Systematic Literature Review: Mathematical Critical Thinking Ability Viewed from Students' Curiosity PjBL Assisted by Virtual Reality

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Abstract

Research has been carried out on the implementation of the PjBL model with the help of virtual reality media on students' mathematical critical thinking abilities in terms of curiosity. This study aims to review that the Virtual Reality (VR) assisted Project Based Learning (PjBL) model can improve students' critical thinking ability and curiosity. The method used is Systematic Literature Review (SLR). The research was conducted by collecting, reviewing, and concluding from several articles in the last 6 years (2017-2023) in national and international journals related to the topic of discussion, critical thinking abilities in the VR-assisted PjBL learning model. The results showed that students' mathematical critical thinking abilities could be improved through the VR-assisted PjBL learning model. The results of the study also show that students' curiosity can be developed by using VR-assisted PjBL learning. It is hoped that this article can provide insights for readers to carry out research related to students' critical thinking ability and curiosity in VR-assisted PjBL learning

Keywords:

Mathematical critical thinking, Curiosity, PjBL, VR.

1. Introduction

In the 21st century, learning focuses on critical thinking ability, the ability to connect a science with reality, mastery of information and communication technology (ICT), and students' collaboration ability. In the implementation of the Independent Curriculum, higher order thinking skills or HOTS do not only depend on the selection of problem models, but also include the selection of learning models. In other words, the learning model used must be able to support the development of higher order thinking ability. Since the implementation of the 2013 curriculum until now it has changed to using the Merdeka curriculum, high-order thinking ability are important to be applied in all subjects, one of which is mathematics in which students do not only use the formulas provided in working on test questions, but it is the students themselves who will design a way and make a solution to a problem related to everyday life. Therefore, students' critical thinking ability are one of the important elements that must be developed in the process of learning mathematics.

Unfortunately, the level of students' critical thinking ability in Indonesia is still relatively low. The results of the 2018 Program for International Student Assessment (PISA) and the 2015 International Trends in International Mathematics and Science Study (TIMSS) show that the ability level of students, especially in mathematics in Indonesia, is still at the level of understanding to application but has not yet reached the aspect of critical thinking ability. In mathematics, PISA 2003, Indonesian students got an average score of 360. The highest average score was in 2006, 391 points. Meanwhile, in PISA 2018, Indonesian students obtained an average score of 379 points. The results of the TIMSS study show that Indonesian students consistently rank at the bottom. In TIMSS 2015, Indonesia was ranked 44th out of 49 countries.

Susanto (in Rahayu, B. N. A., et al., 2020) states that there are several factors that contribute to the low mathematical ability of students, one of which is a teacher-centered learning strategy. The application of conventional learning models causes students to tend to be passive in learning activities, so that students have not been able to use their problem solving abilities optimally. Mathematics learning in

Indonesia is generally carried out mechanistically and tends to be taught using practical formulas, so it does not involve construction processes that can improve students' critical thinking ability. One of the criteria for someone having critical thinking ability is showing a high sense of curiosity when exploring Facione information (in Rahayu, B. N. A., et al., 2020). Curiosity is the attitude of someone who always tries to find out more in-depth and detailed information about something they studying, seeing, and listening to (Ministry of National Education, 2011). Curiosity is very important to bring up the interest and motivation of students' learning.

In order to increase the curiosity of students, there needs to be innovation in the implementation of learning. Learning innovations that support the development of students' mathematical critical thinking ability and increase their curiosity. The Project-Based Learning (PjBL) learning model is a student-center learning model that is able to accommodate the development of students' critical thinking ability. In conducting PjBL learning, students analyze, ask questions, interpret, summarize, apply, collaborate and creatively solving problems. Setiono (in Panut et al, 2021) states that the Project-Based Learning model has been able to increase student character values, including curiosity.

