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Critical Thinking Improvement through Numeracy Literacy: Insights from Senior High School Practices

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Abstract

Numeracy literacy skills are the main focus in the Indonesian education system to prepare students for the 21st century. However, in practice, efforts to acculturate numeracy literacy in schools are still not implemented optimally. Therefore, this study has two main objectives, namely: 1) to describe the acculturation of numeracy literacy of senior high school students; 2) to explore the critical thinking disposition of senior high school students. This research is part of a developmental research that focuses on a qualitative approach with an ethnographic design. The subjects in this study were students, subject teachers, and one of the senior high schools in Surakarta. The research data were collected through interviews conducted with teachers, direct observation during classroom learning activities, and documentation related to mathematics assessments used in schools. Data validation was conducted using source triangulation technique to ensure data credibility.

Keywords: advanced level education, critical thinking, critical thinking disposition, education system, innovative learning, learning outcomes, numeracy literacy, PISA

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1. Introduction

Along with the development of the world today, education as the main guard has an important role to prepare students to face global demands in the 21st century. The skills of creative thinking, critical thinking, communication, and collaboration in work are the basic skills needed by a person to be able to adapt in the 21st century (Handayani & Sutama, 2024; Rusiana et al., 2024; Octaviana & Setyaningsih, 2022) . These basic skills need to be developed in classroom learning through the application of effective strategies. It aims to enable students to interpret the text they read and connect it with contextual problems and other relevant texts (Azizah, 2022) . One strategy that is currently being intensively carried out is the development of numeracy literacy skills.

Literacy and numeracy have fundamental differences in definition. According to Daley (1997) literacy is a person's ability to read and write, understand information, and the ability to convey ideas concretely and abstractly. Meanwhile, numeracy according to Han ve diğerleri (2017) is the ability to use various numbers and basic mathematical symbols to solve practical problems in various contexts of daily life, as well as analyse information presented in various forms such as graphs, tables and charts. Based on these two definitions, it can be concluded that numeracy

literacy is a person's ability to understand, analyse and present information obtained in the form of numbers and mathematical symbols based on problems that occur in everyday life.

The importance of numeracy literacy skills is a major focus in the education system in Indonesia. This is reflected in the Minimum Competency Assessment policy in 2021 where literacy and numeracy are the main components (Azizah, 2022) . The Minimum Competency Assessment is an aspect that measures students' cognitive abilities which include students' reading literacy and mathematical literacy (Ministry of Education and Culture, 2021) . However, this policy has not resulted in significant improvements in the level of students' numeracy literacy skills in the PISA event.

The results of the PISA test show that students' numeracy skills in Indonesia remain a serious challenge within the education system. In 2018, Indonesia's average score only reached 378, placing it in 73rd position out of 79 PISA member countries (OECD, 2019). This situation worsened in 2022, where Indonesia's average score dropped by 13 points to 366, with a slightly improved ranking at 69th out of 81 countries (Ahn et al, 2024). This decline reflects the still low ability of students to understand, analyze, and apply mathematical concepts in everyday life. The low level of numeracy can lead to difficulties in logical thinking, solving data-based problems, and developing the skills needed in the digital and industrial era. Therefore, more innovative learning strategies are needed, such as the implementation of digital modules based on problem-based learning (PBL) and formative assessments, to enhance students' critical thinking skills and conceptual understanding in numeracy (Silwana et al., 2021; Adhantoro et al., 2025). The declining results reflect that there are still shortcomings in the development of numeracy literacy in learning.

