JPPI (Jurnal Penelitian Pendidikan Indonesia)
Volume 11, Number 1 2025

Analysis of complex problem-solving skills using vr-based interactive media through an ethnopedagogy approach

Author Name(s): Andi Nurannisa, Andi Muhammad Irfan Taufan Asfar, Andi Muhamad Iqbal Akbar Asfar, Yulita Yulita

Publication details, including author guidelines
URL: https://jurnal.iicet.org/index.php/jppi/about/submissions#authorGuidelines
Editor: Alief Budiyono

Article History
Received Jul 01st, 2024
Revised Mar 25th, 2025
Accepted Apr 07th, 2025

How to cite this article (APA)
Nurannisa, A., Asfar, A. M. I. T., Asfar, A. M. I. A., & Yulita, Y. (2025). Analysis of complex problem-solving skills using vr-based interactive media through an ethnopedagogy approach. Jurnal Penelitian Pendidikan Indonesia 11(1), 54-65. https://doi.org/10.29210/020254360

The readers can link to article via https://doi.org/10.29210/020254360

JPPI (Jurnal Penelitian Pendidikan Indonesia)
ISSN: 2502-8103 (Print) ISSN: 2477-8524 (Electronic)
Vol. 11, No. 1, 2025, pp. 54-65
DOI: https://doi.org/10.29210/020254360

Analysis of complex problem-solving skills using vr-based interactive media through an ethnopedagogy approach

Andi Nurannisa[1], Andi Muhammad Irfan Taufan Asfar[1*)], Andi Muhamad Iqbal Akbar Asfar[2], Yulita Yulita[3]
[1] Mathematics Education Study Program, Muhammadiyah University of Bone, Indonesia
[2] Chemical Engineering, Ujung Pandang State Polytechnic, Indonesia
[3] Educational Technology Study Program, Muhammadiyah University of Bone, Indonesia

Article Info

Article history:

Received Jul 01st, 2024
Revised Mar 25th, 2025
Accepted Apr 07th, 2025

Keywords:

Complex problem solving,
Interactive teaching media,
Virtual reality,
Ethnopedagogy approach

ABSTRACT

Complex Problem-Solving is one of the essential skills needed to navigate the workforce. However, students' mastery of Complex Problem-Solving remains relatively low, particularly in mathematics. This study is a quantitative research aimed at analyzing Complex Problem-Solving skills using interactive teaching media based on virtual reality through an ethnopedagogy approach. The research was conducted at UPT SMP Negeri 1 Kahu by dividing the trial classes into limited trials, extensive trials, and experimental trials.To assess Complex Problem-Solving skills, five essay questions were used, reflecting indicators such as identifying complex problems, evaluating/analyzing problem information, and generating problem-solving solutions. The results showed that the average Complex Problem-Solving skills of students in the trial classes increased by 87%. Meanwhile, in the control class, students' learning outcomes only improved by approximately 62%. These findings indicate that using interactive learning media based on virtual reality through an ethnopedagogy approach effectively enhances students' Complex Problem-Solving skills.

Corresponding Author:

Andi Muhammad Irfan Taufan Asfar,
Universitas Muhammadiyah Bone
Email: tauvanlewis00@gmail.com

Introduction

Complex Problem-Solving skills are among the most essential competencies needed to navigate the workforce in the next five years in the digital society era (World Economic Forum, 2023; Gnaldi et al., 2020; Kipman et al., 2022). This skill is defined as a process involving the identification, evaluation, and review of factual information related to a complex problem, as well as constructing rational interpretations to formulate effective solutions (Molnar & Greiff, 2023; Grezo & Sarmany-Schuller, 2022). Complex Problem-Solving can also be understood as a paradigm for comprehending cognition in real-life situations, with a focus on learning, knowledge acquisition, and decision-making (Nicolay et al., 2021; Nurannisa et al., 2024). However, the level of Complex Problem-Solving proficiency among students remains relatively low, particularly in mathematics (Pamungkas, Waluya, & Mariani, 2023;

Solihah et al., 2024). This indicates a gap between the skills required for the future and the competencies currently possessed by students.

Students' low Complex Problem-Solving skills are reflected in mathematics learning outcomes which are still below standard. Public Education Report Data for 2022 shows that students' numeracy abilities are below the minimum competency with a learning quality index that is still not optimal due to a lack of thinking activities (Pusmendik, 2022). A similar situation was seen in Bone Regency, where students' mathematics scores only reached 46.15, which placed them in the low category (Puspendik, 2019). This finding is in accordance with the results of observations during the Introduction to Schooling Field (PLP) activities at UPT SMP Negeri 1 Kahu, namely that students were not fully able to analyze mathematical material in the Two Variable Linear Equation System (SPLDV). Students experience difficulty in identifying and evaluating two variables and determining the variable value correctly. This indicates students' difficulties in identifying complex problems, evaluating/reviewing problem information, and creating Problem-Solving solutions which are indicators of Complex Problem-Solving skills. This statement is strengthened by the results of interviews with the deputy head of curriculum, subject teachers, as well as the results of summative assessments of students which show achievement below the AKM standard, namely <50%.

One of the factors causing low student mathematics learning outcomes is the lack of use of adequate learning facilities. So far, the majority of teachers have implemented various learning methods, but are not supported by the use of appropriate teaching media (Asfar and Paronda, 2024; Asfar et al, 2021; Asfar et al., 2022). In fact, the use of teaching media is still monotonous in textbooks and occasionally using projectors to deliver presentations. As a result of using less interactive teaching media, students start to feel bored and unmotivated in learning, especially in the mathematics learning process which is synonymous with formulas, objects, graphs and complex data (Asfar and Asfar, 2020; Asfar and Asfar, 2021; Asfar et al., 2021). Seeing the low mathematics learning outcomes, efforts are needed to support Complex Problem-Solving in facing the era of digital society.

