The Effectiveness of AR-Geometry Interactive Book in Increasing Students’ Mathematical Reasoning Skill

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Abstract. Mathematics is a subject that requires the students to gain reasoning abilities. Reasoning ability can be found when students learn geometry material. However, several studies concluded that geometry material is one of the difficult material for students. Difficulty of geometry is caused by the majority of mathematics teachers still use conventional media and teaching instruments in learning, especially in term of constructing the space. This is implemented on the AR-Geometry Interactive Book. This book is designed by using the principle of interactive 3D (three-dimensional) appearance by utilizing Augmented Reality (AR) based technology. This research uses a combination of qualitative and quantitative methods. The first qualitative data was taken by depth interviews to 4 informants selected with certain conditions using purposive sampling technique. The first phase of data collection aims to explore the information related to student interest in using the AR-Geometry Interactive Book. Furthermore, the second stage data was taken using a questionnaire to 21students in class VIII of SMPN 4 Ujung Batu. The second stage of data collection aims to support the results of the first phase of the research, all data in the second stage were then analyzed descriptively using quantitative analysis tools. Overall, the results of the second analysis indicate that the AR Geometry Book is appropriate to use in learning. To see students’ mathematical reasoning abilities, tests were conducted by testing 3 essay questions. The results of the study prove that the use of AR-Geometry Interactive can improve students' mathematical reasoning abilities.

Introduction

Improving the quality of education can be done in the learning process, one of which is in mathematics class. Mathematics learning aims to train students’ thinking and reasoning ability in drawing conclusions and foster their self-confidence and honesty to solve existing problems. Mathematics lessons emphasize ratios (reasoning), not experimental results or observations. This is because mathematics is formed by human thoughts, which are related to ideas, processes, and reasoning [1]. It means that learning mathematics requires students to have reasoning abilities. In the learning process, students can assess their reasoning abilities in geometry.

In studying geometry, students are required to understand and master the concepts well. According to [2], in studying geometry, students are expected to be able to visualize, describe and compare geometric shapes in various positions. In other words, students need reasoning skills in applying concepts and skills in geometry learning. However, [3] suggest that the lowest average percentage achieved by Indonesian students in the cognitive domain at the level of reasoning ranged from 17%. That finding shows that students' reasoning abilities are still low.
Based on the survey results of the Programme for International Student Assessment (PISA), it was found that students’ ability were very low in geometric material, especially in understanding figures and forms[4]. In addition, the facts show that students tend to have a lack of mastery and the ability to use good reasoning skills in solving mathematical problems [5]. This idea is also reinforced by 2015 TIMSS (Trends in International Mathematics and Science Study) data that the achievement of students in solving geometry content is only 28% compared to other mathematics content [6]. The results of the survey on Training Need Assessment (TNA) conducted on 286 junior high school teachers shows that three dimensional geometry materials in junior high schools are considered difficult for students [7]. The idea means that students do not quite understand the concepts and principles of geometry.

Increasing students' mathematical reasoning abilities can be done by using various learning media in mathematics lessons. Several previous studies [8], [9], [1] showed that the use of instructional media can improve the quality of learning and develop mathematical abilities. In line with the finding, efforts to improve students' reasoning abilities include using technology-based learning media. The use of technology is unavoidable in every aspect of learning. [10] suggest that the use of technology in the form of the latest software in developing children's thinking about geometry is necessary, including abstract reasoning skills for higher levels of mathematical thinking.

The role of the teacher in using technology as a learning medium is very important. However, the learning media used is less attractive. This idea is in line [11] which states that the use of textbook media or power point presentation solely means moving geometry material in the form of a visual display of images contained in books to LCD media in the learning process. Furthermore, the use of conventional teaching aids that are usually given in schools such as nets packed using iron to form a solid figure.

Less attractive or monotonous learning media make the learning process seem uninteresting. Boredom in learning will make students experience anxiety. This anxiety eventually leads to the difficulty of learning mathematics compared to other lessons. An action is necessary to change the perception that mathematics is one of the subjects that are not favored by students, especially in geometric material which makes students' reasoning abilities low.

Related to the previous elaboration, in improving students' mathematical reasoning abilities, the use of technology-based learning media can help the learning process. [12] reveals that an interactive book combined with Augmented Reality technology can support teaching and learning on geometry topics that include solid figures. This is reinforced by Correa [13] research on AGeRA which consists of geometry books and applications that are able to display 3D objects, sounds, animations and other interactive elements when placed in front of the camera of a mobile device. Research reveals that using technology-based learning media make geometry learning and teaching to be more interesting and fun.

