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Students', Pre-Service Mathematics Teachers', and In-Service Mathematics Teachers' Perception on Calculus Learning Video

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abstract

Calculus is a branch of mathematics that must be studied in school, especially at the high school level. One of the subject in calculus is the application of integral on the volume of solid of revolution. The use of learning video as media can help students in a conceptual understanding of the volume of solid of revolution which is one of the abstract objects in calculus. This article discusses the development of volume of solid of revolution learning videos and describes the perception of students, pre-service mathematics teachers, and in-service mathematics teachers the video. The subjects who participated in this study were 48 students at grade 12 in one of state high school in Sambas Regency, West Borneo, 8 pre-service mathematics teachers of one of the universities in Yogyakarta, and 3 high school mathematics teachers in Sambas Regency. Data were collected by using questionnaire consisting of several open questions. Through open questions, subjects were intended to express their ideas or opinions of what they think about the learning video. The finding showed that most of the respondents have positive perceptions on calculus learning video. 76,74% students agree that the video is suitable for use at the beginning of learning this subjects; all of the in-service mathematics teachers agree, and 75% pre-service mathematics teachers also agree. This indicates that the learning video can be used as one of teaching aids in learning of solid revolution.

Keywords:
Conceptual understanding, Learning video, Solid of revolution.

INTRODUCTION

Objects in mathematics are abstract objects. Some of the topics in mathematics require learning media in order to be able to bridge the topic to be taught and the students themselves. First, we need to know what media is? Media is a plural noun of a medium. Medium is something that is used to communicate directly with humans, without having to meet face-to-face (Buckingham, 2003). Meanwhile, Heinich, Molenda, Russel, & Smaldino (1996) medium is defined as a communication channel, derived from the Latin "between" which refers to anything that carries information between the source and recipient. For example, television, books, videos, computers, and others. Learning media can include technology assistance because teaching will be more effective using the right technology assistance. Some reason why technologies are used in the learning of mathematics is because it can facilitate the understanding of the concepts, and it is also superior in doing mathematical tasks (Cuoco, Goldenberg, & Mark, 1995).

One of technology-based learning media that has proven effective to help students understand mathematical concepts is learning videos. New concepts in mathematics can be introduced through learning videos (Niess & Walker, 2009) which can provide a visual picture or demonstration and is a good way to explain a concept (Graham & Berry, 1992). The use of video in learning activities is relevant to the current learning paradigm that demands student-centered learning. By observing well-designed learning videos, students can become active to explore new ideas in mathematics and not just become passive audiences (Niess & Walker, 2009). Learning activities using computer videos can be a solution to improve mathematics skills and concepts who do not experience a normal increase (Henderson, Landesman, & Kachuck, 1985). The use of learning video can help mathematics learning activities become more effective and improve student learning outcomes (Purwanti, 2015). Students who are taught by using video have an average of learning achievement that is better than students who are not taught by using video (Muna, Nizaruddin, & Murtianto, 2017).

Learning video is also effective to be used in higher education. Pre-service teachers who get learning using video, experience increased observational skills, especially in the ability of teachers in the mathematics content of the lesson, the ability to pay attention to classroom environmental features, and the communication of teachers and students during the lesson (Star & Strickland, 2008). It was also found that the use of interactive videos can improve students' mathematical abilities and motivation (Labasariyani & Marlida, 2017).

One of the abstract topics in mathematics is the volume of solid of revolution that uses an integral concept. This topic is one of the topics that is considered difficult by most students, even for students in university. In studying the concept of the volume of solid of revolution, students must know and understand the process of discovering the formula. To be able to understand the process, students are required to be able to imagine the object of solid of revolution which is certainly not easy for some students. If the teacher just provides an explanation through pictures in a book, blackboard, or students are asked to explore with the help of the internet without using adequate media assistance, then students will have difficulty in understanding the concept of the volume of solid of revolution.

Application of integral to the volume of revolution is an abstract topic that requires good visual or spatial ability. Some experts defined the volume of revolution. If an area is revolved about a straight-line, it will generate a volume of revolution (Lynn, 1985). Kuhfitting (1984) defined solid of revolution is defined as a region that is approximated by a rectangle and rotated about an axis. The volume can usually be determined using integration. There are three ways to determine the volume of revolution by integration,

namely disk method, washer method and shell method. The principle of the disk method and the washer method is determining the volume by using the formula of volume of a cylinder. The First step is drawing a typical element. Next step is constructing a disk (obtained from a thin cylinder), then obtaining the integral from the disk (Kuhfitting, 1984). The principle of shell method is determining the volume by using the formula of the lateral surface area of a cylinder. The first step is drawing a typical element, next step is constructing a shell, then obtaining the integral from the shell (Kuhfitting, 1984).