Improving Complex Problem-Solving skills can be done by integrating the ethnopedagogy approach, which is a breakthrough in the world of education that prioritizes the cultural richness, values and experiences of students as a foundation learning (Wang et al., 2023; Rayimov, 2023; Asfar et al., 2023). This approach not only recognizes cultural diversity, but also makes it a valuable resource in the learning process in the form of adapting teaching strategies and media (Adela, Suastra and Lasmawan, 2023; Asfar, Asfar and Nurannisa, 2021; Asfar, Asfar and Nurannisa, 2022). One aspect of the local culture of the Bugis community that is rich in educational values is the Pajoge Makkunrai dance. This dance has a long history during the Bone kingdom, serving as a means of educating noble children in ethics and manners. Each movement of the Pajoge Makkunrai dance reflects the philosophical values of the Bugis community (Martiara, Mangkona and Supriyanti, 2020), including sipakatau (humanizing humans), sipakalebbi (respecting each other), and sipakainge (reminding each other). These three philosophies are really needed for students to adapt to change, especially in facing the era of digital society. Therefore, exploring the philosophical values full of meaning in the Pajoge Makkunrai dance is very important as a form of preserving knowledge to support cultural resilience.

The form of exploration of the Pajoge Makkunrai dance in the era of digital society will be carried out through the development of interactive teaching media based on Virtual Reality. The concept of instructional media in this study provides a virtual learning simulation for teachers and students to interact in exploring the philosophical values embedded in each movement of the Pajoge Makkunrai dance. The cultural elements within this media support students' understanding in enhancing Complex Problem-Solving (CPS) by linking the symbolic meaning of each dance movement to problem-solving concepts, such as systematic thinking patterns, adaptation to dynamic situations, and context-based decision-making. Thus, students not only perceive the dance as a cultural heritage but also as a model for critical and strategic thinking in solving complex problems. The teaching media developed is expected to support students' Complex Problem-Solving optimally in the era of digital society with an ethnopedagogy approach in creating joyful and meaningful learning. This is in line with research by Joksimovic et al., (2023) that the escalation of Complex Problem-Solving can be realized with artificial intelligent opportunities. Putra et al., (2021) and Asfar et al., (2024) in their research also proved the positive influence on the application of augmented reality through the blended learning method in

supporting Complex Problem Solving. However, the majority of research so far does not explain in detail how the ethnopedagogy approach can influence students' Complex Problem-Solving skills, especially in the aspect of applying technology in the era of digital society. Therefore, the aim of this research is to analyze students' Complex Problem-Solving skills using virtual reality-based interactive teaching media through the Pajoge Makkunrai dance ethnopedagogy approach.

Method

This study is a quantitative experimental research aimed at analyzing students' Complex Problem-Solving skills using interactive learning media based on virtual reality through an ethnopedagogical approach. The population in this study consists of students at UPT SMP Negeri 1 Kahu. The sampling method used is random sampling, with class VIII E as the limited trial class, class VIII D as the extensive trial class, and class VIII C as the experimental class.The implementation of interactive learning media based on virtual reality in this study involves exploring the Pajoge Makkunrai dance movements within the four core stages of learning, as follows:

Table 1. Learning Stages

Stages	Teacher Activities	Student Activities
Muttama' Makkasiwiyang (*Review*)	▪ The teacher asks students about the knowledge they have regarding the subject matter. ▪ The teacher connects students' knowledge with the material to be presented. ▪ The teacher gives a little explanation about the lesson material (System of Linear Equations in Two Variables).	▪ Students are given the opportunity to express their opinions. ▪ Students ask questions about what they don't understand about the lesson material (System of Linear Equations in Two Variables).
Mangngade Mappatabe (*Extending*)	▪ The teacher divides students into several heterogeneous groups. ▪ The teacher gives various practice questions to each group through virtual reality media. ▪ The teacher monitors the progress of each group's work on the questions.	▪ Each group looks for answers to the practice questions given with their group friends. ▪ Each group enthusiastically worked on the practice questions given by demonstrating every Pajoge Makkunrai dance movement through virtual reality media.
Massampeang (*Problem Solving*)	▪ The teacher asks about the material that has been studied by linking various practice questions. ▪ The teacher gives evaluation questions to students to practice Complex Problem-Solving skills.	▪ Students align their perceptions of Problem-Solving based on the results of their own reasoning. ▪ Students work on evaluation questions individually.
Sere Massimang (*Recap*)	▪ The teacher directs students to carry out a final recapitulation of the material in the form of mind mapping. ▪ The teacher gives students the opportunity to conclude the material they have studied.	▪ Students recapitulate the material by making a mind map (concept map). ▪ Students conclude each work result by adjusting the formulation in the textbook.

The research instruments used in this research are observation, interviews, written tests, and documentation. The written test used is a Complex Problem-Solving skills test consisting of 5 essay questions arranged based on Complex Problem-Solving skill indicators. The indicators used in this research were adopted from research by Molnar and Greiff (2023), Grezo and Sarmany-Schuller (2022),

Mount et al., (2020), including skills (1) identifying complex problems, (2) evaluating/reviewing information problems, (3) creating Problem-Solving solutions.

The data analysis technique used in this research is descriptive statistics to describe the Complex Problem-Solving skills of students in each testing class. Several aspects included in descriptive statistics include presenting data through tables, graphs, mean, median, mode, standard deviation, and percentage calculations. The category index for Complex Problem-Solving skills by Asfar, Asfar and Sulastri (2021), Damayanti et al., (2022) can be seen in the following table.

Table 2. Complex Problem-Solving Skill Category Index

Value (%)	Category
$70 \leq X \leq 100$	High
$50 \leq X < 70$	Medium
$0 \leq X < 50$	Low

The Complex Problem-Solving (CPS) Skill Category Index is a framework used to measure and categorize an individual's complex problem-solving skills based on various cognitive indicators and thinking strategies. This index is often used in research and educational evaluations to understand how individuals or groups solve problems.