Some previous studies still show a lack of numeracy literacy inculcation in schools, especially to support the Minimum Competency Assessment (MCA) programme. This is an important issue that needs to be considered to improve the quality of education in Indonesia

Based on the analysis conducted, the factors causing low numeracy literacy can come from students, teachers and schools. The factor of low numeracy literacy from students is caused by their habit of memorising and using problem solving procedures as taught by the teacher (Jailani et al., 2020; Kolar & Hodnik, 2021) low habit of students in doing mathematical literacy problems (Aqillah et al., 2023) , low critical thinking ability of students (Kusuma et al., 2022) , and negative disposition of students towards mathematics (Rahmawati et al., 2021). Meanwhile, from the teacher's side, it is caused by giving questions that tend to use closed questions (Domu et al., 2023) and oriented to basic skills (Nasir et al., 2024) . In fact, practice questions to face the Minimum Competency Assessment given by teachers still use textbooks from various publishers that are not in accordance with the characteristics of students (Jannati & Sumardi, 2023) . This is due to the difficulties experienced by teachers to develop mathematical literacy questions that are in accordance with student characteristics (Apriatni et al., 2022; Jannati & Sumardi, 2023; Mukhlis et al., 2023) . The difficulties faced by the teacher are due to the lack of experience or special training in preparing numeracy literacy questions during the education period (Ulger et al., 2022) . The school as a place of learning is also an obstacle in acculturating numeracy literacy, where there are still limitations in providing adequate training for teachers to

design higher order thinking assessments (Mukhlis et al., 2023) . This is because in preparing numeracy literacy questions, special preparation is needed for teachers to focus on preparing and modelling the context of everyday life in mathematics problems into numeracy literacy questions (Steen et al., 2007).

Critical thinking skills are an important part of numeracy literacy and are interrelated (Kusuma et al., 2022). Critical thinking skills are not an innate talent, but rather an ability that can be learnt and developed through continuous practice (Arisoy & Aybek, 2021). The presentation of higher order thinking problems can help develop critical thinking skills (Winarti et al., 2023; Octaviana & Setyaningsih, 2022) and students' mathematical literacy skills (Setyaningsih & Mukodimah, 2022). In Indonesia, higher order thinking skills (HOTS) are always associated with Bloom's taxonomy, where HOTS are associated with cognitive skills in the levels of analysing, evaluating and creating (Asrafil et al., 2020).

Critical thinking itself consists of two interrelated dimensions, namely skills and dispositions. Mathematical disposition is the way a person views mathematics as something that can be understood and useful with diligent and tenacious effort (Hutajulu et al., 2019). Dispositional ability can support someone to use their critical thinking skills (Evans, 2020). Thus, often dispositions that are associated with critical thinking are called critical thinking dispositions. The definition of critical thinking disposition itself is a person's tendency or attitude to think critically consistently (Ennis, 1996). The two abilities support each other, where students who have a high critical thinking disposition will have high thinking skills as well (Sulistiowati, 2024).

Based on the background that has been presented, this research has two main objectives, namely: 1) describing the acculturation of numeracy literacy of senior high school students 2) exploring the critical thinking disposition of senior high school students.

2. Method

This research is part of development research focused on a qualitative approach with ethnographic design. Qualitative research with ethnographic design is research conducted with objects that develop as they are in a community group to study their cultural practices (Sutama, Hidayati, & Novitasari, 2022; Sugiyono, 2010). The subjects in this study were students of class XI-4, subject teachers, and SMA Muhammadiyah PK Kottabarat Surakarta. This activity was carried out in the odd semester of the 2024/2025 academic year. The selection of 15 research participants selected by convenience sampling technique in class XI-4 was carried out based on the availability of access obtained by the researcher (Golzar et al., 2022).

Research data were collected through interviews conducted with teachers, direct observation during classroom learning activities, and documentation related to mathematics assessments used in schools. The components of critical thinking disposition used in this study are: *Inquisitiveness, Systematicity, Analyticity, Truth-seeking, Open-mindedness, Self-Confidence, Maturity*. Data interpretation based on research conducted by (Rahardhian et al., 2022) is in the following table.