Based on the problems, the interactive AR-geometry interactive book has been designed using the principle of interactive 3D (three-dimensional) appearance by utilizing AR (Augmented Reality) based technology. In addition to being able to bring up solid figure objects in the books into the form of 3D objects (three dimensions) and their animations that will be displayed through the VirGo (Virtual Geometry) application, the AR-geometry interactive book also contains the material and students’ worksheets on geometry lessons, especially solid figures. The collaboration between learning media and Augmented Reality technology is one of the creative and innovative efforts offered to students. Thus, further research is needed on the effectiveness of AR-geometry interactive book in improving students' mathematical reasoning abilities on geometry material.

**Research methodology**

The research employed the theory of mixed methods research, where quantitative methods were used to determine the effectiveness of AR-geometry interactive book in improving students' reasoning abilities on geometry material. The qualitative research method in this study was used to describe students' mathematical reasoning abilities through AR-geometry interactive book. This research was conducted at SMP Negeri 7 Padang. The sample used was students in the eighth level.
The research used two methods or a combination of qualitative and quantitative or better known as mixed methods designs. Based on the theory of mixed methods designs, this research used a sequential mixed methods strategy. [14], a sequential sequential exploratory research design requires the researcher to collect data and analyze qualitative data which is then followed by the collection and analysis of quantitative data based on initial quantitative results. The main emphasis on this method is the qualitative method. Mixing the two methods was aimed at connecting (connecting) between the results of the first research and the next stage. [15], the the use of two methods in a study can also provide a more detailed picture of a problem being studied. They also stated that the use of two methods has its own advantages in gathering and analyzing data that can produce a more robust and better quality research result.

The first qualitative data was taken from 5 people as informants for in-depth interview data. The first phase of the data aimed to find information related to student interest towards the AR-geometry interactive book. The first stage of informant retrieval was determined by a purposive sampling technique. All interview data were thematically analyzed using Nvivo 8 analysis tool. Thematic analysis is one of the more flexible ways to identify, analyze, and report qualitative research data. Before all data was submitted into the Nvivo 8 analysis tool, all the results of informants’ interviews were transcribed, reduced, grouped into a theme to be reported in the form of dialogue or verbatim [16]. Furthermore, the second stage data was taken using questionnaires and tests of students' mathematical reasoning abilities. Questionnaires were given to 21 students in class VIII Junior High School (SMPN 4 Ujung Batu) and analyzed descriptively using SPSS Windows 18.0. Whereas to test the students' reasoning abilities, a test related to the students' reasoning abilities which consisted of 3 items were given to 21 students.

Results and Discussion

1.1. Research result
In this section, the overall results of this study are reported in two stages, namely; first, the results of thematic analysis of qualitative data taken through direct interviews to all informants; second, the results of the quantitative analysis taken using questionnaires and tests administered to all research respondents.

Based on the results of the interview, the thematic analysis found that the use of AR-Geometry Interactive Book could attract students’ interest in learning and was able to develop students' abilities. This idea was conveyed by the information the interviews, even though there were differences related how the matters were conveyed by the informants, but they had more or less the same point of view. The excerpts of the interview are illustrated in the following tables.

Table 1. Excerpts of interviews related to students’ interest in the AR-Geometry Interactive Book at the first meeting

| No | Informant | Interview Excerpts |
|----|-----------|--------------------|
| 1  | Informant 1 | ...I think the book is very interesting. I like using this book. It even has a Virtual Geometry application. |
| 2  | Informant 4 | I am happy, ... this book is interesting, by using a mobile phone and directing the camera to the book, 3D cube objects and other solid figures of flat plane shapes appear. |
| 3  | Informant 2 | I have the same opinion, hehehe, ... very interesting. It helps deepen our understanding on geometry lessons. |
| 4  | Informant 3 | This book is interesting, it can facilitate learning. Moreover, I have never used this kind of books and applications before. |
Table 2. Excerpts of interviews related to students’ interest in the AR-Geometry Interactive Book at the second meeting

| No | Informant | Interview Excerpts |
|----|-----------|--------------------|
| 1  | Informant 1 | ... After using this book several times, I get more interested, it is a good book because it has a three-dimensional display in the Virtual Geometry application. |
| 2  | Informant 2 | ... this book is useful, simple, hehehe, it is not difficult for me to understand ...... ,, also encourages me to learn mathematics. |
| 3  | Informant 4 | I think it is a good book, after using it again, I can understand the material related to geometry (solid figures) at home. |
| 4  | Informant 3 | This book is interesting, ... it also has interesting colors and can help to understand geometry (especially about solid figures). |

