Proving the Formula for the Area of a Circle using Hawgent Dynamic Mathematics Software

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Abstract. The purpose of mathematics learning is to understand the basic concept and use it in everyday life. So teaching and learning activities should be centered on the basic concepts. The author use Hawgent dynamic mathematics software to prove the formula for the area of a circle. This research uses the ADDIE model. According to the evaluation result of education and information technology experts, Hawgent dynamic mathematics software can prove the formula for the area of a circle. According to the actual teaching and feedback from teachers and students, Hawgent dynamic mathematics software plays a positive role in proving and understanding of the area formula of a circle. Therefore, using Hawgent dynamic mathematics software in teaching can better help students' classroom learning.

1. Introduction
Teaching problem solving skills is the base of mathematics teaching [1]. The direct presentation of problem solving ability is the students' mastery of mathematical problem solving skills. Basic mathematics plays an important role in mathematics learning. When learning mathematics, theory does not only focus on the mathematics knowledge but also how we can apply them in our everyday life [2]–[4]. In other countries' curriculum, the understanding of basic mathematics concept is also more important. At the same time, when students use technology in class, they would be able to understand the basic concept and the concept origin [5]. This causes the students to have a better and deeper understanding towards the mathematics concept. However, the traditional teaching method, it is difficult to directly present mathematical concept to students. With the development of science and technology, visual teaching tools are developed which provides a wider range of choice of teaching methods.

There are a lot of basic concept that are required to be mastered by students such as proving the formula for the area of a circle, probability and etc. But due to various limitation, teachers were unable to explain the concept clearly. With the rapid development of visual teaching tools, it provide wider range of choices to teach mathematics.

Hawgent dynamic mathematics software is a visual mathematics teaching software with a complete range of functions and its easy to operate [6], [7]. One of the features of Hawgent dynamic mathematics software is that it can visually show various mathematics concept such as functions, geometry, algebra, probability and etc [5], [8], [9]. Another feature of Hawgent is that it has an elegant selection buttons, rich operation function and simple program script for better interaction and to carry out various experiments [10]. The author uses Hawgent dynamic mathematical software to prove the formula for area of a circle. This paper consist of relevant research and thinking in order to provide a reference to primary and secondary teachers.
2. Experimental Method
This study uses the ADDIE model [11]. The ADDIE design model includes Analysis, Design, Development, Implementation and Evaluation. The target for this research is junior high school students from SMP Putra Juang, Jawa Barat, Indonesia. Analysis mainly refers to the analysis of teaching objects, teaching objectives and teaching tasks, such as the analysis of key and difficult points in proving the formula for the area of circle and the analysis of students’ learning scope and situation. Design refers to the learning design based on the curriculum, learning purpose and difficulties faced by teachers and students. Development refers to the learning media that would be validated by material and media experts to know the worthiness and drawback of the learning media. Implementation is when researchers try the learning media in schools to know the students’ learning attitude and response towards the learning media. Evaluation refers to the evaluation of the learning media and how we can improve the learning media.

![ADDIE framework](image1.png)

**Figure 1.** ADDIE framework

Based on the ADDIE model shown above in figure 1, the researchers carried out an experiment on 6th grade students and collect the data needed. The qualitative method is used to collect the data. Some of the data that the researchers needed to collect were the evaluation questionnaire answers that were filled by the material and material experts as well as the teachers, interview result that interviews 5 students about the proving of formula for area od a circle. The criteria of the questionnaire are shown in table 1.

| Criteria       | Percentage |
|----------------|------------|
| Not feasible   | 0%-20%     |
| Less feasible  | 21%-40%    |
| Enough feasible| 41%-60%    |
| Feasible       | 61%-80%    |
| Very feasible  | 81%-100%   |

3. Result and Discussion

3.1. Analysis
In the analysis stage, aside from collecting the difficulties faced by students from their homework and examination papers, researchers also collected the teaching materials about proving the formula for the area of a circle that can be difficult for students to understand. Table 2 shows the summary of the difficulties faced by students when learning how to prove the formula for the area of a circle.
Table 2. Difficulties faced by students when proving the formula for the area of a circle

| Student difficulties | Description |
|----------------------|-------------|
| Low analytical ability | It is difficult to imagine the actual problem with mathematical symbols. |
| Wrong procedure      | The way in which circles are converted into rectangles is unclear |

Students find it difficult to describe practical problems using mathematical language. One of the main problems faced by students is that their class participation level is low which causes an unclear understanding on the mathematical concept. Based the problems, researchers then designed a learning media for the students. Hawgent dynamic mathematics software can show the specific process on how to prove the formula for the area of a circle. This way, the students would be able to independently operate the learning media and help them to understand and master the formula for the area of a circle.

Teachers and students felt that proving the formula for the area of a circle is a difficult topic to be understood. That is why it is necessary for Hawgent dynamic mathematics software to provide an interesting and easy-to-learn learning media to help students understand the topic better and also to make the teaching-learning process to be more interesting[12].