From the brief description of the topic above, it can be seen that it would be difficult for students to understand the topic if only using images in books, or pictures on the board, especially for students with low spatial abilities. This is because they have to imagine three-dimensional objects using two-dimensional media. Therefore, learning media are needed to facilitate students to understand the concept of the volume of revolution by displaying three-dimensional objects that can be easily imagined by students.

Several studies have been conducted to develop learning media for the topic of integral and its application to the volume of solid of revolution. For example, interactive learning media developed by Mustafidah & Aryanto (2010). However, the product developed does not contain videos that can be used as a media for understanding concepts for students. Another product is media developed by Suryadi (2014) in the form of software used to calculate the volume of a rotating object. The product focuses on the final result of the calculation, emphasizing the media as a calculation tool, not for planting concepts for students. Another media are those developed by Arcana (2011) which is integral learning in the form of a CD containing material enriched with animation that focuses on understanding concepts. But the product developed is a product for students in university. Therefore, researcher are interested in developing a learning video of the volume of solid of revolution with the disk method as the first stage of development which is then tested on students, pre-service mathematics teachers, and in-service mathematics teachers and then describing their perception of the learning video developed as an evaluation to make an improvement of the next phase.

Based on the description above, the purpose of this study is to develop calculus learning videos, especially on the topic of the volume of revolution with the disk method, and to describe the perception of students, pre-service mathematics teachers, and in-service mathematics teachers on volume of solid of revolution learning video.

METHODS

The product developed is calculus learning video using the ADDIE development model specifically developed by (Branch, 2009). ADDIE stands for Analyze, Design, Develop, Implement, and Evaluate. The video developed has been through the first three phases and has been validated by an expert.

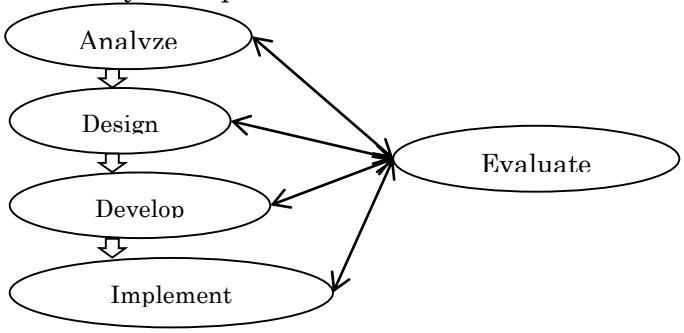

Figure 1 ADDIE concept

The first three phases in the process of developing this product are:

1. Analyze
   At this phase, what is done is to find out the difficulties of students in studying this topic by conducting interviews with several students, pre-service mathematics teachers, and in-service mathematics teachers and by finding out if they need media when studying this topic and find out what learning media is suitable for use in this topic. At this phase, an analysis of instructional goals is also carried out, which is expected that students can gain an understanding of concepts from this topic.

2. Design
   At this phase, researcher designed learning media in the form of videos that can help students to understand the concept of the volume of revolution and provide the needs of students in studying the topic based on the results of the analysis phase. The video contains steps in finding the formula of the volume of revolution and the principle used in the formula.

3. Develop
   At this phase, researchers develop products that have been designed at the design phase. The video developed contains animation about the steps of discovering the formula for the volume of solid of revolution and the duration is 6 minutes 35 seconds. Overview of the learning video of the volume of revolution can be seen in Figure 2.

