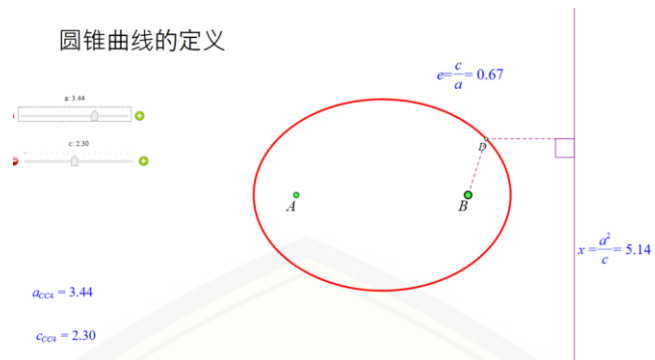
Figure 4. Track of kinetochores *p* when *a < c*
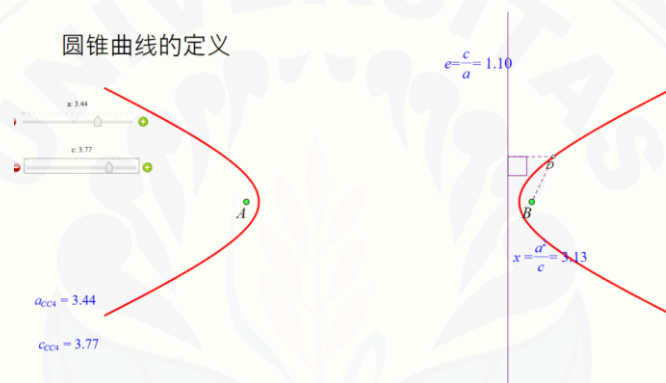
Figure 5. The trajectory of moving point *p* when *a > c*

Development Stage

After designing the learning media about conic section using Hawgent software, the learning media validated by the material experts and media experts to analyze the learning media's efficiency. Based on the validator's validation decision (Table 3), the pictures, animation, and display of the learning media are beautiful, and the average results are 4.5 or 90%, which falls in the excellent category. In the media practicality component, the average score given is 4.7 or 94%. This data means that Hawgent dynamic mathematics software is straight forward and practical for the teachers to use. The experts gave an average score of 4.1 or 82% for the students' attractive component, which means students are delighted to use Hawgent software to learn conic section. The average sum

percentage of all the components from the validator is 88%, which means that the material validator can further validate Hawgent software before being implemented in school.

Table 3. Validation result from media expert

Aspect	Item	Validation point	%	Criteria
Picture, animation, display	3	4.5	90	Excellent
Media practicality	3	4.7	94	Excellent
Students' interest in the media	3	4.1	82	Good
Average		4.4	88	Excellent

Based on the validation result from the material expert in Table 4, the conic section component got an average score of 4.57, in the excellent category. The validator gave an average score of 4.8 or 96% for teaching conic section, which falls in the excellent category. For teaching curves of conic in-depth, the average score given was 4.5, which falls in the excellent category. The material experts' average total score is 91%, which means that Hawgent is qualified to be implemented in school.

Table 4. Validation result from material expert

Aspect	Item	Validation point	%	Criteria
Explaining conic section	3	4.8	96	Excellent
Explaining Hyperbole	3	4.5	90	Excellent
Explaining the curves of conic	3	4.5	88	Excellent
Average		4.57	91	Excellent

Implementation and Evaluation Stage

After the modeling or designing learning media using the Hawgent Dynamic mathematics software is stated feasible and can be implement in secondary schools, researchers then used two classes as a random sample. One experimental class was taught using the Hawgent software, and the control class was taught using traditional teaching methods.

The sample size of the data involved in this experiment has two classes so that use the test of Kolmogorov-Smirnov[a] statistical. If the test results follow a normal distribution, then an independent sample *t* test is performed; if the test results do not follow a normal distribution, then an independent sample non parametric test is performed.

First, the Kolmogorov-Smirnov[a] statistical test was carried out on the pre-test scores of the two classes to test whether the pre-test scores of the two classes corresponded to a normal distribution in Table 5.

Table 5. Normality test of pre-test of control and experiment class

	Kolmogorov-Smirnova		
	Statistics	Df	Sign.
Control Class	0.077	65	0.200*
Experiment Class	0.075	65	0.200*

The Table 5 show the significant probability of the pre-test scores of the control class is $p=0.200>0.05$, and the pre-test scores of the control class is normal distribution; the significant probability of the pre-test scores of the experimental class is $p=0.200>0.05$. The test scores are also a normal distribution, so the pre-test scores of the two classes are a normal distribution, which found the premise of the independent sample *t* test whether there is a significant difference in the pre-test scores.

