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Differences in Students' Computational Thinking Mathematical Ability Using Augmented Reality Based on Gender

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Abstract: This study aims explicitly to look at differences in computational thinking and mathematical ability of students who received learning with augmented reality media based on gender. Background Problems: This research is motivated by students' low mathematical Computational Thinking (CT) ability and the rapid development of information technology in the digital era. Augmented Reality is a technology that combines three-dimensional virtual objects into a natural environment and then projects these virtual objects in real-time. The research subjects were 30 class VII students of SMPN 34 Pekanbaru in the 2022/2023 school year, randomly selected. This research was conducted on flat geometric materials, especially triangles and quadrilaterals. The data collection methods used a test of mathematical computational thinking ability. Parametric statistical tests processed test results data. The results showed differences in computational thinking and mathematical ability of students who received learning using augmented reality media based on gender. Male students' computational thinking and mathematical ability are better than female students.

Keywords: Computational Thinking; Augmented Reality; Mathematical Ability; Gender

1. Introduction

Computational Thinking (CT) is one thing that is very necessary for learning mathematics. (Kawuri, 2019; Kusumawati & Achmad, 2022; Mauliani, 2020; Nurmahmudah et al., 2020; Syafril et al., 2022). Mathematics learning includes solving problems that require students to have CT ability. Components in CT train students' thinking activities, starting from understanding the context of the problem, then students will reason up to the abstraction stage and end in solving systematic problems (Angeli et al., 2016; Cahdriyana & Richardo, 2020; Città et al., 2019; Grover et al., 2015; Lee et al., 2014; Sondakh, 2019; Wing, 2014; Yadav et al., 2017; Zhong et al., 2016; Zydney et al., 2020.) Components in CT train students to solve the problems they face in a structured, creative, and logical completion sequence.

Computational thinking is an essential ability that must be possessed by all students in addition to the ability to read, write, and do arithmetic in the current curriculum, which is closely related to technology and information (Bower et al., 2017; Mohaghegh & Mccauley, 2016; Román-González et al., 2018; Tabesh, 2017; Voogt et al., 2015; Winthrop et al., 2016; Wing, 2014). Computational thinking is solving complex problems and breaking them down into smaller, easier-to-solve ones (Chahyadi et al., 2021; Harmini et al., 2020;

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Sondakh, 2019). Furthermore, in this study, the computational thinking ability component refers to the computational thinking component as described in (Andrian & Hikmawan, 2021; Maharani et al., 2019; Trisnowati et al., 2021; Veronica et al., 2022). These components are problem decomposition, pattern recognition, abstraction and generalisation, and algorithmic thinking.

Problem decomposition is the ability to break down complex problems into simpler parts that are easier to understand and solve (Angeli & Giannakos, 2020; Shute et al., 2017). Pattern recognition ability relates to situations in which students have to identify regularities and deduce or construct ruler formations. (Barcelos, 2018). Abstraction is the ability to give meaning (modelling) to critical aspects of a problem. (Barcelos, 2018; Shute et al., 2017; Weintrop et al., 2016). Creating these computational abstractions is essential in solving many structurally similar problems but differ in detail. Generalisation is the ability to formulate solutions in general so that they can be applied to other problems (Ansori, 2020; Yasin et al., 2021).

Augmented reality-based digital teaching materials are a solution that can make it easier for students to learn spatial geometry, especially geometric materials. AR media can support learning activities in the classroom and enrich information when used outside the classroom. (Ismail et al., 2021; Jannah et al., 2021)AR media can be integrated into books as media capable of displaying 3D objects virtually on smartphone devices, making learning more effective and efficient. (Ahmadi et al., 2020; Deli, 2020; Farsi et al., 2021; Wikayanto, 2020).

Previous research studies have revealed some results from augmented reality (AR). Augmented reality makes it easier for students to understand math material and increases students' motivation to learn mathematics (Estapa & Nadolny, 2015; Lubis & Dasopang, 2020; Mubarok et al., 2020). AR makes it easier for students to understand learning concepts and is more motivated in the learning process between parents and children. (Cheng, 2017; Fauziah & Sulisworo, 2019; Tsai, 2020; Zulherman et al., 2021). AR is becoming a trend in the field of education; AR makes explanations more effective when applied to learning (Bacca et al., 2014; Fauziah & Dwi, 2021; Indarta et al., 2022; Irwansyah et al., 2019; Putri & Frans Aditia Wiguna, 2020; Vázquez-Cano et al., 2020; Yanuarto & Iqbal, 2022).