Results and Discussions

Needs Analysis

The implementation of learning at the UPT SMP Negeri 1 Kahu location is currently implementing the 2013 Curriculum by emphasizing student-centered activities. However, the results of observations supported by data analysis of pretest results in class VIII mathematics subjects show that students are not yet fully able to understand contextual-based questions and high order thinking skills, especially in Complex Problem-Solving skills. Students are not used to working on questions that require them to reason with more complex sentences and are not used to answering questions by presenting known information, analyzing and drawing conclusions. Based on the results of the needs analysis, a picture of the condition of students in working on questions is obtained, namely that they tend to think about the results rather than the steps that must be taken. This problem is caused by a lack of questions that stimulate students to think and reason in answering mathematics questions. Apart from the problems above, it was also found that the condition of interaction between teachers and students was still lacking due to the inability to control the class as a whole, so that teachers were unable to meet the overall needs of students in the class. In fact, the lack of provision of teaching materials (materials) results in teachers only presenting questions contained in textbooks. This results in students only being able to work on questions that have been demonstrated by the teacher (repetition of questions), and when faced with more complex problems (Complex Problem Solving) in the form of reasoning, students become confused and find it difficult to answer them.

Based on the needs analysis that has been carried out, it appears that learning at UPT SMP Negeri 1 Kahu, especially in class VIII mathematics subjects, is still very lacking in terms of student activity and skills in solving Complex Problem-Solving problems. Several factors that can influence this are the lack of use of teaching media that can stimulate students' activeness and learning motivation. This is in line with Lubis (2023) that teaching media is one aspect of learning that greatly influences students' interest and motivation in learning mathematics. Furthermore Firdaus et al., (2023) in their research mentioned teaching media as a crucial thing which if not implemented then the learning process cannot run smoothly according to the expected goals. Teaching media in this case is an important aspect that will make it easier for teachers to convey the learning process to achieve the goals formulated, as well as make it easier for students to understand what is being conveyed (Fortuna, Purnamasari and Dikananda, 2023; Damayanti et al., 2023; Dewi et al., 2024). Appropriate teaching media can help increase students' interest and motivation in learning mathematics (Novelza and Handican, 2023; Dewi et al., 2022; Junaede et al., 2024). Therefore, it is necessary to have teaching media that can help increase student activity and attract their interest and motivation in learning mathematics. It is also hoped that the use of learning media in this research can stimulate students' skills to be able to solve

various problems, so they can easily identify complex problems, evaluate/review problem information, and create Problem-Solving solutions.

Analysis of Complex Problem-Solving Skills

Analysis of Complex Problem-Solving skills in this research can be seen from the results of the pre-test and post-test which are based on three indicators of Complex Problem-Solving skills, where these three indicators are included in each question (test) given.

Table 3. Percentage Analysis of Errors in Complex Problem-Solving Skill Indicators

Class	Test	Answer	Indicator 1		Indicator 2				Indicator 3				Percentage (%)	Level of Achievement
			1a	1b	2a	2b	3a	3b	4a	4b	5a	5b		
Limited Trial	*Pretest*	ΣBB	27	15	23	21	20	21	2	0	2	0	32,75	RD
		ΣBS	0	8	4	2	7	2	21	15	15	6	20	RD
		ΣSS	0	4	0	4	0	4	4	12	10	21	14,75	RD
	Posttest	ΣBB	26	25	17	27	23	23	20	18	24	14	54,25	SD
		ΣBS	1	2	10	0	4	4	7	5	3	6	10,5	RD
		ΣSS	0	0	0	0	0	0	0	4	0	7	2,75	RD
Extensive Trial	*Pretest*	ΣBB	32	23	30	24	12	26	5	1	1	0	38,5	RD
		ΣBS	1	10	3	8	20	5	18	22	22	23	33	RD
		ΣSS	0	0	0	1	1	1	10	10	10	10	10,75	RD
	Posttest	ΣBB	32	31	29	23	32	33	30	20	19	9	64,5	SD
		ΣBS	1	2	4	10	1	0	2	10	12	21	15,75	RD
		ΣSS	0	0	0	0	0	0	1	3	2	3	2,25	RD
Experimental Test	*Pretest*	ΣBB	17	8	17	17	13	16	0	0	0	0	22	RD
		ΣBS	1	9	0	0	0	1	0	0	3	3	4,25	RD
		ΣSS	0	1	1	1	4	1	18	18	15	15	18,5	RD
	Posttest	ΣBB	18	17	17	15	18	18	16	17	15	16	41,75	RD
		ΣBS	0	1	1	3	0	0	2	1	3	2	3,25	RD
		ΣSS	0	0	0	0	0	0	0	0	0	0	0	RD
Control Class	*Pretest*	ΣBB	18	10	18	16	16	17	0	0	0	0	23,75	RD
		ΣBS	0	7	0	0	0	1	1	0	5	5	4,75	RD
		ΣSS	0	1	0	2	2	0	17	18	13	13	16,5	RD
	Posttest	ΣBB	18	18	16	13	18	17	5	6	8	6	31,25	RD
		ΣBS	00	00	02	50	00	10	85	57	91	93	9,25	RD
		ΣSS											4,5	RD

Information: Achievement Level consists of Low (RD), Medium (SD), High (TG)

The Complex Problem-Solving skills test used is an essay with five questions, each of which is divided into two parts. The pretest and posttest data were analyzed by referring to the Complex Problem-Solving skill category index to determine the percentage of students' answer errors in answering the questions given. Each answer is analyzed to see the percentage with three criteria, namely "able to solve Complex Problem-Solving questions" taken from students' answers with correct answers (BB), "an error occurred in answering Complex Problem-Solving questions" from correct-wrong answers (BS), and "unable to answer the question" are taken from answers with wrong-wrong (SS) criteria. Students' answers are obtained from the results of the pre-test and post-test that have been given to compare the suitability of the answers, so that the percentage of students' Complex Problem-Solving skills is obtained. The results of the analysis of the percentage of students' errors in answering questions for each indicator can be seen as follows (Table 3).