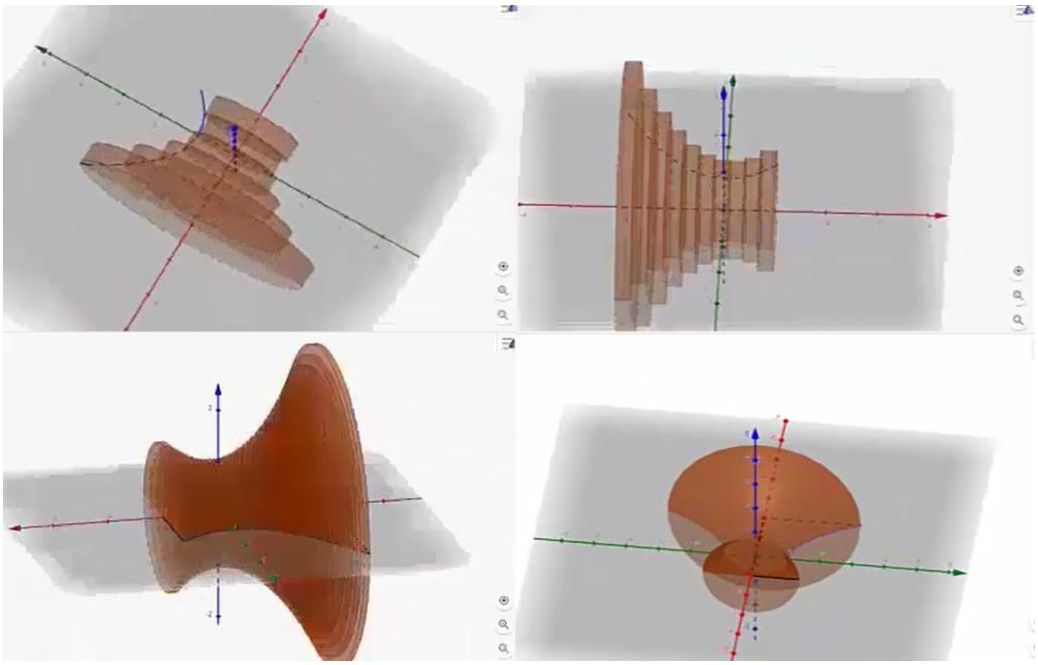

Figure 2 Overview of The Calculus Learning Video

Figure 2 shows the steps in finding the formula of volume of revolution by forming partitions that will lead to conclusions about the formula and the concept of determining the volume of revolution.

Before proceeding to the Implement phase, the video is first tested on a small scale to obtain suggestions as an evaluation to revise the product. The subjects involved were 48 students in one of the public high schools in Sambas Regency, West Borneo, 8 pre-service mathematics teachers registered at one of the universities in Yogyakarta, and 3 in-service

mathematics teachers in Sambas Regency. The students involved are students who have studied the volume of solid of revolution. The data was obtained by giving questionnaires containing several open questions that will be used to describe the perceptions of subjects on the learning video of the volume of revolution.

The instrument used are three types of questionnaires, each of which is used to obtain data from students, pre-service and in-service mathematics teachers that have been validated by an expert. Questionnaires consisted of questions before watching the video and questions after watching the video. The questionnaires used can be seen in Table 1 for students, Table 2 for pre-service teachers, and Table 3 for in-service mathematics teachers.

Table 1

Questionnaire for Students

Before watching the video	After watching the video
1. Is the topic of Volume of Revolution difficult for you?	1. Do you become more aware of the concept of the volume of revolution?
2. What is the teaching method provided by your teacher?	2. Is it easier for you to remember the formula?
3. Does your teacher use the media to teach this topic?	3. Do you feel more interested and eager to learn it?
4. What are your difficulties in studying this topic?	4. What are the advantages and deficiencies of this video?
5. How should learning activities for this topic that you expect?	5. Is the video suitable to be presented at the beginning of the learning activity in class?
If there are any additional comments, please write below	

Table 2

Questionnaire for Pre-service Mathematics Teacher

Before watching the video	After watching the video
1. Have you studied the volume of solid of revolution in calculus courses?	1. Do you become more aware of the concept of the volume of revolution?
2. Is this topic difficult for you?	2. Is it easier for you to remember the formula?
3. Do you understand the concept?	3. Is the video suitable to be presented at the beginning of the learning activity in class?
4. Do you think the topic is difficult for students? If so, what is the cause?	4. What are the advantages and deficiencies of this video?
5. According to you, what are the challenges that will be faced by the teachers in teaching this topic to students?	5. Do you think the video can help students to understand the concept of the volume of revolution?
6. If you become a teacher, how do you teach this topic to students?	
If there are any additional comments, please write below	

Table 3

Questionnaire for In-service Mathematics Teacher

Before watching the video	After watching the video
1. Do you understand the concept of Volume of Revolution (about how the formula is discovered? 2. What are your difficulties from the experience of teaching this topic? 3. From your experience, what are the obstacles faced by students in learning this topic? 4. Do you use the media in teaching this topic? What is your reason?	1. Is the video suitable to be presented at the beginning of the learning activity in class? 2. Do you think the video can help students to understand the concept of the volume of revolution? 3. Do you think this video can help students to remember the formula easily? 4. What are the advantages and deficiencies of this video?
If there are any additional comments, please write below	