Table 1 . Critical Thinking Disposition Interpretation

Score	Interpretation
1 - 1.79	Very Low
1.80 - 2.59	Low
2.60 - 3.39	Medium
3.40 - 4.19	High
4.20 - 5	Very High

The numeracy literacy indicator that will be achieved in the given numeracy literacy problem, namely (1) learners are able to identify the information given in the problem and relate it to the concept of trigonometric comparison (*Mathematical Thinking and Reasoning*); (2) learners are able to make a mathematical model of the situation presented in the problem (*Modelling*); (3) learners are able to answer with a logical and structured arrangement of problem solving steps (*Mathematical Communication*); and (4) learners are able to represent the situation in the problem (*Representation*)

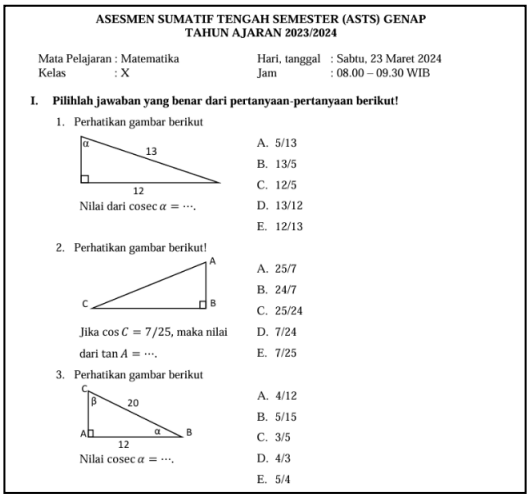
Data validation was carried out using source triangulation techniques to ensure data credibility. This is done by checking the data that has been obtained through several sources.

3. Result and Discussion

a. Acculturating Numeracy Literacy in Schools

This research was started by conducting interviews with teachers and observing the assessments used in learning mathematics. The material chosen in this study is trigonometric comparison material. The material is taught in grade X in Senior High School. Understanding the basic concepts of trigonometric comparison regarding the relationship between sides and angles in a right triangle angle is needed to be able to help students understand trigonometric material at an advanced level education.

Interview activities related to the research were conducted briefly with the mathematics teacher at the school. The teacher revealed that grade X students in the odd semester had not received trigonometric comparison material. The curriculum change that occurred, causing trigonometry material previously given in the odd semester is now given in the even semester of the 2024/2025 school year. However, based on the advice given by the teacher, the research can be conducted in class XI. One of the classes recommended by the teacher based on students' high enthusiasm in learning is class XI-4. When the researcher asked for documentation of assessments used for observation purposes, the teacher only provided data on summative assessment questions for mathematics class X in the 2023/2024 academic year.



ASESMEN SUMATIF TENGAH SEMESTER (ASTS) GENAP
TAHUN AJARAN 2023/2024

Mata Pelajaran : Matematika
Kelas : X
Hari, tanggal : Sabtu, 23 Maret 2024
Jam : 08.00 – 09.30 WIB

I. Pilihlah jawaban yang benar dari pertanyaan-pertanyaan berikut!

1. Perhatikan gambar berikut

Nilai dari cosec $\alpha = \cdots$.

A. 5/13
B. 13/5
C. 12/5
D. 13/12
E. 12/13

2. Perhatikan gambar berikut!

Jika cos $C = 7/25$, maka nilai dari tan $A = \cdots$.

A. 25/7
B. 24/7
C. 25/24
D. 7/24
E. 7/25

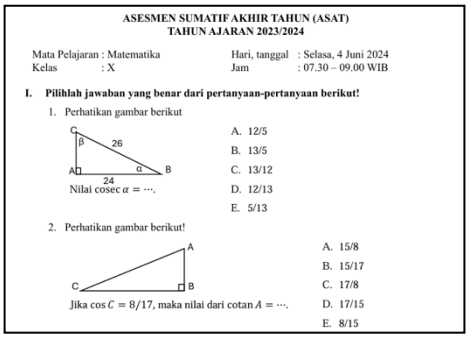
3. Perhatikan gambar berikut

Nilai cosec $\alpha = \cdots$.

A. 4/12
B. 5/15
C. 3/5
D. 4/3
E. 5/4

Figure 1 . Midterm Summative Assessment

Figure 1 shows the trigonometric comparison questions used by teachers in the midterm summative assessment. In the figure, there are only three out of 20 questions in multiple choice format on the trigonometric comparison material presented. Based on observations of the summative assessment given, the assessment only focuses on measuring students' basic conceptual abilities. The cognitive level presented in the question is only at the level of basic knowledge (C1) and understanding (C2). To answer the question, students only need to remember and understand the formula for trigonometric comparison in right triangles to find the answer. Cognitive development is a crucial aspect that needs nurturing (Nasution et al., 2024; Winarti et al., 2024).