AR media in learning can display 3D forms in full and accurately to clarify the material in teaching materials. Delivering material with the addition of AR will make students more comfortable understanding material concepts. Students can learn concepts quickly, effectively, and interactively. AR can also train students' creativity in learning activities that are not boring. (Mantasia & Jaya, 2016; Nurrisma et al., 2021; Sulaksono, 2021).

Augmented reality applications can be used on smartphones with the Android Operating System (Aminuddin & Djauhari, 2021; Cundana & Pernando, 2022; Syahidi et al., 2021). AR media can be used as a support for learning activities in the classroom and helps enrich information when used outside the classroom (Ambarwulan & Muliyati, 2016; Kristian et al., 2020) AR media enables learner-centred learning and creates opportunities for collaboration that foster a deeper understanding of content. The use of AR media in learning can be integrated into books as media capable of displaying 3D objects virtually on mobile devices, making learning more effective and efficient (Albar et al., 2022; Elmqaddem, 2019; Fakhrudin et al., 2019; Jannah et al., 2021; Wahyudi & Arwansyah, 2019), by integrating AR into books, students can observe many objects and phenomena displayed in 3D.

Research related to the importance of CT ability has been carried out by (Cahdriyana & Richardo, 2020; Kadarwati et al., 2020; Lestari & Annizar, 2020; Tresnawati et al., 2020; Zahid, 2020). Researchers focused on identifying the effectiveness of CT ability in increasing student creativity, identifying the relationship between CT ability and critical thinking, identifying CT ability through the Bebras challenge, and identifying CT ability in learning mathematics. While research on the application of AR media in learning has been carried out by (Idhami et al., 2020; Mustaqim, 2016; Mustaqim & Nanang, 2017; Nugroho & Pramono, 2017; Nuraisa et al., 2019; Rosali & Suryadi, 2021; Saputri & Sibarani, 2020; Setyawan, 2019; Sidik & Vivivanti, 2021; Suciliyana & Rahman, 2020; Yuntawati et al., 2021). Researchers focused on identifying the application of AR in recognising building objects, identifying the application of AR as a child health medium, identifying the application of AR in mathematics learning, identifying the application of AR as a learning medium, identifying the application of AR in computer network installations, identifying the application of AR as a science learning medium, identifying the application of AR for interior design. This study examines the application of augmented reality for differences in students' computational thinking and mathematical ability based on gender.

Acquiring computational thinking ability is vital for the new generation of learners, an essential ability set in the twenty-first century. For this reason, teaching computational thinking ability and researching the factors that influence this ability is essential. The first factor that comes to mind is gender because girls and boys behave and perform differently, even in simple reading and writing tasks. (Merisuo-Storm, 2006). Research on comparisons of the development of CT ability between the sexes in information technology activities is still rare. (Atmatzidou & Demetriadis, 2016; Yadav et al., 2011). Recently (Angeli & Valanides, 2020) Stated that gender was a significant variable in research where they developed early childhood computational thinking ability at the preschool level. Based on a meta-analysis study, it was stated that CT appears to be moderately gender-biased because the items have a sizeable visuospatial load that men might prefer. (Román-González et al., 2018).

2. METHOD

This research was carried out at one of the Pekanbaru State Middle Schools for class VIII students for the 2021/2022 school year on flat shapes (triangles and quadrilaterals). The subjects of this study consisted of 30 students from 2 classes who were taught using AR-based learning media with Unity 3D. The subjects in this study were relatively small because the number of students in each class was only around 18 people. However, during the learning process, some were affected by COVID-19, so only 15 people routinely took part in offline learning from the start to the end of each class. Although the subject of this study was relatively small, according to (Gall, 2007), specifically for simple research experiments with tight control, research success can be achieved by using a sample of 15-30 respondents per group.

The research subjects in each group were 12-13 years old. The same teacher and treatment taught both groups. Learning by AR media aims to improve students' computational thinking ability. It is arranged based on indicators that measure computational thinking ability, namely decomposition, patterns and generalisations, abstractions, and algorithms.

This research was carried out for six meetings (almost 1 month). Before applying the learning media, the researcher gave a test to determine the initial mathematical ability of each group. Furthermore, after the sixth meeting, the researcher gave a final test to see the improvement in each learning group. At each meeting, each group studied the same material, namely about flat shapes (triangles and quadrilaterals), where the same teacher taught each group the same amount of learning time and learning media that emphasised learning to improve computational thinking ability.