Table 3. Excerpts of interviews related to students’ comprehension of geometry Material using the AR-Geometry Interactive Book at the first meeting

| No | Informant | Interview Excerpts |
|----|-----------|--------------------|
| 1  | Informant 2 | In my opinion, this book motivates me, this book contains formulas and materials of solid figures (flat plane shape) and really helps me understand and work on the problems. |
| 2  | Informant 4 | ... this book has cube material and other solid figures of flat plane shapes, so it is very helpful in comprehending geometry material. |
| 3  | Informant 1 | In addition, it makes it easier to work on the questions, as in the cube material, ....It is also very helpful as it is in the form of an application ... hehe, yes then three-dimensional images appear. |
| 4  | Informant 3 | ... I have the same point of view, it makes it easier to work on the problems (questions) related to solid figures (flat plane shapes) and I better understand the shape of solid figures in a three-dimensional view. |

Table 4. Excerpts of interviews related to students’ comprehension of geometry material using the AR-Geometry Interactive Book at the second meeting

| No | Informant | Interview Excerpts |
|----|-----------|--------------------|
| 1  | Informant 3 | This book and application are very helpful and also further deepen my comprehension related to solid figures (flat plane shapes). |
| 2  | Informant 4 | In my opinion, this book can be useful to comprehend material related to solid figures (flat plane shapes) and also display objects in three-dimensional shapes. |
| 3  | Informant 1 | ..., the application really helps me by displaying elements of solid figures such as edges and vertices and also giving examples which I can easily relate to in everyday life. So the book is very interesting. |
| 4  | Informant 2 | For me, this book can help me to comprehend material related to solid figures that is usually only depicted on the board. hehe ,, with the help of the application, the learning gets easier. |

To strengthen the qualitative data obtained in this study, the authors then took the data quantitatively using tests and questionnaires in the second stage. First, the research instrument in the second stage was taken based on the results of the interview in the first stage. This research instrument was in the form of a questionnaire that had been analyzed descriptively (frequency). The results showed that, overall, twenty-one (21) respondents acknowledged that the AR-Geometry Interactive Book was appropriate to
use. The description and discussion of the results of the analysis can clearly be seen in the following table.

**Table 5. Descriptive Analysis of the Use of AR-Geometry Interactive Book**

| No. | Statement                                                                 | N= 21 respondents (total number of respondents) | Frequency and Percentage |
|-----|---------------------------------------------------------------------------|-----------------------------------------------|-------------------------|
|     |                                                                           | Strongly agree (SS) | Agree (S) | Less Agree (KS) | Disagree (TS) | Total |
| 1   | **A. Interest**                                                           | 13                | 3         | 3              | 2             | 21    |
|     | *AR-Geometry Interactive Book looks interesting*                          | (61.9%)           | (14.3%)   | (14.3%)        | (9.5%)        | (100%)|
| 2   | *AR-Geometry Interactive Book makes me more enthusiastic in learning mathematics* | 0                 | 15        | 3              | 3             | 21    |
|     |                                                                           | (0%)              | (71.4%)   | (14.3%)        | (14.3%)       | (100%)|
| 3   | *This book throws away boredom in math lessons.*                          | 2                 | 14        | 2              | 3             | 21    |
|     |                                                                           | (9.5%)            | (66.7%)   | (9.5%)         | (14.3%)       | (100%)|
| 4   | *AR-Geometry Interactive Book supports students’ mastery of math lessons, especially related to solid figures (flat plane shapes)* | 9                 | 7         | 1              | 4             | 21    |
|     |                                                                           | (42.9%)           | (33.3%)   | (4.8%)         | (19%)         | (100%)|
| 5   | *The presence of motivational words in the AR-Geometry Interactive Book affects students’ daily life.* | 8                 | 9         | 2              | 2             | 21    |
|     |                                                                           | (38.1%)           | (42.9%)   | (9.5%)         | (9.5%)        | (100%)|
| 6   | *The illustration motivates students to study the material*               | 0                 | 6         | 11             | 4             | 21    |
|     |                                                                           | (0%)              | (28.6%)   | (52.4%)        | (19%)         | (100%)|
| 7   | **B. Material**                                                           | 13                | 2         | 5              | 1             | 21    |
|     | *Materials presented in the AR-Geometry Interactive Book are related to daily life.* | (61.9%)           | (9.5%)    | (23.8%)        | (4.8%)        | (100%)|
| 8   | *Materials presented on AR-Geometry Interactive Book are easy for me to understand.* | 8                 | 9         | 3              | 1             | 21    |
|     |                                                                           | (38.1%)           | (42.9%)   | (14.3%)        | (4.8%)        | (100%)|
| 9   | *In the AR-Geometry Interactive Book, there are several parts where I can find the concept myself.* | 2                 | 11        | 0              | 8             | 21    |
|     |                                                                           | (9.5%)            | (52.4%)   | (0%)           | (38.1%)       | (100%)|
| 10  | *Material presentations on the AR-Geometry Interactive Book encourage me to discuss with other friends.* | 2                 | 14        | 4              | 1             | 21    |
|     |                                                                           | (9.5%)            | (66.7%)   | (19%)          | (4.8%)        | (100%)|
| 11  | *This AR-Geometry Interactive Book encourages me to write things I understand in the "Reflection" section.* | 8                 | 8         | 2              | 3             | 21    |
|     |                                                                           | (38.1%)           | (38.1%)   | (9.5%)         | (14.3%)       | (100%)|
| 12  | *The AR-Geometry Interactive Book contains evaluation tests that can evaluate how well I comprehend the material related to solid figures (flat plane shapes).* | 7                 | 9         | 4              | 1             | 21    |
|     |                                                                           | (33.3%)           | (42.9%)   | (19%)          | (4.8%)        | (100%)|
Secondly, to find out that AR-Geometry Interactive Book can improve students' mathematical reasoning abilities, a test is conducted with 3 items about mathematical reasoning abilities. The test results are illustrated in the following bar diagram.