ASESMEN SUMATIF AKHIR TAHUN (ASAT)
TAHUN AJARAN 2023/2024

Mata Pelajaran : Matematika
Kelas : X
Hari, tanggal : Selasa, 4 Juni 2024
Jam : 07.30 – 09.00 WIB

I. Pilihlah jawaban yang benar dari pertanyaan-pertanyaan berikut!

1. Perhatikan gambar berikut

Nilai $\operatorname{cosec} \alpha = \cdots$.

A. 12/5
B. 13/5
C. 13/12
D. 12/13
E. 5/13

2. Perhatikan gambar berikut!

Jika $\cos C = 8/17$, maka nilai dari $\operatorname{cotan} A = \cdots$.

A. 15/8
B. 15/17
C. 17/8
D. 17/15
E. 8/15

Figure 2 . End of Year Summative Assessment

The same thing is also shown in Figure 2. There are 20 multiple choice questions presented. However, two of them have not linked the basic concepts of trigonometric comparison to everyday life. The questions used in the summative assessment do not contain numeracy literacy elements. From the assessment questions presented, it can be seen that the numeracy literacy acculturation efforts made by teachers to improve students' numeracy literacy skills in learning are still not visible. This can result in students' critical thinking skills experiencing difficulties. Learning at theseschools faces challenges in improving learning outcomes and students' critical thinking skills (Ajid et al., 2025). Critical thinking skills are essential for students to develop their ability to explore problems, questions, or situations, find a solution, and justify their positions (Rusiana et al., 2024; Adhantoro et al., 2024).

b. Implementation of Numeracy Literacy Culture

After an initial analysis of literacy acculturation carried out at school. Researchers compiled numeracy literacy acculturation implementation activities with numeracy literacy-oriented assessment sheets on trigonometric comparison material. Before the implementation of the product was carried out at the first meeting of learning, the researcher gave two numeracy literacy questions as a pre-test and gave a critical thinking disposition questionnaire. The pre-test was given to determine the initial ability of students' numeracy literacy. Meanwhile, giving a questionnaire is done to find out the initial disposition of students before being given treatment.

During the administration of the pre-test questions, some students complained about the numeracy literacy questions they had to do. They stated that their teachers had never given trigonometric comparison problems in the form of story problems. The students' statements strengthened the indication that there was no numeracy literacy culture carried out by the teacher in learning.

The next meeting, the researcher gave a re-explanation of the trigonometric comparison material using the assessment sheet that had been developed. During learning, researchers facilitated students with guided practice through controlled exercises on the assessment sheet. The controlled exercises provided contained sample problems equipped with steps for solving trigonometric comparison problems. At the end of the meeting, students were directed to do a competency test on the assessment sheet to measure the improvement that had been achieved in product implementation.

In the last meeting, the research activities carried out were only giving the same numeracy literacy questions as the questions given during the pre-test and critical thinking disposition questionnaire. Giving the same questions and questionnaires aims to see if there is an increase in students' understanding and abilities after being given the treatment of implementing numeracy literacy culture using the assessment sheet that has been developed. All student scores obtained during learning activities are presented in the following table:

Table 2 . Student Learning Outcomes

Activities	Average Value
Pre-Test	57.67
Competency Test	63.13
Post-Test	77.67

Table 2 shows the students' learning outcomes during the research activities. It can be seen that students' learning outcomes increased gradually during the research activities carried out with the implementation of numeracy literacy-oriented assessment sheets. The assessment sheet facilitated with a brief explanation of the material, controlled exercises, and independent exercises by analysing a problem. In the controlled exercises, there are problem-solving steps that can facilitate students in learning. However, during the pre-test and post-test activities, there was one problem that students complained about as shown in Figure 3.