Besides that, improving students' ICT skills is also one of the focal points of 21st century learning. Therefore, the PjBL learning model can be applied by integrating Virtual Reality into the learning process. Integrating Virtual Reality into the classroom increases students' interest and curiosity, making mathematics lessons more interesting and easier to understand. Virtual Reality has been used in geometry learning such as the NeoTrie VR application (Rodriguez et al., 2021). The use of Virtual Reality enables better presentation of images, geometric building concepts, and other problems described in learning activities.

Based on the above description, in this case the research aims to compile and describe studies regarding improving students' critical thinking ability and curiosity in VR-assisted PjBL learning model.

2. Method

The method used in this study is the Systematic Literature Review (SLR) method. The SLR method is a method of identifying, reviewing, evaluating and interpreting all available research with related to the chosen topic in order to answer certain relevant questions. In the SLR method, the authors review and identify journals or articles systematically in each process by following predetermined steps or procedures (Triandiani et al, 2019). In general, the stages of research using the SLR method are as follows:

2.1. Research Question (RQ) namely research questions that are made based on the needs of the chosen topic.
2.1. Can the VR-assisted PjBL method improve students' mathematical critical thinking ability?
2.1.1. Can the VR-assisted PjBL method increase students' curiosity?
2.2. Search Process, namely the process of searching for relevant literature to answer the Research Question, literature searches are carried out through Google Scholar relating to the selected topic and other related references.
2.3 Inclusion and Exclusion Criteria. This stage is carried out to decide whether the literature data found is suitable for use in SLR research or not. Inclusion and Exclusion Criteria in this study are as follows:

Table 2. 1 Inclusion and Exclusion Criteria

Inclusion	Exclusion
The data used is in the 2017-2023 timeframe	The data used is in the 2017-2023 timeframe

The data used relates to the topic of Mathematical Critical Thinking Ability in View from Students' Curiosity in PjBL Assisted by Virtual Reality	Data that is not related to the topic of Mathematical Critical Thinking Ability in View from Students' Curiosity in PjBL Assisted by Virtual Reality
The data used is in Indonesian or English	Data that is not in Indonesian or English

Furthermore, all articles and journals obtained will be analyzed and summarized into one complete discussion.

3. Result and Discussion

After completing all protocol stages, the following 16 articles were obtained:

Table 3. 1 Articles of Mathematical Critical Thinking Ability Viewed from Student Curiosity in VR Assisted PjBL Learning Model

No	Author, Year	Journal	Participant	Research Approcah	Focus
1	(Khairunnisa, K et al., 2022)	Journal of Science Education Innovation	High school students	Pre-experiment, One group pretest-posttest design	Virtual reality, critical thinking ability
2	(Rahayu, B. N. A., et al, 2022)	Proceedings of the National Mathematics Seminar	Junior high school students	Theoritical review	Critical thinking ability, curiosity
3	(Agoestanto, A. et al, 2019)	Proceedings of the National Mathematics Seminar	Junior high school students	Qualitative	Critical thinking, curiosity
4	(Hidayat. R., 2017)	Eduma: Mathematics Education Learning and Teaching	Junior high school students	Quasi Experimental Design	Project-based learning, mathematical critical thinking ability
5	(Setiono, P., et al, 2021)	Journal of Basic Education	Junior High School Students	Kemmis model class action	Attitude of curiosity, project-based learning
6	(Bulu, V. R. & Tanggur, F., 2021)	Journal of Mathematics Education	College Student	Quantitative	PjBL, critical thinking ability
7	(Paranduri, I. H., 2018)	Journal of Mathematics Education Studies	Junior High School Students	Quasi Experimental, Cluster	Project-based learning model, critical thinking ability