Indicator 1, namely the skill of identifying complex problems, can be found in questions number 1a, 1b, and 2a. The implementation of limited trials in class VIII E showed that 21.7% of students were able to solve Complex Problem-Solving questions, 1.3% of students were unable to answer questions, and 4% of students experienced errors in answering Complex Problem-Solving questions. After carrying out treatment by applying interactive teaching media based on virtual reality through an ethnopedagogy approach, the participants' skills were improved students' ability to identify complex problems has increased, namely 22.7% of students were able to solve Complex Problem-Solving questions, 4.3% experienced errors in answering questions, and there were no more students who were unable to answer Complex Problem-Solving questions. In extensive trials in class VIII D, it was found that the percentage of students who were able to solve Complex Problem-Solving questions was 28.3% and 4.7% experienced errors in answering the questions. After carrying out treatment, there was an increase in students' skills in answering Complex Problem-Solving questions, namely 30.7% were able to solve Complex Problem-Solving questions and 2.3% experienced errors in answering questions. During the experimental test in class VIII C, it was found that the percentage of students who were able to solve Complex Problem-Solving questions was 14% and 3.3% experienced errors in answering the questions. After carrying out the treatment, there was an increase, namely 17.3% of students were able to solve Complex Problem-Solving questions and only 0.7% of students experienced errors in answering questions. Meanwhile, the Complex Problem-Solving skills of students in the control class seen from the pre-test results are still very low, namely 15.3% were able to solve Complex Problem-Solving questions, 2.3% experienced errors in answering questions, and 0.3% were unable answer Complex Problem-Solving questions. The post-test results for the control class were not much different from the previous results, namely 17.3% were able to solve Complex Problem-Solving questions and 0.7% were unable to answer the questions.

Indicator 2, namely skills in evaluating/reviewing problem information, is spread across questions number 2b, 3a, and 3b. In limited trials, the average number of students who were able to solve Complex Problem-Solving questions was 20.7%. Meanwhile, 2.7% of students were unable to answer Complex Problem-Solving questions and 3.7% of students experienced errors in answering questions. After carrying out the treatment, there was an increase in the students' Complex Problem-Solving skills, namely 24.3% were able to solve the questions, 2.7% experienced errors in answering the questions, and there were no more students who were unable to answer the questions. In extensive trials, it was found that the percentage of students who were able to solve the questions was 20.7%, 11% experienced errors in answering the questions, and 1% were unable to answer the questions. After undergoing treatment, 29.3% of students were able to solve Complex Problem-Solving questions and 3.7% still experienced errors in answering questions. In the experimental test class, the percentage of students who were able to solve the questions was 15.3% and 0.3% experienced errors in answering the questions, and 2% of students were unable to answer the questions. After carrying out treatment, there was an increase, namely 17% of students were able to solve questions and 1% experienced errors in answering questions. Meanwhile, the Complex Problem-Solving skills of students in the control class still looked very low, namely 16.3% were able to solve Complex Problem-Solving questions, 0.3% experienced errors in answering questions, and 1.3% were unable to answer questions. The post-test results for the control class were not much different from the previous results, namely 16% were able to solve the questions and there were still 2% of students who experienced errors in answering questions.

Indicator 3, namely skills in creating Problem-Solving solutions, is grouped into four question sections, namely questions number 4a, 4b, 5a, and 5b. The implementation of limited trials showed that the percentage of students who were able to solve Complex Problem-Solving questions was 1%, while 11.75% of students who were unable to answer the questions and 14.25% experienced errors in answering the questions. After carrying out treatment, students' skills in Complex Problem-Solving increased, namely 13.5% were able to solve questions, 5.25% experienced errors in answering questions, and 2.75% were unable to answer questions. In a wide trial class, the percentage of students who were able to solve the questions was 1.75%, 21.25% experienced errors in answering the questions, and 10% were unable to answer the questions. After carrying out treatment, 19.5% of students were able to solve questions well, 11.25% still experienced errors in answering questions, and 2.25% were unable to answer questions. In the experimental test class, it showed that 1.5% of students experienced errors in answering questions and 16.5% were unable to answer questions. After carrying out treatment, there was an increase, namely 16% of students were able to solve Complex Problem-Solving questions and 2% experienced errors in answering questions. Meanwhile, the skills of students in the control class as seen from the pre-test results were still very low, namely 2.75% had errors in answering questions and 15.25% were unable to answer questions. The post-test results for the control class were not much different from the previous results, namely only 6.25% of students were able to solve the questions, 7.75% experienced errors in answering the questions, and 4% were unable to answer the questions.The results of this study support the finding that after the intervention, students were better able to solve problems with a lower error rate compared to before the intervention. As explained by Jonassen (2011), learning strategies focused on problem-solving can help students develop higher-order thinking skills, such as analysis and information synthesis

Based on the results of the analysis of the percentage of errors for each indicator of the Complex Problem-Solving skill above, it can be seen that the majority of students experienced errors in answering questions, only a few were able to solve the questions, and there were even still students who were unable to answer Complex Problem-Solving questions. However, after treatment using interactive teaching media based on virtual reality through an ethnopedagogy approach in each testing class (limited trial, extensive trial, experimental test) it showed that the percentage of students' errors for each indicator changed and increased towards being able to solve questions.

Comparison of Complex Problem-Solving Skill Indicators

The Complex Problem-Solving skills of students in each testing class experienced a significant increase after implementing virtual reality-based interactive teaching media through an ethnopedagogy approach. This increase can occur due to the application of interactive teaching media based on virtual reality through the Pajoge Makkunrai dance ethnopedagogy approach. Through a series of learning stages using this teaching media, students are slowly able to hone their Complex Problem-Solving skills, including the skills of identifying complex problems, evaluating/reviewing problem information, and creating Problem-Solving solutions. Students' skills in identifying complex problems are formed when the teacher provides stimulation (review) in the form of various questions through virtual reality-based interactive teaching media, which in the learning process is referred to as the muttama' makkasiwiyang (review) stage and the manngde mappatabe (extending) stage. By providing various questions, students can more easily understand a series of questions, especially in this research using material on Systems of Linear Equations in Two Variables. Even though in each question there are two different types of variables (variables x and y), it is easier for students to differentiate and determine them because they are used to solving similar questions. Meanwhile, students' skills in evaluating/reviewing problem information to be able to create Problem-Solving solutions are formed when students align their perceptions at the massampeang (problem solving) stage, and can be evaluated through the sere massimang (recap) stage.