RESULT AND DISCUSSION

1. Students' Responses

Students as respondents in this study are 48 people. Not all of them give responses to every question in the questionnaire. But the students had previously studied the topic about the volume of solid of revolution a few days before they watch this learning video. Their responses to the questionnaire before watching the video are represented in Table 4. After watching the video, the students gave responses to the questionnaire as seen in Table 5.

Table 4

Students' Responses on Questionnaire before Watching the Video

Question	Responses (%)					
Is the topic of Volume of Revolution difficult for you?	Difficult		Quite difficult		Easy	
	52.08%		33.33%		14.58%	
What is the teaching method provided by your teacher?	Lecture and discussion			Giving same question/ problem with the task		
	97.83%			2.17%		
Does your teacher use the media to teach this topic?	Yes (the whiteboard)			No		
	100%			0%		
What are your difficulties in studying this topic?	Lack of exercises	difficult to understand the problem	difficult to determine integrals	difficult to sketch the graphs	not understand the concept	difficult to remember the formula
	1.54%	20%	18.46%	21.54%	23.08%	15.83%
learning activities that you expect	Many examples	Deep explanation	Slow explanation	Using media	Discussion	
	47.62%	23.81%	7.14%	16.67%	4.76%	

Table 5
Students' Responses on Questionnaire after Watching the Video

Question	Responses (%)		
Do you become more aware of the concept of the volume of revolution?	Yes	Understand enough	No
	26.09%	23.91%	50%
Is it easier for you to remember the formula?	Yes	Easy enough	No
	47.83%	10.87%	41.30%
Do you feel more interested and eager to learn it?	Yes	Interested enough	No
	68.89%	6.67%	24.44%
What are the strengths and the weakness of this video	Too fast	Not detail	Lack of example
	75.68%	18.92%	5.41%
	Interesting and variative	Helping to remember the formula	Discovering the formula
	46.15%	10.26%	43.59%
Is the video suitable to be presented at the beginning of the learning activity in class?	Yes	Suitable enough	No
	76.74%	2.33%	20.93%

2. Pre-service Mathematics Teachers' Responses

From 8 pre-service mathematics teacher involved in this study, all of them had learned about the volume of solid of revolution. Their responses to a few questions can be seen in Table 6. About the challenges that they think they will face in teaching this topic, 4 of respondents agree that it will be difficult to make illustration for student, 1 of them state that it will be difficult to teach this topic based on the level of students, 2 of them agree that it will be difficult to teach this topic for the students' with low spatial ability skill, and another one said that it will be a challenge to have a skill of using media as teaching aids like software to teach this topic.

In responding the question 'If you become a teacher, how do you teach this topic to students?', 6 respondents said that they will use teaching aids or software to make illustration about the 3-dimensional objects, 1 respondent said that he will use the teaching method that will make students involved actively, and 1 respondents said he will teach the tricks about how to draw the graphs and how to find the volume.

According to respondent, this learning video has advantages. 2 respondents said that this video is presented in a structured manner with content aimed to achieve conceptual understanding, 2 respondents said that this video can help students to imagine solid objects formed by revolution. And 1 respondents said it gives an explanation about the discovery of the formula. This video also has deficiencies. 3 respondents said that it is lack of example, 4 of them said it is too fast, too short and not enough explanation in the video.

Table 6

Pre-service Mathematics Teachers' Responses

Question	Responses (person)		
	Yes	**Enough**	**No**
Before watching the video			
Is this topic difficult for you?	2	5	1
Do you understand the concept?	4	3	1
Do you think the topic is difficult for students?	6	2	0
After watching the video			
Do you become more aware of the concept of the volume of revolution?	7	1	0
Is it easier for you to remember the formula?	8	0	0
Is the video suitable to be presented at the beginning of the learning activity in class?	6	1	1
Do you think the video can help students to understand the concept of the volume of revolution?	8	0	0

3. In-service Mathematics Teachers' Response

Three in-service mathematics teacher involved in this study stated that they did not understand the concept of volume of revolution yet. Their responses can be seen from Table 7. The difficulty experienced by respondents when teaching this topic is how to make students able to draw graphs before continuing with drawing and imagining objects of solid of revolution. Two respondent admitted that they did not use the media for teaching this topic because of not enough time, while another one claimed to use the media which is GeoGebra. But she uses GeoGebra as media just to give an overview of the object to be calculated by volume, not to explain the concept.