				random sampling	
8	(Kristiyanto, D., 2020)	Mimbar Ilmu Journal	Elementary School Students	Class action, kemmis and carr	Critical thinking ability, project-based learning
9	(Bukhori, H. A., et al, 2022)	Journal of Learning Innovation	20 college students	Qualitative	Virtual reality, project-based learning
10	(Ratno, S., et al, 2022)	School Education Journal PGSD FIP UNIMED	Elementary School Students	Literature search	Project-based learning, critical thinking
11	(Afifah, A. N., et al, 2019)	Journal of Education and Biology	High School Students	Pre-Experimental	PjBL, Critical Thinking Skills
12	(Kartika, Y. K., et al, 2019)	Unnes Journal of Mathematics Education	Junior High School Students	Experimental research	Student curiosity, project-based learning
13	(Anggreani, L., et al, 2021)	Kappa Journal	Physics education students	Pre-experimental design	Virtual reality, critical thinking
14	(Mardhiyana, D., 2017)	Scientific Journal of Mathematics Education	25 5th semester students	Classroom action research	Curiosity, Project based learning
15	(Wicaksana, Y., Wardono, W., & Ridlo, S., 2017)	Unnes Journal of Mathematics Education Research	High School Students	Mixed method with concurrent embedded design	Epistemic curiosity, Project Based Learning
16	(Priatna, N., et al, 2020)	Journal of Educational Research	Junior High School Students	Research and Development	Mathematical critical thinking ability, PjBL

In **Table 3. 1** above, 16 articles have been collected through Google Scholar and have gone through the inclusion-exclusion process. Based on the articles that have been collected in **Table 3. 1**, it is found that:

Mathematical Critical Thinking Ability

The word critical comes from the Greek word, critics which means judgment or wisdom. (Rahayu et al., 2022) states that critical thinking is reflective and reasoned thinking that focuses on the best decisions to believe and make. The ability to think critically mathematically is the ability of students to solve mathematical problems through the activity of collecting various kinds of information that they know and then making evaluative conclusions from the acquisition of this information, Rochmad (in Rahayu et al., 2022). People who have ideal critical thinking ability are people who have high curiosity, extensive experience, full of confidence, open-minded, flexible, diligent in finding relevant information, and reasonable in selecting criteria (Facione, 2000). Critical

thinking ability are not obtained through physical growth, but continuous training (Fakhriyah, 2014).

One of the characteristics that a person has the ability to think critically is showing a high sense of curiosity when exploring appropriate and logical information in selecting Facione criteria (in Agoestanto et al., 2019). Furthermore, Rahayu et al., 2022, classifies indicators of mathematical critical thinking ability into 4 parts namely (1) clarification, (2) assessment, (3) conclusion, and (4) strategy/tactics. In this case clarification means defining the problem, assessment means using relevant information in problem solving, inference means drawing the right conclusions, and strategy/tactics means evaluating the results of problem solving.

Curiosity

Curiosity is an attitude and action that always seeks to know more deeply and broadly from something that is learned, seen, and heard (Ministry of National Education, 2011: 24). One of the characteristics that a person has the ability to think critically is showing a high sense of curiosity when exploring appropriate and logical information in selecting criteria (Facione in Agoestanto et al., 2019).

Curiosity can be classified into 2 forms, namely (1) Epistemic-Cognitive, in the form of a desire to obtain information and knowledge, (2) Perceptual-Sensory, namely how one pays attention to things that are uncertain Berlyne (in Rahayu et al. , 2022). Meanwhile, Reio et al (in Rahayu et al., 2022) divide curiosity into three parts, namely (1) Cognitive Curiosity, (2) Physical, and (3) Social Sensory Curiosity which is a willingness to experience new situations. Curiosity will make students more critical when observing the phenomena and events around them. With high curiosity, students will focus their attention on something new and foreign in themselves. Therefore, the character of student curiosity is very important to be developed in schools.

Project Based Learning (PjBL)

Susanto (in Putra, 2017) revealed that there were several factors that contributed to the low mathematical abilities of students, including teacher-centered learning strategies. The application of conventional learning models also causes students to tend to be passive in learning activities so that students do not use their problem solving abilities optimally. Therefore, it is necessary to have a learning climate in the classroom that is able to foster students' critical thinking ability in schools through a series of student-centered learning steps.

One of the student-centered learning is Project Based Learning (PjBL). Joel L Klein et al (in Widyantini, 2014: 3) explains that project-based learning is a learning model that empowers students to acquire new knowledge and understanding based on their experiences through various presentations. The PjBL learning model is very much in accordance with Permendikbud No. 81 A of 2013 Appendix IV which discusses the learning process which must contain 5 things, namely (1) observing, (2) asking questions, (3) gathering information, (4) associating, and (5) communicating.