![The Results of Reasoning Ability Test Student's of SMP N 4 Ujung Batu](image)

**Figure 1.** The diagram of the test results of reasoning abilities student’s

From the diagram, it was found that as many as 21 students were given test questions before using the AR-Geometry Interactive Book. The results showed that as many as 33.3% of students could solve the problem above KKM $\geq 60$. Furthermore, the results of the study proved that there were 66.7% of students who could solve the problem above Minimum achievement criteria $\geq 60$. So, it can be said that students' reasoning abilities increased by 33.4%.

1.2. Research discussion

Mathematics learning utilizes manipulative objects to be able to improve understanding of geometric concepts and reasoning abilities. In this study, manipulative media (books and props) commonly used are equipped with technology. Most textbooks cause students to feel bored, and less interested in reading [17]. Therefore, the teacher must be creative in using various tools and learning media to make students easily understand the material and the lesson delivered. A mathematics teacher must not be too textual, theoretical and rigid in delivering subject matter. Mathematics teachers must be creative and skillful at using learning tools and media [18]. One of the attempts to overcome the issue is to use technology in the learning process, especially for teaching materials. *Augmented Reality* (AR) is a technology that is able to join the virtual and real world through visualization of 3D (three-dimensional) shapes that are presented interactively.
AR-Geometry Interactive Book is an interactive book with a composition of textbooks and Augmented Reality (AR) technology. This book is equipped with the Virtual Geometry application to display 3D objects (three dimensions) of solid figures, namely cubes, cuboids, prisms, and pyramids. The results showed that the use of AR-Geometry Interactive Book improved students' reasoning abilities and made the learning process to be more active. In general, based on qualitative data (interviews) supported by quantitative data (questionnaires), informants and respondents agreed that the learning process was more interesting, interactive and fun. This idea was also supported by data obtained from test results of students' reasoning abilities, in which the results of the tests showed that 80% of students were able to answer the questions given after learning the solid figures using the AR-Geometry Interactive Book.

The application of augmented reality technology in children's three-dimensional interactive books can present interesting, interactive, in-depth, and realistic learning experiences for children [19]. This research is also in line with [20] which integrated Augmented Reality elements into children's storybooks. Books designed with a virtual (real) model allows users to see objects in the book in real terms [19]. Referring to the previous research, this research reveals that the use of AR-Geometry Interactive Book can assist students to improve their learning of mathematics, especially in the matter of geometry (solid figures). Contextual and collaborative learning are the benefits resulting from the integration of AR into the learning and learning goals that are in line with the current development can also be achieved [21]. It also goes the same as [8] which reveals that students' mathematical learning outcomes on geometry material are better when using the aid of teaching aids and other learning media.

Conclusion
One of the important roles of technology is the application of AR-Geometry Interactive Book. Based on the results of the analysis, the use of the AR-Geometry Interactive Book proves that the technology of Augmented Reality (AR) has been successfully implemented and can display 3-dimensional objects solid figures. By using this book, the learning process becomes more interesting, interactive and fun. The finding also shows that by using the book there is an increase (reaching to 33,4% increase) in students' reasoning abilities from the beginning.

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