

THE USE OF AUGMENTED REALITY THROUGH ELEMENT LEARNING TO IMPROVE STUDENTS' MATHEMATICAL LITERACY

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Abstract: *This Classroom Action Research (CAR) aims to analyze the improvement of students' mathematical literacy through the use of Augmented Reality (AR) media within the Estafet Learning model. The research was conducted over two cycles with 33 students of class X IPA 2 at SMA Negeri 1 Angkola Selatan. Data was collected through tests, observation, and questionnaires. The results prove that the combination of AR and Estafet Learning effectively enhanced mathematical literacy. Questionnaire data showed an increase in students in the 'high' category, from 9% (Cycle I) to 85% (Cycle II). The percentage of worksheet completion also significantly increased from 37.5% to 87%. Augmented Reality successfully visualized abstract mathematical concepts, while Estafet Learning fostered active collaboration and in-depth understanding through its relay stages. Thus, the integration of these two strategies is proven effective and is recommended as an innovative learning approach to optimize students' mathematical literacy.*

Keywords: *Augmented Reality, Estafet Learning, Mathematical Literacy*

Introduction

21st-century education demands mastery of mathematical literacy, defined as an individual's capacity to formulate, employ, and interpret mathematics in a variety of contexts (Amaliya & Fathurohman, 2022; Ayunis & Dorisno, 2022). This ability plays a significant role in enhancing technological proficiency (Chasanah et al., 2020; Eka Saputri, 2023; Rahmasari & Setyaningsih, 2023). It encompasses reasoning and the use of mathematical concepts to explain and predict phenomena (Madyaratri et al., 2019).

However, observations at SMA Negeri 1 Angkola Selatan indicate symptoms of low mathematical literacy: 65% of 33 tenth-grade students had difficulty solving word problems requiring mathematical modeling; nearly 70% gave up on non-routine (HOTS) problems; and only 30% could logically explain their problem-solving steps. This indicates that learning is still focused on memorizing procedures without an emphasis on conceptual understanding and real-world application.

This low level of literacy is a serious challenge, including from the global OECD perspective. Students' difficulties reflect abilities below PISA Level 2, particularly in problem-solving and logical thinking (Johar, 2022; Yulianto et al., 2024; Zahrah, 2024). Therefore, systematic learning is needed to build students' understanding and reasoning abilities (Madyaratri et al., 2019). Effective learning must be contextual, student-centered, and encourage active engagement, one of which can be achieved through *estafet learning* (relay learning),

which focuses on student activities in answering questions in turns until the target of correctness is achieved (Herwanto, 2020; Madyaratri et al., 2019).

In a modern context, Augmented Reality (AR) emerges as a promising medium for concretizing abstract concepts. AR allows students to manipulate 3D geometric objects and visualize problems directly within their environment (Ardani & Fitriyah, 2023; Qorimah & Sutama, 2022; Thahir & Kamaruddin, 2021). The high interactivity of AR can create an immersive learning experience and build a deep conceptual understanding, which is the foundation of mathematical literacy. However, the effectiveness of AR is highly dependent on learning design that meaningfully integrates it into instructional goals.

Literature Review

This research is motivated by the low mathematical literacy of Indonesian students, as reported in PISA studies (Johar, 2012; Yulianto et al., 2024). Mathematical literacy, defined as the capacity to formulate and employ mathematics in diverse contexts, is a crucial 21st-century skill. To address this issue, this study integrates two innovative approaches. The *Estafet Learning* model (Herwanto, 2020) is applied to foster active and collaborative learning. Meanwhile, Augmented Reality (AR) (Ardani & Fitriyah, 2023) is utilized to visualize abstract mathematical concepts into interactive 3D forms. The synergy between this collaborative learning strategy and an immersive visual medium is hypothesized to effectively enhance students' conceptual understanding and overall mathematical literacy skills.

Method

This research employs Classroom Action Research. The study was conducted in two cycles, with each cycle consisting of four main stages: planning, acting, observing, and reflecting (Suherman, 2022; Sukardi, 2022). The research takes place in Class X at SMA Negeri 1 South Angkola. The study is carried out over a specific period covering the preparation process, the implementation of cycles I and II, and data analysis. The subjects of this research are all 33 students of Class X at SMA Negeri 1 South Angkola. The object of this research is improving students' mathematical literacy skills through the application of the relay learning model assisted by augmented reality media. Data collection techniques in this study include tests, observation, and angket (Sormin & Sormin, 2020). The data analysis techniques used are Quantitative Data Analysis and Qualitative Data Analysis (Purnomo, 2011; Sukardi, 2022).