3.2. Design
Five interactive buttons were designed to help teachers and students to operate and explore the proving process of the formula for the area of a circle more effectively. The “separate into N parts” button could be used to control the number of cuts in the circle. The “unfold” button could be used to control whether the circle is expanded or unfolded. The “merge” button could be used to merge two or more parts together. The “reset” button could be used to restore the cut pieces into a full circle. The “show/hide outline” button could be used to hide or show the rectangle borders.

Figure 2. Proving Process of the formula for the area of a circle

Firstly, click the “separate into N parts” button and input the value of n as 8 so that the circle would be cut into 8 equal parts. Teachers can ask “What figure outlines this circle” and guide the students to think. Gradually teachers can connect the learned topics, as shown in figure 2.

We can also separate the circle into 16 parts by inputting 16 as the value of N. Guide the students to observe what figure they see after merging them. Teachers can also gradually increase the number of cut pieces into 48 and 100 to see the changes in the figures as shown in figure 3.
Figure 3. Separate the circle into 16, 48 and 100 pieces

Through the actual input and change of numbers of cuts, students and computers interaction were enhanced. This resulted in students wanting to explore more by using other buttons to see the changes made. Not only teach students the formula for the area of a circle but it also teaches students how to prove the formula for the area of a circle. Through the exploration, the learning media that was operated by teachers and students was able to effectively stimulate students’ thirst for knowledge and enhance their learning interest. The specific teaching process is shown in table 3.

Table 3. Specific teaching process

| Study plan       | Purpose                                                        | Time |
|------------------|-----------------------------------------------------------------|------|
| analysis         | The teacher gives a problem of using the area of the circle in life, and guides the students to analyze the problem. | 5min |
| planning         | The teachers show the formula for the area of a square, rectangle and parallelogram and ask the students if we can use the formula to find the area of a circle. | 5min |
| implementation   | Teachers uses the learning media to show and proves the formula for the area of a circle. | 15min|
| Review and evaluation practice | Review the area formula of circle in the form of mind map, consolidate the knowledge. Give a variant exercise, let students practice in class, further use the knowledge. | 5min |

3.3. Development
The result of the questionnaire by Hao Jun on the purpose of Hawgent dynamic mathematics software shows that the average evaluation score from the media experts were 94.5%. This means that the learning media can be use by students to help them prove the formula for the area of a circle. The specific evaluation criteria and data are shown in table 4.
### Table 4. Evaluation results from the media expert

| Validator       | Component       | Score validation | Percentage | Criteria         |
|-----------------|-----------------|------------------|------------|------------------|
| Media expert    | Interactivity   | 4.8              | 96%        | Very feasible    |
|                 | Easy to use     | 4.8              | 96%        | Very feasible    |
|                 | Enrichment      | 4.6              | 92%        | Very feasible    |
|                 | Appearance      | 4.7              | 94%        | Very feasible    |
|                 | **average**     | **4.7**          | **94.5%**  | Very feasible    |

The average evaluation result from the material experts were 87.5%. this means that the learning media can be used effectively to help students understand the origin of the formula for the area of a circle. The detailed result by the material experts can be seen in table 5.

### Table 5. Evaluation result from the material experts

| Validator         | Component       | Score validation | Percentage | Criteria         |
|-------------------|-----------------|------------------|------------|------------------|
| Material expert   | Deep learning   | 4.7              | 94%        | Very feasible    |
|                   | Easy to understand | 4.5             | 90%        | Very feasible    |
|                   | Content of material | 4.2             | 84%        | Very feasible    |
|                   | language        | 4.1              | 82%        | Very feasible    |
|                   | **average**     | **4.1**          | **87.5%**  | Very feasible    |

### 3.4. Development

From the analysis of the learning media effect, Hawgent dynamic mathematics software can effectively help students to understand the proving process of the formula for the area of a circle. In addition, the learning media has various advantages such as Hawgent dynamic mathematics software has more abundant media resources and it has a simple design with a beautiful interface that can attract students’ attention and stimulate their learning motivation. Another advantage is that it is easy for the teachers to use and able to help teachers explain difficult theories with the various effects.

After using the learning media, students find mathematics more interesting to learn. This has also been proved in previous researches which stated that with the use of technology, it can increase the students’ learning interest [13]. Researchers interviewed 4 students as a representative from the 36 students to get feedback about Hawgent dynamic mathematics software.

### Table 6. Student Feedback towards Hawgent dynamic mathematics software

| Student | Statement |
|---------|-----------|
| S-1     | Hawgent dynamic mathematics software is better than other softwares |
| S-2     | I didn’t know where formula π came from. |
| S-3     | Geometric theories are more interesting when teachers explain it using Hawgent |
| S-4     | Hawgent makes me happy to learn mathematics |

### 4. Conclusion

Based on the research above, Hawgent dynamic mathematics software can be use to teach the proving of formula for the area of a circle. The average evaluation score from the media and material experts were 94.5% and 87.5% respectively that can be classified in the excellent grade of learning media. This evaluation score indicates that the learning media has a nice design and also a good teaching material. During the teaching process, students’ response was very positive and also said that learning
using the learning media is more interesting. Not only that, they also found that proving the formula for the area of a circle is easier to understand than when teachers use the traditional teaching method.

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