The following is a bar diagram that illustrates the increase in each indicator in the Complex Problem-Solving skill after implementing virtual reality-based interactive teaching media through the Pajoge Makkunrai dance ethnopedagogy approach. Based on the graph, it is evident that among the three indicators of Complex Problem-Solving skills, students faced the greatest difficulty in answering questions related to the third indicator, which involves generating problem-solving solutions. In each test, students struggled to draw accurate conclusions regarding the given problems. They not only failed to construct problem-solving evidence following the correct procedures but also provided

reasoning that was less logical and not supported by systematic analysis. This indicates that their ability to understand and resolve complex problems remains limited (OECD, 2014; Funke, 2010). However, after the implementation of interactive teaching media based on virtual reality through an ethnopedagogical approach, there was a significant improvement in how students understood and solved complex problems. Students began to show progress in several key aspects of problem-solving, including the ability to identify the core issue, critically evaluate and analyze information, and formulate effective and systematic solutions. According to Jonassen (2011), learning environments that integrate problem-solving strategies with interactive media can enhance students' cognitive engagement and higher-order thinking skills.

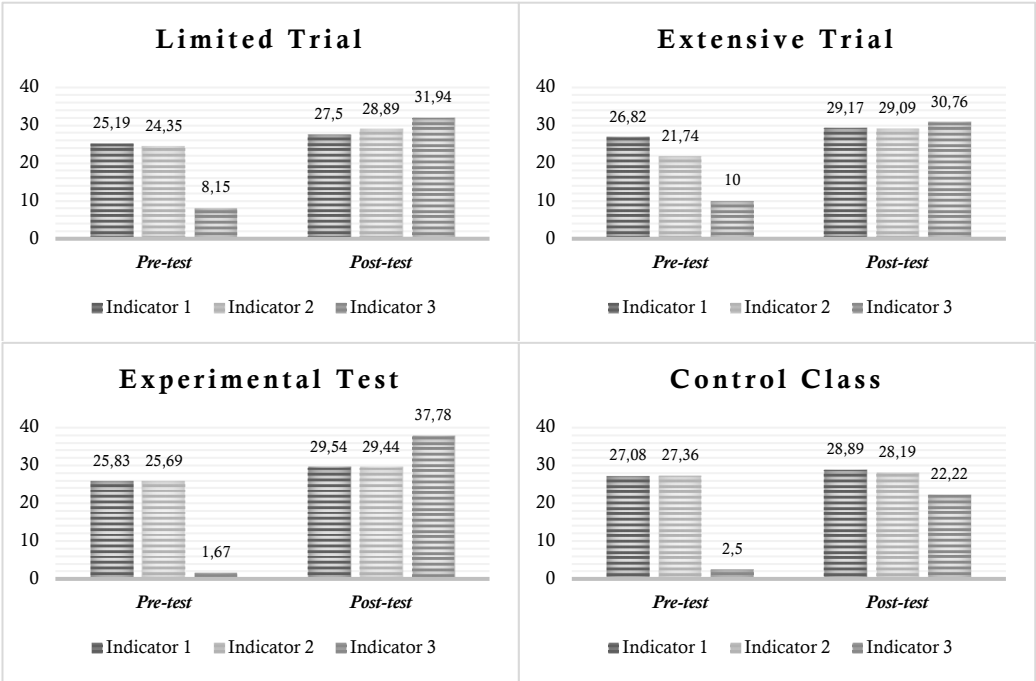

Figure 1. Comparison of Complex Problem-Solving Skill Indicators

This improvement was particularly evident in solving problems related to the System of Two-Variable Linear Equations (SPLDV), where students demonstrated the ability to apply more structured strategies based on a deeper understanding of the taught concepts. These findings indicate that the application of interactive teaching media based on virtual reality through an ethnopedagogical approach not only enhances students' complex problem-solving skills but also helps them develop a more mature analytical and reflective mindset in solving mathematical problems independently and systematically (Hmelo-Silver, 2004; Anderson, 2015).

Virtual Reality-Based Interactive Teaching Media Using an Ethnopedagogy Approach

The application of virtual reality-based interactive teaching media in this research was carried out with several core stages adapted from the Pajoge Makkunrai dance variety. This dance is known for its graceful and gentle movements, consisting of eight movements (Sulfiana, 2013), namely the muttama' (entering movement), makkasiwiyang (respect), mannggade (adab), mappatabe (asking for permission), massampeang (rejecting evil), mali siparappe rebba sipatokkong, sere, and massimang (please say goodbye). Based on the eight Pajoge Makkunrai dance movements, the application of teaching media in this learning process consists of four core stages, namely the muttama' makkasiwiyang stage (review), the mannggade mappatabe stage (extending), the massampeang stage (problem solving), and the sere massimang stage (recap). The following are learning stages adapted from the Pajoge Makkunrai dance variety.

To make it easier for students to explore the philosophical values contained in the Pajoge Makkunrai dance movement, this research was carried out by providing a virtual reality-based learning experience. This application is a guide between the use of virtual reality-based learning through the Pajoge Makkunrai dance ethnopedagogy approach. This provides new experiences for students in the

learning process, thus having an impact on their motivation and interest in learning. One of the main factors causing low student learning outcomes in mathematics subjects is a lack of motivation and interest in carrying out the teaching and learning process (Magfirah et al., 2022; Nurannisa, Asfar and Asfar, 2021; Nurannisa et al., 2021).

Students' motivation and interest in learning can be increased by presenting an interesting and enjoyable learning process (Nurlia et al., 2022; Nursyam and Asfar, 2024). So far, students feel stressed when hearing the word mathematics, which indirectly affects their motivation and interest in learning (Rahayu et al., 2022; Nursyam and Asfar, 2023; Sua, Asfar and Adiansyah, 2023). Through the application of interactive teaching media based on virtual reality, students can be directly involved in the learning process (student centered).