All of teachers agreed that this video is suitable to be presented at the beginning of the learning activity in class and can help students to understand the concepts. They also agreed that this video can make can help students to remember the formula easily, but there are deficiencies in this video. They said it is too fast and the explanation is not detailed. They stated that this video has advantages, that the visualization is interesting, that the explanation of the discovering the formula is good and that students can see the shape of solid of revolution.

Table 7
Pre-service Mathematics Teachers' Responses

Question	Responses (person)		
Before watching the video			
Do you understand the concept?	Yes	Enough	No
	0	0	3
What are your difficulties from the experience of teaching this topic?	Drawing graphics	Not mastering the concept	
	1	2	
Obstacles faced by students?	Drawing graphics	Other	
	1	0	
Do you use the media in teaching this topic?	Yes (Whiteboard)	No	
	1	2	
After watching the video			
Is the video suitable to be presented at the beginning of the learning activity in class?	Yes	Enough	No
	3	0	0
Do you think the video can help students to understand the concept of the volume of revolution?	3	0	0
Do you think this video can help students to remember the formula easily?	3	0	0

The product developed in this study is a calculus learning video that focuses on the topic of the volume of solid of revolution. This video contains animations about how to find the formula for the volume of solid of revolution. The video was developed based on the results of the Analysis and Design phases in the ADDIE development model. After this product is developed, it is then tested on a small scale to find out students, pre-service mathematics teachers' and in-service mathematics teachers' perceptions on this learning video. The result will be used to evaluate the product before being tested on a large scale in the next phase (Implement phase).

Based on the data obtained from the questionnaire, the majority of respondents gave positive perceptions on the learning video of the volume of revolution. Most of the students stated that they have difficulties in learning this topic, but after watching the video, 47.83% of them agreed that this learning video help them to remember the formula easily and 68.89% of them stated that they feel more interested in learning this topic, but 50 % students stated that they do not become more aware about the concept of this topic. This is because this learning video is designed not to be a substitute for the teacher in teaching the topic of the volume of revolution, but be a media for teachers in teaching and learning topic of the volume of revolution. In this case, students only watched the video without getting explanations from the teacher. This is consistent with what was stated by Niess & Walker (2009), that learning video can help to improve student mathematics learning and bind mathematical thinking of students if guided by potential and experienced teachers. For large-scale implementation, this learning videos will be tested together with lesson plans and worksheet that consist learning activities that will support the enhancement of conceptual understanding of this topic.

Pre-service mathematics teachers also indicate positive responses. After watching the learning video, all of 8 respondents agreed that it is easier for them to remember the formula, 7 of them agreed that it helped them to understand more about the concept, and they agree that this learning video potentially can help students to understand the concept of volume of revolution and is suitable to be used at the beginning of learning activity in class. Some of them commented on the weaknesses of this video. They said that this video is too fast, too short and lack of explanation. This was intentionally designed because if the learning video was too long, it would make students feel bored and sleepy. The lack of explanations was designed so that teachers could provide explanations and that students were not only presented with material, but they were also expected to develop their own concepts with the help of worksheets to support learning activities in a classroom. If the video provides a very clear explanation, learning will not be student-centered because students understand the concept, not through their activities.

All of three in-service mathematics teachers agree that this video is good for helping student remembering the formula because the explanation based on the discovery of the formula. They also agree that this video is suitable to be presented at the beginning of the learning activity in class, and also they agree that this video can help to improve students' conceptual understanding about the volume of revolution. Most of the respondents gave comments about deficiencies of this learning video, and it will be used to make improvement and revised this product with the validation of the expert.

CONCLUSION AND IMPLICATION

Overall from the results of this study, students, pre-service mathematics teachers, and in-service mathematics teacher have positive perceptions on calculus learning video. All of the in-service mathematics teachers agreed that this learning video can be used at the beginning of learning activity to study about the volume of solid of revolution, 75% pre-service mathematics teacher and 76.74% students also agreed. It means that after being revised, this learning video will be ready to be tested on a large scale (Implement phase) as learning media to support the topic of the volume of solid of revolution learning activities so that students can understand the concept.

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