Table 6. Equality of variance and independent sample *t*-test

	Levene's Test for Equality of Variances		t-test for Equality of Means	
	F count	Sign.	Df	Sign. (2-tail)
Equal variances assumed	0.149	0.700	128	0.558
Equal variances not assumed			127.969	0.558

Based on the Table 6 show that the *F*-value of "Levene's test for equality of variances" reached the level of significant difference (*F*=0.149, *p*=0.700>0.05), indicating that the two classes have the same quality of variance in the pre-test scores, using the corrected t-test, at which point one should check the value in the column "Assuming equality of variances " column, the degree of freedom df=128, the probability of significance (two-tailed) *p*=0.558>0.05, indicating that there is no significant difference between the pre-test scores of the two classes.

After the first-line teachers finished teaching this part of the conic section, the students of the two classes uniformly took the midterm test organized by the school, and this midterm test was on the content of the conic section subject, then the score was used as the students' post-test score.

The Kolmogorov-Smirnov[a] statistical test was conducted to test whether the post-test scores of the two classes conformed to the normal distribution show in the Table 7.

Table 7. Normality test of post-test of control class and experiment

	Kolmogorov-Smirnova		
	Statistics	df	Sign.
Control Class	0.075	65	0.200*
Experiment Class	0.085	66	0.200*

Table 7 show the significant probability of the pre-test scores of the control class is $p=0.200>0.05$, and the significant probability of the post-test scores of the experimental class is $p=0.200>0.05$, The test scores are also a normal distribution, so the post-test scores of the two classes are a normal distribution, which found in the independent sample *t* test. whether there is a significant difference in the post-test scores.

Table 8. Equality of variance and independent sample test

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F count	Sign.	df	Sign. (2-tail)
Score	Equal variances assumed	4.375	0.039	129	0.040
	Equal variances not assumed			123.938	0.040

Based on the table 8, the *F*-value of "Levene's test for equality of variances" does not reach the level of significant difference ($F=4.375$, $p=0.039<0.05$), indicating that the quality of the variance of the post-test scores of the two classes is different, using a corrected *t*-test, at which point one should check the value in the column "Assuming that the variances are not equal", with a degree of freedom df=123.938 and a significant (two-tailed) probability $p=0.040<0.05$. The value in the column of "Assumption of unequal variance", with the degree of freedom df=123.938 and the probability of significance (two-tailed) $p=0.040<0.05$, indicates that there is a significant difference between the post-test scores of the two classes.

The Hawgent Dynamic Mathematics software received good feedback from teachers and students based on their responses to the learning media at school. From on the Table 9, we can see that students' feedback on Hawgent Dynamic Mathematics software was very useful and positive changes in students' knowledge and skills, learning process and attitudes towards learning occurred.

Table 9. Student feedback

Aspect	Student's feedback	Suggestion
Knowledge and Skills	Using Hawgent dynamic can help me a lot to understand the concept of conic section	Students hope the teacher can operate and explain a lesson using Hawgent
	I learned to derive the equation of the trajectory of an ellipse	
Process and Method	I now know where the equation for the trajectory of the ellipse comes from	The animation plays slower
	When solving problems, I can clearly know what each symbol represents	
Emotional Attitude	I am curious and interested in new knowledge	Add more funny sounds and cute pictures
	I no longer feel sleepy in mathematics class	

CONCLUSION

Based on the ADDIE framework, this study optimized the learning materials designed with Hawgent Dynamic Mathematics software and designed a comparison experiment in which Hawgent Dynamic Mathematics software was used to teach conic curves in a way that significantly improved learning outcomes. Firstly, we collected and analyzed students' difficulties, secondly, we designed learning materials using Hawgent Dynamic Mathematics software, then, the learning materials were valuated by media experts and material experts, and the designed learning materials were given to help teachers for classroom teaching, and finally, we collected feedback from students who participated in the experiment. The results of the study showed that, compared with traditional teaching methods, designing learning materials with the help of Hawgent dynamic mathematics software can present the formation process of conic section to students visually, thus can be help

students to understand mathematical concepts effectively and stimulating their curiosity and curiosity. To sum up, when the teachers teach conic section, the appropriate use of Hawgent Dynamic Mathematics software to optimize learning materials can help improve students' learning attitude and understanding.

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