The research data was collected through tests. The test given is in the form of questions about CT ability. Tests are given at the beginning and the end of learning. Experts first validated the test. Then, the data was analysed using a parametric test. Before the parametric test is carried out, the data is subject to prerequisite testing, in this case, to ensure that the data meets the normality and homogeneity assumption tests. The test consisted of 5 questions, each with a maximum of 20 points. The test results for each student were calculated based on the answer keys that had been prepared.

3. RESULTS AND DISCUSSION

This study aims to look at differences in students' computational thinking and mathematical ability based on gender through learning that applies augmented reality media. Data on initial mathematical ability were collected and analysed to determine students' initial mathematical abilities before this research was carried out. Mathematical initial ability is obtained from the value of mathematics on the previous subject. The following is a description of the initial ability of the research sample.

Table 1 - Description of Student Pretest Data

Descriptive Statistics	Male	Female
N	15	15
$\bar{X}$	5,13	5,67
Sd	4,25	4,60
Max	12	15
Min	0	0

Table 1 shows that the description of the female is better than the male students, but the difference is not too significant. Next, a test for the equivalence of the initial mathematical ability of the two groups will be carried out using the t-test. However, before carrying out the t-test, a data normality test and a variance homogeneity test are first carried out. The data normality test used is the Kolmogorov-Smirnov test. The results of the data normality test of the initial mathematical ability of students in the two study groups are presented in the following table:

Table 2 - Normality Test of Student Pretest Data

Kolmogorov-Smirnov	Male	Female
N	15	15
Sig.	0,17	0,16
Description	H0 accepted	H0 accepted

In Table 2, it can be seen that the probability value (sig.) of data is more than 0.05. This means that H0 is accepted, so it can be concluded that the sample data for the two groups come from normally distributed populations. Next, the homogeneity of the variance of the initial mathematical ability of the two groups will be tested using the Levene test. The results of the homogeneity test of variance data on the initial mathematical ability of students in the two learning groups are presented in the following table:

Table 3 - Student Pretest Data Homogeneity Test

Levene's Test	Data	Criteria
N	30	H0 accepted
Sig.	0,79	

Table 3 shows that the data's probability value (sig.) is more significant than 0.05. This means that H0 is accepted, so it can be concluded that the data variances of the two groups are homogeneous. Furthermore, the t-test will be used to test for the equality of the initial mathematical ability data. The results of the data equivalence test of students' initial mathematical ability based on learning are presented in the following table.

Table 4 - Pretest Data Equivalence Test

t -Test	Data	Criteria
N	30	H0 accepted
Sig. (2-tailed)	0,75	

Table 4 shows that the probability value (sig.) is more significant than 0.05, so H0 is accepted. Thus, there is no difference in the average initial mathematical ability between female and male students who receive learning with augmented reality media with Unity 3D. This further strengthens the statement in Table 1 above that, overall, there is no significant difference in the description of the initial mathematical ability of the two groups.

Furthermore, the differences in the computational thinking and mathematical ability of students who received learning with augmented reality media based on gender will be seen. The following table summarises the results of the descriptive analysis of the data on computational thinking mathematical ability based on gender.

Table 5 - Data Description of Students' Computational Thinking Mathematical Ability Based on Gender

Descriptive Statistics	Male	Female
N	15	15
$\bar{X}$	80	77
Sd	11,01	17,8
Min	60	60
Max	100	100

Table 5 shows that the description of the data on the computational thinking mathematical ability of male students is better than that of female students. This means there are differences in students' computational thinking and mathematical ability based on gender. Before testing the average difference, the normality of the data and the homogeneity of the variance of the data on students' computational thinking mathematical ability will be tested first. The data normality test used is the Kolmogorov-Smirnov test. The results of the data normality test for students' computational thinking mathematical ability are presented in the following table:

Table 6 - Normality Test of Students' Computational Thinking Mathematical Ability Based on Gender

Kolmogorov-smirnov	Male	Female
N	15	15
Sig.	0,16	0,11
Description	H0 accepted	H0 accepted

Table 6 shows that the significance value of the computational thinking mathematical ability of the two groups is more significant than 0.05. This means the null hypothesis is accepted. This means that the data on the computational thinking and mathematical ability of male and female students are typically distributed. Next, the homogeneity of the variance of the computational thinking ability of the two sample groups will be tested using the Levene test. The results of the homogeneity test of variance data on the computational thinking mathematical ability of the students of two groups are presented in the following table.