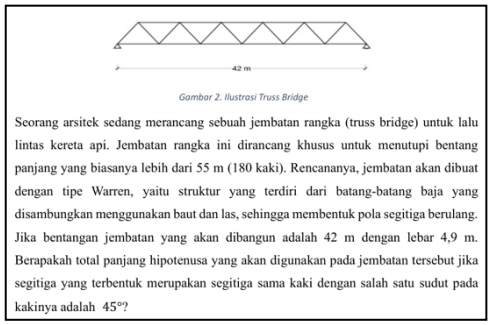


Figure 3 . Numeracy Literacy Problem

The problem is a numeracy literacy problem that contains information on the application of trigonometric comparisons in a bridge design. students said that the problem was a relatively new problem for them. The question given was also not included in the assessment sheet used during the lesson.

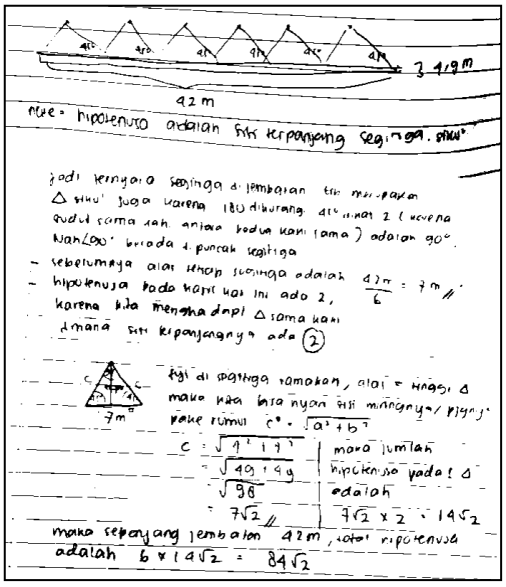


Figure 4 . Student Pre-Test Results

Figure 4 is one student's pre-test answer with an explanation. It can be seen that the student can identify what important information is contained in the problem. The student can also represent the information in a picture illustration that can support understanding to support problem solving. However, in solving the problem some students still use *phytagoras* material as in the picture. This shows that the modelling and mathematical communication aspects of the students' answers have not been fully met, although the solution steps are presented quite logically.

Student completion can be supported by the condition of students' critical thinking disposition at the beginning of the meeting. The results of critical thinking disposition obtained are presented in Table 3 below as follows:

Table 3 . Critical Thinking Disposition Results (Pre-Test)

Scale	Average
Truth - seeking	2.757
Open Mindedness	2.848
Analyticity	2.685
Systematicity	2.685
Critical Thinking selfconfidence	2.665

Scale	Average
Inquisitiveness	2.630
Cognitive Maturity	2.464
Average	2.693

In Table 3, it can be seen that the average obtained from the critical thinking disposition ability of 15 students in class XI-4 shows moderate results. This means that of the seven components assessed in the critical thinking disposition questionnaire, all of them show that students' enthusiasm in learning mathematics still needs to be improved.

The truth-seeking component is one of the important components in critical thinking disposition that can be used to support the development of numeracy literacy skills. In this component, a person will tend to look for evidence before accepting information. Table 3 reflects that students' eagerness to seek information from new knowledge in a particular context shows a moderate level. Providing numeracy literacy-oriented problem exercises in learning can help students in developing their enthusiasm in learning.

Furthermore, the Open-mindedness component which shows the highest mean score among others indicates an open-mindedness so that students are able to accept input on different views. This component can support students' collaborative attitude which is needed to support the development of numeracy literacy skills.

In the Analyticity component, the score shows a medium category. This component is an important component in learning mathematics where this component can be used to show one's ability to use logical reasoning in solving a problem. In the figure, it can be seen that students' analytical skills can be seen that students' analytical skills are still moderate. The ability to analyse can be information that by providing problem exercises with a critical thinking level can develop students' analytical skills.

The Systematicity component used in the questionnaire is a component used to measure students' systematic ability to organise, focus, and be thorough in the tasks they do. The moderate category obtained shows that students' focus and thoroughness in solving problems are still not optimal. This can be seen in the student's work in Figure 3 where the lack of focus and thoroughness on the student causes the student to use different concepts in solving the problem.