Learning success is determined by three indicators:

1. Improvement in students' mathematical literacy skills, evidenced by at least 75% of students achieving a Minimum Completion Score (KKM) of 75.
2. Improvement in student learning activities, achieving at least 80% on the student questionnaire.
3. Improvement in teacher performance, achieving at least 80% on the teacher performance observation sheet through the implementation of the relay learning model.

Result and Discussion

This Classroom Action Research (CAR) was designed in two cycles, with each cycle consisting of the four classic stages: planning, action, observation, and reflection. Each cycle was conducted over two meetings, with data collection instruments including a mathematical literacy skills test, student activity observation sheets, teacher competency observation sheets, and student response questionnaires. The success benchmark was determined based on a Minimum Completion Criteria (KKM) of 75 for individuals and a classical completion rate of 75%.

Description and Reflection of Cycle I: Initial Problem Identification

Cycle I served as the foundation for understanding the students' initial conditions and the challenges in implementing this new model.

1. Mathematical Literacy Skills Test Results (Still Low)

The test results in Cycle I showed that students' mathematical literacy skills had not met expectations. Out of 33 students, only 16 students (48.48%) achieved a passing score (≥ 75), while 17 students (51.51%) had not passed. The overall class average score was 69.24. A deeper analysis of the score distribution is as follows:

Table 4.2 Description of Students' Mathematical Creative Thinking Ability Scores in Cycle I

Interval	Number of Students	Percentage	Category
90-100	0	0%	Very High
80-89	6	18.18%	High
65-79	16	48.48%	Medium
55-64	11	33.33%	Low
0-54	0	0%	Very Low
Total	33	100%	

This data reveals that the majority of students (48.48%) were in the "Medium" category, and as many as 33.33% were still categorized as "Low". This clearly indicates that the success indicator set (classical completion $\geq 75\%$) had not been achieved.

2. Student Activity Observation Results (Not Yet Evenly Distributed)

Observations of 10 aspects of students' mathematical literacy activities yielded a varied picture. Of the 10 observed aspects, 6 aspects were in the "Medium" criteria (marked by participation of 15-18 students), while the other 4 aspects were still in the "Low" criteria (only 10-11 active students). This finding indicates that although the Estafet learning model had begun to attract the interest of some students, its implementation was not yet even and had not fully succeeded in activating all aspects of mathematical literacy in all students. Several specific indicators remained weak points requiring further intervention.

3. Teacher Competency Observation Results (Needs Refinement)

The teacher's performance in managing learning in Cycle I was generally good, with the highest scores on aspects of material mastery and assessment. However, reflection revealed several areas for improvement, specifically in motivating students at the start of the lesson, managing classroom order, providing broader opportunities for students to express opinions, as well as clarity in summarizing the material and assigning tasks at the end of the session. These weaknesses were suspected to be one of the causes of the suboptimal student learning outcomes.

4. Student Response Questionnaire Results (Still in the Adjustment Phase)

Student responses to this new learning model in Cycle I tended to be moderate. As many as 26 students (78.79%) were in the "Medium" category, 4 students (12.12%) in the "High" category, and 3 students (9.09%) in the "Low" category. This indicates that most students were

still in the process of adapting to the estafet learning model and the AR aids. They might have been interested but not yet fully understood or comfortable with the new approach.

5. Reflection and Improvement Plan for Cycle II

Based on the findings in Cycle I, the researcher and teacher conducted an in-depth reflection. Several identified obstacles included: students still being frequently noisy, lack of clarity regarding discussion materials, and social dynamics within the groups. The improvement plan for Cycle II focused on:

- o Improving the teacher's explanation of the material and discussion flow.
- o More effective classroom management strategies to create a conducive learning environment.
- o Optimizing the use of the AR application to visualize Systems of Linear Equations in Two Variables (SPLDV) problems more attractively, thereby sparking student curiosity and creativity.