Table 7- Homogeneity Test of Students' Computational Thinking Mathematical Ability Based on Gender

Levene's-Test	Data	Criteria
N	30	H0 accepted
Sig.	0,19	

Table 7 shows that the significance value of the homogeneity of variance data on the computational thinking mathematical ability of the two groups of students is more significant than 0.05. This means the null hypothesis is accepted. Because the data on the computational thinking mathematical ability of the two learning groups met the assumptions of normality of data and homogeneity of variance, it was then to see if there was a significant difference between the average students' computational thinking mathematical ability in terms of gender. The calculation results are presented in the following table.

Table 8 - Computational Thinking Mathematical Ability Equality Test

t-Test	Data	Criteria
N	30	H0 rejected
Sig. (2-tailed)	0,05	

Table 8 shows that the gender factor significantly influences students' mathematical computational thinking ability. This can be seen from the significance value obtained by 0.05. This means there is a difference between the average computational thinking and mathematical ability of the two groups of students based on gender. Male students' computational thinking and mathematical abilities are better than female students.

The AR media contains: (1) Home page (initial) is the initial display that appears when the learning media is operated; this page contains the title of the learning media, the "start" button to enter the main menu page, and there are navigation buttons such as the exit button and volume button at the top right of the display. (2) The main menu page is the page that appears after the user presses the "start" button on the home screen. On this page, there is also an exit navigation button, and there are menus that the user can select (students), namely instructions, introduction, competency, material, evaluation, and profile menu buttons. (3) This menu has functions of all navigation and menu buttons contained in this learning media. So that users (students) can use this learning media independently. (4) This menu contains core competencies, essential competencies, indicators, and learning objectives for learning activities. (5) This menu displays the meeting menu button. Four meetings, one and three of which contain triangular material, while two and four contain quadrilateral material. (6) This evaluation menu is opened after studying the material contained in the material menu. After pressing the start button, the user starts working on the evaluation questions; after the students answer the questions at the end, there are the total scores obtained by these students and the number of correct answers and the number of wrong answers. Students can repeat the problem by pressing the "try again" button. (7) The profile menu page contains the identity of learning media developers, learning media makers, and those who assist development in perfecting learning media. During learning in the control class, students showed their enthusiasm in participating when the teacher gave practice questions. They offer themselves in turn to answer the exercise. The control class uses interactive multimedia, which is arranged by paying attention to the stages of computational thinking.

Hendriyani et al., (2019) Revealed that augmented reality technology can create any 3D model that may be difficult to visualise in the classroom, on the computer, or in students' minds. According to Sa'diyyah et al., (2021) It states that using augmented reality technology in learning has several advantages, namely having excellent potential and excellent benefits in the learning process. The following is a display of Augmented reality media on triangular and rectangular material:

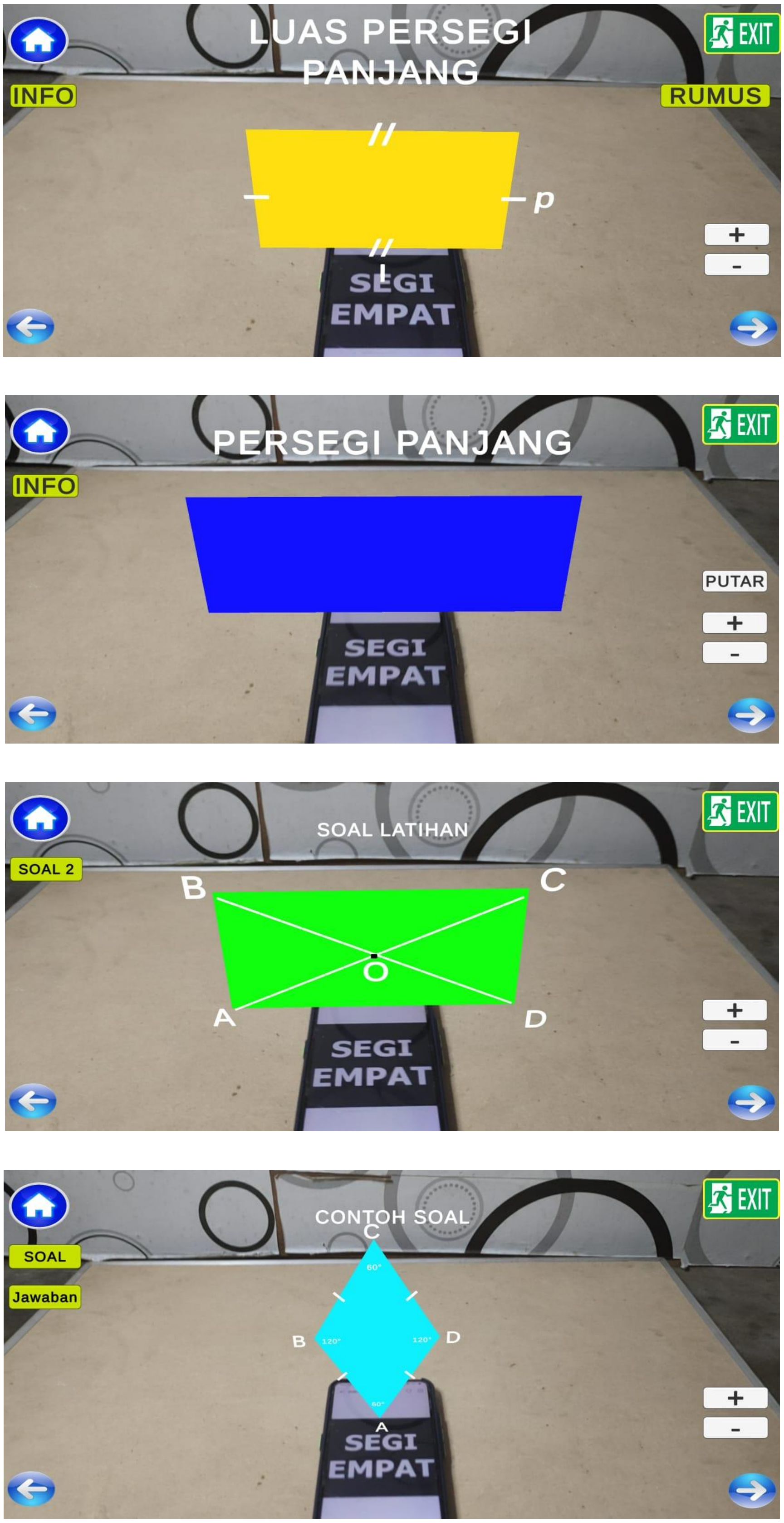

Fig 1. Display of Augmented Reality on triangular and rectangular material

AR is a form of human and media interaction that brings new experiences to its users. AR's advantage is that it can cause animated picture effects in the real world. Augmented Reality has advantages as an educational medium. This study has proven that this technology has a considerable influence on improving the computational thinking and mathematical ability of students who acquire learning with augmented reality media with Unity 3D. Learning augmented reality media with Unity 3D positively influences students' mathematical computational thinking ability, especially in flat-shaped material. In addition to learning factors, gender influences students' mathematical computational thinking ability. Male students' computational thinking mathematical ability is better than female students' computational thinking mathematical ability. This is supported by (Román-González et al., 2018) Male students tend to be more active in using information technology and are more interested in exploring technology; this has implications for male students' computational thinking ability to improve.

During the learning process, researchers discovered that male students were more enthusiastic about using AR media; their enthusiasm can be seen by: 1) being more active in asking questions, 2) going forward to explain the results of solving the problems given, and 3) moving augmented reality applications. According to the researchers, the factors of interest of each gender must be considered when implementing learning through augmented reality media. Male and female students' interests can also be used to differentiate their computational thinking abilities. The high interest in operating augmented reality media tends to have a positive influence as well; the interest factor is considered essential to pay attention to when observing differences in the computational thinking abilities of male and female students when learning using augmented reality media.

CONCLUSIONS

Based on the data processing, analysis, and discussion presented in the previous chapter, the following conclusions are obtained: The results showed differences in computational thinking and mathematical ability of students who received learning using augmented reality media based on gender. Male students' computational thinking mathematical ability is better than female students' computational thinking mathematical ability. Computational thinking and critical thinking abilities are closely related; students with good computational thinking abilities also tend to have good higher-order thinking abilities. Furthermore, it is necessary to look at the differences in the critical thinking ability of students who received learning using augmented reality media based on gender. The sample size in this study is relatively small and should be increased. A larger sample size will help to validate the findings and potentially broaden the findings. The findings of this study do not consider the initial mathematical ability factor of each gender. Given that the initial mathematical ability factor contributes to each student's computational thinking achievement, it should be considered a determining variable in differentiating computational thinking ability based on gender in learning utilising augmented reality.

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