PjBL is able to provide opportunities for students and teachers to determine learning evaluation problems, explore, identify and reflect on them. In PjBL learning, students are conditioned to observe problems, investigate problems, collect information about problem solving, and solve problems to think critically. Learners will find it easier to

understand the concept because it is related to real life experiences. Students also become more creative and critical because they are guided to plan and make projects.

Virtual Reality

Virtual reality is a technology to solve real-world problems today and feel real-world sensations in cyberspace. Virtual reality media is used as an educational goal which has the potential to encourage student learning retention (Supriadi & Hignasari, 2019). Virtual reality provides an attractive appearance and refers to the use of interactive simulations for users to engage in environments that may appear similar to real world events (Abdussalam et al., 2018).

Improving Mathematical Critical Thinking Ability in View of Students' Curiosity in VR Assisted PjBL Learning

The PjBL model is a collaborative learning model that encourages students to design project plans, discuss planned projects in groups, and carry out the project. This encourages learners to sharpen their critical thinking ability. Specifically, students are trained to be independent in groups during the discovery stage in order to develop the knowledge gained and conduct research that is beneficial to their critical thinking training.

Based on research (Agoestanto et al., 2019), students with low curiosity do not connect questions with other circumstances that are not in the problem. This indicates that students have less ability to connect the information in the problem with relevant information. Khairunnisa et al, 2022, states that one of the indicators of critical thinking ability is reason, where this is trained when students are asked to provide hypotheses or answers to the problems faced based on relevant facts/evidence. So based on these indicators, students with low curiosity are considered lacking in their critical thinking ability.

In the study (Bulu, V. R., et al. 2021), the Table N-Gain Test Result on Students' Critical Thinking Ability shows that there is an increase in students' critical thinking ability by applying the PjBL learning model by 59.85% compared to students by applying the PjBL learning model. conventionally which is only 40.13%, the effect size of the application of this PjBL model on critical thinking ability is 1.45 which is relatively high.

Based on the results of the study (Khairunnisa, K., et al, 2022) the average level of attainment of critical thinking ability during the pretest and posttest of students before and after learning with virtual reality media was 25.10% and 77.71% respectively. This shows that there is a positive impact from the implementation of virtual reality media on students' critical thinking ability.

Table 3. 2 Stages of the PjBL Assisted by Virtual Reality

Phase	Description
Fundamental Questions	In the determining basic questions phase, teachers ask specific questions that stimulate students to identify problems and root causes.

Project Design	In the second phase, teachers distribute LKPD. It contains a series of steps to carry out project activities and guides students in preparing the necessary tools and materials.
Schedule Arrangement	Teacher and students make an agreement regarding the time required to carry out the project, the teacher also responsible for guiding students to divide tasks among group members so that the projects can be completed quickly.
Monitoring	As a facilitator and catalyst, teachers monitor and guide students as they complete project activities. Teachers carry out project assessments.
Presentation	Students present the results of projects they have carried out, teachers and other students give feedback and provide suggestions and opinions.
Conclusion	Draw conclusions and reflect together on what have been learned.
Evaluation	The evaluation phase carried out to strengthen concepts that students learned during working on the project. At this phase, students work on problems in the form of exercise sheets.

4. Conclusion

From the results of the discussion, we can state that virtual reality can increase students' curiosity in learning, where we already know that curiosity is an indicator of critical thinking. In addition, student-centered PjBL will help improve students' critical thinking ability. By collaborating with PjBL with virtual reality, students' critical thinking ability and curiosity will increase. So, it can be concluded that the implementation of the PjBL model with virtual reality media can improve students' critical thinking ability. Implementation of PjBL with virtual reality media can increase and develop students' curiosity.

It is hoped that this article can provide insights for readers to carry out research related to students' critical thinking ability and curiosity in PjBL assisted by Virtual Reality.

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