Description and Success of Cycle II: Significant Improvement

The implementation of Cycle II, which had undergone improvements based on the reflection from Cycle I, yielded very encouraging results and showed a significant leap in all observed aspects.

1. Mathematical Creative Thinking Test Results (Drastically Improved)

The most noticeable increase was seen in the results of the students' creative thinking ability test. The number of students who passed learning surged from 16 to 28 students. Thus, the percentage of classical completeness reached 84.84%, exceeding the set success indicator (75%). The class average score also increased sharply, from 69.24 to 80.54.

Table 4.7 Description of Students' Mathematical Critical Thinking Test Scores in Cycle II

Interval	Number of Students	Percentage	Category
90-100	5	15.15%	Very High
80-89	15	45.45%	High
65-79	13	39.39%	Medium
55-64	0	0%	Low
0-54	0	0%	Very Low
Total	33	100%	

A comparison with Table 4.2 from Cycle I shows a dramatic shift in composition. The "Low" category, previously occupied by 11 students, has now disappeared, shifting to the "Medium" and "High" categories. Furthermore, the "Very High" category emerged, which was absent in Cycle I. This proves that the improvements made were successful not only in raising the average score but also in distributing student abilities to a higher level.

2. Student Activity Observation Results (Predominantly High Criteria)

Observations of student activities in Cycle II showed very rapid progress. Of the 10 observed aspects, 6 aspects had reached the "High" criteria (marked by participation of 22-32 students), and the other 4 aspects were in the "Medium" criteria. Notably, not a single aspect was in the "Low" criteria. This indicates that the AR-assisted estafet learning model had successfully

created a consistently active learning environment and encouraged most students to engage in the creative thinking process.

3. Teacher Competency Observation Results (Reached Very Good Level)

The teacher's performance in managing learning in Cycle II showed improvement across almost all aspects. The teacher was assessed to have made improvements in the previously weak areas, such as motivating students, managing class order, providing opportunities for opinions, and closing activities. Several key aspects even achieved a perfect score (5), such as mastery of subject matter, clarity of presentation, and assessment. This improvement in the teacher's skills became a key factor supporting the success of learning in Cycle II.

4. Student Response Questionnaire Results (Very Positive Response)

Student responses to the learning model changed very positively. As many as 28 students (84.85%) now gave responses in the "High" category, while only 5 students (15.15%) were in the "Medium" category, and there were no longer any students with a "Low" response. This shift indicates that after going through the adaptation process in Cycle I, students ultimately felt interested, motivated, and assisted by the AR-assisted estafet learning model.

Discussion: Synthesis of the Two Cycles

The comparison between Cycle I and Cycle II clearly illustrates a successful journey of improvement. The implementation of the AR-assisted estafet learning model proved effective in improving students' mathematical literacy skills, but this effectiveness only became optimal after going through a refinement process based on reflection. The synergy between estafet learning and AR is suspected to be the key to this success. The estafet learning model challenged students to solve real-world (contextual) problems, triggering the processes of asking questions, formulating strategies, and evaluating solutions inherent to mathematical literacy. Meanwhile, the presence of Augmented Reality acted as a "bridge" connecting the mathematical abstraction in SPLDV with a tangible, interactive, and engaging visual representation. This visualization helped students who struggled with pure abstraction to understand the concepts, allowing them to be more confident and creative in exploring various possible solutions.

The improvement that occurred was also holistic, not only in cognitive test results. Student activities, which were initially passive and uneven, became active and predominantly at a high level. The teacher's ability to manage innovative learning was also honed, showing that this model also provides a impact on professional development for educators. The positive response from students created a virtuous feedback loop; because they felt happy and interested, they were more motivated to engage, which ultimately impacted the improvement of learning outcomes.

Conclusion

Based on the entire series of studies, it can be concluded that the estafet learning model assisted by Augmented Reality (AR) is significantly effective in:

1. Improving students' mathematical literacy skills on the topic of Systems of Linear Equations in Two Variables (SPLDV).
2. Increasing student activity and participation during the learning process.
3. Enhancing the teacher's ability to manage innovative learning.
4. Receiving very positive responses from students.

Thus, this research does not merely stop at proving the effectiveness of a learning model, but also provides a blueprint that can be used as a reference for creating more relevant, enjoyable, and creativity-stimulating mathematics learning in the 21st century.

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