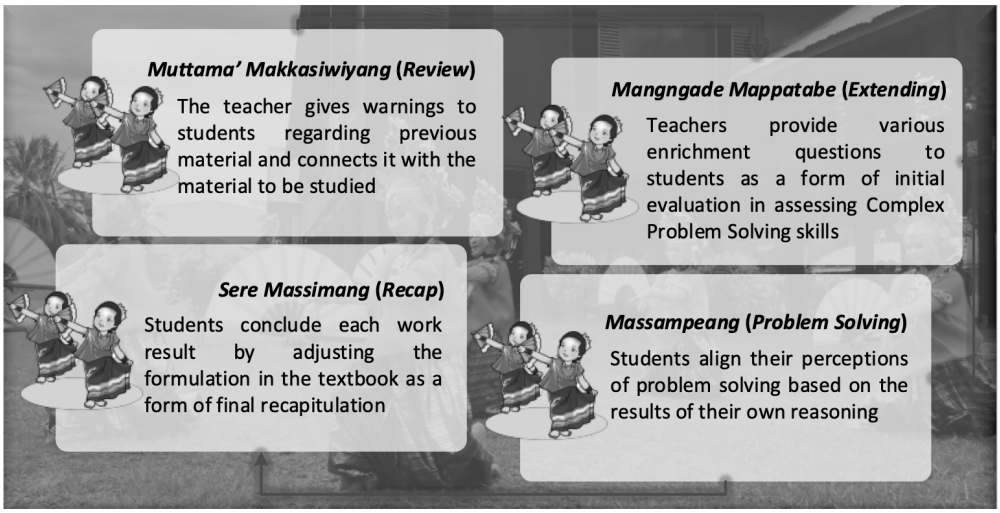

Figure 2. Stages of Implementing Teaching Media

This is something that has just been implemented in the school (UPT SMP Negeri 1 Kahu) which can attract the attention of many students. Increasing students' interest in learning can be seen from their enthusiasm during the learning process. Even though they have been divided into groups to gradually explore learning, students still struggle because they are curious about the teaching media used. This learning is even more interesting when explored directly together with one of the local wisdoms that is familiar to students, namely the Pajoge Makkunrai dance.

The application of virtual reality-based interactive teaching media through an ethnopedagogy approach means that students explore each variety of Pajoge Makkunrai dance in the form of animated videos using a tool in the form of a VR box. Students can see live animations that demonstrate the Pajoge Makkunrai dance from each stage. Apart from that, another thing that is of interest to students is that there are various questions given at each stage of the dance. When the animation has demonstrated a variety of dance, a prize box will appear containing numbers. Each number contains 5 questions to fill in as a form of quiz for students to choose from. By providing various questions can improve students' skills in solving Complex Problem-Solving questions. The application of virtual reality-based interactive teaching media through an ethnopedagogy approach in testing classes (limited trials, extensive trials, experimental trials) can improve Complex Problem-Solving skills because of its unique stages in stimulating students' thinking/reasoning processes to solve various problems. This is in line with research by Angraini et al., (2024) that students' mathematical understanding can be improved by implementing virtual-based teaching media. Students can easily solve every problem with the help of interactive teaching media (Suherman, Komaro and Ana, 2023).

Conclusions

The analysis results of students' Complex Problem-Solving abilities using interactive learning media based on virtual reality through an ethnopedagogical approach show a significant improvement. Based on a comparative analysis of Complex Problem-Solving ability indicators, it was found that the average

score of students in the experimental class was significantly higher than that of the control class, which did not implement interactive learning media based on virtual reality through an ethnopedagogical approach. This indicates that the application of interactive learning media based on virtual reality through an ethnopedagogical approach can enhance Complex Problem-Solving skills across various indicators. A suggestion for future research is to design and develop a virtual reality-based learning model that is more specific to different fields of study while taking into account existing local wisdom.

References

Adela, D., Suastra, I. W., and Lasmawan, I. W. (2023). Enculturation of Bugis Sidenreng Rappang Local Wisdom Through Ethnopedagogy of Traditional Games. International Journal of Elementary Education, 7(3), 21-32.

Anderson, J. R. (2015). *Cognitive Psychology and Its Implications* (8th ed.). Worth Publishers.

Angraini, L. M., Susilawati, A., Noto, M. S., Wahyuni, R., and Andria, D. (2024). Augmented Reality for Cultivating Computational Thinking Skills in Mathematics Completed with Literature Review, Bibliometrics, and Experiments to Students. Indonesian Journal of Science & Technology, 9(01).

Asfar, A. M. I. A., Ahmad, M. A., and Asfar, A. M. I. T. (2021). Elaboration of Active Knowledge Sharing Learning Model to Improve High Order Thinking Skills Integrated 4C. Asian Journal of Applied Sciences, 9(4).

Asfar, A. M. I. A., Trisnowali, A., Dahlan, J. A., Prabawanto, S., and Nurannisa, A. (2022). Validity and Practicality of learning model development of LAPS-Heuristics with local wisdom on Students' Metacognitive Ability. Jurnal Penelitian dan Pengembangan Pendidikan, 6(3), 492-499.

Asfar, A. M. I. T., and Asfar, A. M. I. A. (2020). Case-based games learning strategies to improve conceptual understanding in mathematics. Journal of Physics: Conference Series, 1663(1), 012060. IOP Publishing.

Asfar, A. M. I. T., and Asfar, A. M. I. A. (2021). The effectiveness of distance learning through Edmodo and Video Conferencing Jitsi Meet. Journal of Physics: Conference Series, 1760(1), 012040. IOP Publishing.

Asfar, A. M. I. T., and Paronda, N. (2024). Perbandingan Model Pembelajaran GO CAR (Guided, Orientation, Challenge, Analysis, and Review) dengan Model Pembelajaran GOLD (Guided, Organizing, Leafted, Discovery) terhadap Peningkatan Kemampuan Penalaran Matematika Siswa. Proximal: Jurnal Penelitian Matematika dan Pendidikan Matematika, 7(1), 122-132.

Asfar, A. M. I. T., Ahmad, M. A., Gani, H. A., Asfar, A. M. I. A., and Nurannisa, A. (2021). Development of Connecting Extending Review (CER) Learning Model to Improve Student's Mathematical Reasoning Ability. Asian Journal of Applied Sciences, 9(4).

Asfar, A. M. I. T., Asfar, A. M. I. A., and Nurannisa, A. (2021). Integration of local traditions bugis-makassarese: Learning strategies to improve mathematical communication skills. Journal of Physics: Conference Series, 1808(1), 012064. IOP Publishing.

Asfar, A. M. I. T., Asfar, A. M. I. A., and Nurannisa, A. (2022). Analysis of students' mathematical reasoning ability using connecting, extending, review (CER) learning model. AIP Conference Proceedings, 2577(1). AIP Publishing.

Asfar, A. M. I. T., Asfar, A. M. I. A., and Sulastri, S. (2021). Improving student's complex Problem-Solving through LAPS-Talk-Ball learning integrated with interactive games. Journal of Physics: Conference Series, 1722(1), 012105. IOP Publishing.

Asfar, A. M. I. T., Sumiati, S., Asfar, A. M. I. A., and Nurannisa, A. (2022). Analysis of Students' Mathematical Connection Ability Through Learning Strategies Based on Local Wisdom. Jurnal Didaktik Matematika, 9(1), 170-185.

Asfar, A. M. I. T., Syaifullah, A., Asfar, A. M. I. A., Srimularhmah, A., Bonita, A. F. H., and Ekawati, V. E. (2024). Blended learning method with integrated mind mapping lontara script for junior high school students with Bugis cultural environment. AIP Conference Proceedings, 2987(1). AIP Publishing.

Asfar, A. M. I. T., Trisnowali, A., Dahlan, J. A., Prabawanto, S., Asfar, A. M. I. A., and Nurannisa, A. (2023). Local wisdom Bugis Bone in the LAPS-Heuristics learning model: An alternative solution to improve the metacognitive ability. AIP Conference Proceedings, 2886(1). AIP Publishing.

Damayanti, W., Asfar, A. M. I. T., Asfar, A. M. I. A., Nurannisa, A., Yulita, Y., and Ayunita, A. (2023). Learning Mathematics Congruence and Similarity: An Analysis of Student Response to the Exploration of a Traditional Boat of Bugis Specific Phinisi. The 1st International Conference on Mathematic Education and Technology (ICOMET) 2022.

Damayanti, W., Asfar, A. M. I. T., Asfar, A. M. I. A., Nurannisa, A., Yulita, Y., and Ayunita, A. (2022). Enchancement Complex Problem-Solving Siswa SMP pada Materi Kesebangunan dan Kekongruenan Melalui Integrasi Perahu Tradisional Phinisi Khas Bugis. Seminar Nasional Paedagoria, 2, 259-266.

Dewi, S. S., Asfar, A. M. I. T., Asfar, A. M. I. A., and Nurannisa, A. (2024). Traditional game strategy bugis Ma'benteng integrated 4C skills in improving analytical thinking ability. AIP Conference Proceedings, 2987(1). AIP Publishing.

Dewi, S. S., Asfar, A. M. I. T., Asfar, A. M. I. A., Nurannisa, A., Nurhasanah, N., and Rosdaliani, A. (2022). Peningkatan Kemampuan Berpikir Analitik Siswa melalui Elaborasi Permainan Bugis Ma'benteng Terintegrasi 4C Skills Berbasis Android. Seminar Nasional Paedagoria, 2, 286-291.

Firdaus, F., Sari, F. A., Yanuar, M., and Hasanah, H. (2023). Peningkatan Kemampuan Guru dalam Mengembangkan Media Ajar Berbasis Lokal yang Kekinian. ABDIKARYA: Jurnal Pengabdian dan Pemberdayaan Masyarakat, 5(02), 106-112.

Fortuna, S., Purnamasari, A. I., and Dikananda, A. R. (2023). Game Edukasi Menyusun Kata Berbasis Android dengan Metode MDLC sebagai Media Pembelajaran Anak Usia Dini pada PAUD Wijaya Kusuma 1 Kota Cirebon. Jurnal Teknologi Ilmu Komputer, 1(2), 61-65.

Funke, J. (2010). Complex problem solving: A case for complex cognition. *Cognitive Processing, 11*(2), 133–142. https://doi.org/10.1007/s10339-009-0345-0

Gnaldi, M., Bacci, S., Kunze, T., and Greiff, S. (2020). Students' Complex Problem-Solving Profiles. Psychometrika, 85(1), 469-501.

Grezo, M., and Sarmany-Schuller, I. (2022). It is Not Enough to be Smart: On Explaining the Relation Between Intelligence and Complex Problem Solving. Technology, Knowledge and Learning, 27(1), 69-89.

Hmelo-Silver, C. E. (2004). Problem-Based Learning: What and How Do Students Learn? *Educational Psychology Review, 16*(3), 235–266. https://doi.org/10.1023/B:EDPR.0000034022.16470.f3

Joksimovic, S., Ifenthaler, D., Marrone, R., De-Laat, M., and Siemens, G. (2023). Opportunities of Artificial Intelligence for Supporting Complex Problem-Solving: Findings from a Scoping Review. Computers and Education: Artificial Intelligence, 4(100138), 1-12.

Jonassen, D. H. (2011). *Learning to Solve Problems: A Handbook for Designing Problem-Solving Learning Environments*. Routledge.

Junaede, H., Paronda, N., Asfar, A. M. I. T., Aisyah, A., and Nursyam, A. (2024). Efektivitas Model Pembelajaran Connecting, Extending, Review (CER) Terhadap Kemampuan Berpikir Kritis Matematis Siswa. Sigma: Jurnal Pendidikan Matematika, 16(1).

Kipman, U., Bartholdy, S., Weiss, M., Aichhorn, W., and Schiepek, G. (2022). Personality Traits and Complex Problem Solving: Personality Disorders and Their Effects on Complex Problem-Solving Ability. Frontiers in Psychology, 13(788402), 1-10.

Lubis, S. E. F. (2023). Pengembangan Media Ajar Berbentuk Audiovisual Berbantuan Powtoon pada Pembelajaran Matematika Bangun Ruang Siswa Kelas V Sekolah Dasar. ALFIHRIS: Jurnal Inspirasi Pendidikan, 1(3), 99-103.

Magfirah, M., Asfar, A. M. I. T., Asfar, A. M. I. A., Nurwijaya, S., and Fauziah, A. (2022). Improving Mathematical Adaptive Reasoning Through Traditional Game "Lojo-Lojo Pindip" based on Android. AIP Conference Proceedings, 2577(1). AIP Publishing.

Martiara, R., Mangkona, J. A., and Supriyanti, S. (2020). The Main Value of Bugis Women in Pajoge Dance Structure. Proceedings of the 2nd International Conference on Interdisciplinary Arts and Humanities (ICONARTIES).

Molnar, G., and Greiff, S. (2023). Understanding Transitions in Complex Problem-Solving: Why We Succeed and Where We Fail. Thinking Skills and Creativity, 50(101408), 1-18.

Mount, M., Round, H., and Pitsis, T. S. (2020). Design Thinking Inspired Crowdsourcing: Toward a Generative Model of Complex Problem Solving. California Management Review, 62(3), 1–18.

Nicolay, B., Krieger, F., Stadler, M., Gobert, J., and Greiff, S. (2021). Lost in Transition–Learning Analytics on the Transfer from Knowledge Acquisition to Knowledge Application in Complex Problem Solving. Computers in Human Behavior, 115(106594), 1–46.

Novelza, I. D., and Handican, R. (2023). Systematic Literature Review: Apakah Media Pembelajaran Mampu Mempengaruhi Hasil Belajar Matematika?. Griya Journal of Mathematics Education and Application, 3(1), 11-22.

Nurannisa, A., Asfar, A. M. I. T., and Asfar, A. M. I. A. (2021). Learning design: Integrated local tradition maʼ dawa-dawa, maʼ manu-manu, maʼ pettuada based on android. Journal of Physics: Conference Series, 1760(1), 012049. IOP Publishing.

Nurannisa, A., Asfar, A. M. I. T., Asfar, A. M. I. A., and Syaifullah, A. (2021). Improving students' mathematical logical intelligence through the online-based integration of local wisdom of Sulapa Eppa Walasuji. Al-Jabar: Jurnal Pendidikan Matematika, 12(2), 283-294.

Nurlia, N., Asfar, A. M. I. T., Asfar, A. M. I. A., Masri, M., and Sari, T. P. (2022). Integration of Sigajang Laleng Lipa ritual in learning to improve high order thinking skills (HOTS) based on students' mathematical problem solving. AIP Conference Proceedings, 2577(1). AIP Publishing.

Nursyam, A., and Asfar, A. M. I. T. (2023). Pengaruh Model Pembelajaran Read, Answer, Discuss, Explain, And Create (Radec) Terhadap Kemampuan Berpikir Kreatif Matematis Siswa Kelas Xi Ips Ma Asadiyah Uloe Kabupaten Bone. De Fermat: Jurnal Pendidikan Matematika, 6(2), 92-103.

Nursyam, A., and Asfar, A. M. I. T. (2024). Perbandingan Model Pembelajaran Kooperatif Tipe Make a Match dan Numbered Head Together Terhadap Pemahaman Konsep Matematis. Jurnal Pendidikan Inovatif, 6(1).

OECD. (2014). *PISA 2012 Results: Creative Problem Solving: Students' Skills in Tackling Real-Life Problems (Volume V)*. OECD Publishing. https://doi.org/10.1787/9789264208070-en

Pamungkas, M. D., Waluya, S. B., and Mariani, S. (2023). A Systematic Review of Complex Problem-Solving in Education and Mathematics Education. Journal of Higher Education Theory and Practice, 23(16), 87-101.

Pusmendik. (2022). Rapor Pendidikan Publik 2022. URL: https://pusmendik.kemdikbud.go.id/profilpendidikan/profil-wilayah.php. Diakses tanggal 12 April 2024.

Puspendik. (2019). Lapoan Hasil Ujian Nasional 2019. URL: https://hasilun.pusmenjar.kemdikbud.go.id. Diakses tanggal 12 April 2024.

Putra, A., Sumarmi, S., Sahrina, A., Fajrilia, A., Islam, M., and Yembuu, B. (2021). Effect of Mobile-Augmented Reality (MAR) in Digital Encyclopedia on the Complex Problem-Solving and Attitudes of Undergraduate Student. International Journal of Emerging Technologies in Learning (IJET), 16(7), 119-134.

Rahayu, A. S., Asfar, A. M. I. T., Nursyam, A., and Asfar, A. M. I. A. (2022). Massallo kawali tradition integrated in open time learning model improving students' flexible thinking ability. AIP Conference Proceedings, 2577(1). AIP Publishing.

Rayimov, B. U. (2023). Methodology of Formation of Ethno-Pedagogical Values in Students of Pedagogic Higher Education Institutions. Educational Research in Universal Sciences, 2(6), 333-336.

Solihah, P. A., Kaniawati, I., Samsudin, A., and Riandi, R. (2024). Prototype of Greenhouse Effect for Improving Problem-Solving Skills in Science, Technology, Engineering, and Mathematics (STEM)-Education for Sustainable Development (ESD): Literature Review, Bibliometric, and Experiment. Indonesian Journal of Science & Technology, 9(1), 163-190.

Sua, A. T., Asfar, A. M. I. T., and Adiansyah, R. (2023). Penguatan Pemahaman Budaya Indonesia pada SB Hulu Langat Melalui Metode Discovery Learning Cerita Rakyat "I La Galigo". Buletin KKN Pendidikan, 5(1), 27-36.

Suherman, A., Komaro, M., and Ana, A. (2023). E-book multimedia animation implementation on concept mastery and problem-solving skills of crystal structure subjects in engineering materials course. Indonesian Journal of Science and Technology, 8(2), 259-280.

Wang, Y., Xu, Z. L., Lou, J. Y., and Chen, K. D. (2023). Factors Influencing the Complex Problem-Solving Skills in Reflective Learning: Results from Partial Least Square Structural Equation Modeling and Fuzzy Set Qualitative Comparative Analysis. BMC Medical Education, 23(1), 1-17.