In the Critical-Thinking Self Confidence component, which shows a moderate category, it shows that students' ability to make decisions based on their critical thinking is still not optimal. This shows that students still lack confidence in solving problems that require higher order thinking skills. This low self-confidence is likely due to the lack of acculturation of students in solving higher order thinking problems during the learning process.

The Inquisitiveness component in the critical thinking disposition component is a component that can be used to measure students' curiosity in learning new things. In the table, the average score obtained shows that the students' curiosity is still moderate. This may be due to the presentation of the assessment used by the teacher so far is less interesting and students' limitations in understanding the application of the concept of trigonometric comparison in everyday life.

Based on the seven components in critical thinking disposition, only the cognitive maturity component shows a low category. this component is a component that can be used to measure the level of maturity of students in making the right decisions along with the time provided. This means that students are not yet fully capable of making decisions to solve a problem. Problem solving

ability is referred to mathematical power or mathematical skills (doing maths). Problem-solving is the process used in solving problems (Darmawan & Suparman, 2019). So mathematics can be categorised into low-level thinking and high-level thinking (Nurmeidina et al., 2025).

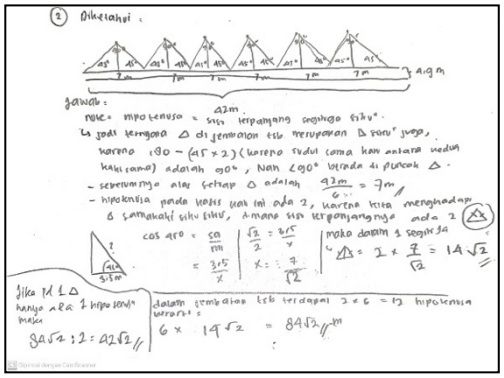


Figure 5 . Student Post-Test Results

Figure 5 shows different results after students were treated using the numeracy literacy assessment sheet. The difference is in the use of the basic concepts of trigonometric comparison in problem solving. However, in the Mathematical Communication indicator, it is clear that students' steps in preparing problem solving steps are still random and there is inaccuracy in problem solving. This is shown in the student's error in multiplying the number of hypotenuses by 6, even though the hypotenuse on the bridge is 12.

In the post-test results, although there are still students who have not fulfilled all numeracy literacy indicators. However, Table 2 shows that the average obtained increased. This is also evident in the average critical thinking disposition of students after being given the treatment contained in the following table:

Table 4 . Critical Thinking Disposition Results (Post-Test)

Scale	Average
Truth - seeking	3.506
Open Mindedness	3.686
Analyticity	3.559
Systematicity	3.574
Critical Thinking selfconfidence	3.387
Inquisitiveness	3.426
Cognitive Maturity	3.314
Average	3.507

Table 4 shows the mean of all scales on critical thinking disposition. The results obtained show an increase from the previous data. The category of students' critical thinking disposition that was previously moderate became high. This increase can be a positive indicator that the acculturation of numeracy literacy using can improve students' critical thinking disposition. Even though the Systematicity component in one of the students in Figure 5 shown is still not optimal.

Based on the results of the research that has been presented, the acculturation of numeracy literacy that exists at SMA Muhammadiyah Special Program Kottabarat has not been carried out by mathematics teachers. When observing the summative assessments used by teachers, the questions used, especially in trigonometric comparison material, have not implemented story problems or questions with higher-level thinking. The reality in the field is that subject teachers are also accustomed to developing mathematical literacy-oriented problems. The same thing is also found with research (Apriatni et al., 2022; Jannati & Sumardi, 2023; Santoso et al., 2023) where teachers are still not accustomed to developing literacy-oriented questions so they use questions in printed books or questions available in the previous year.

The form of questions used by teachers in assessments tends to be in multiple choice format. This causes limited information about the level of student understanding of

trigonometric comparison material. In line with the opinion of (Mania et al., 2020) multiple choice is a form of question that is often used by teachers because of its ease in the assessment process. However, this form of question has its own weaknesses where the answers obtained are not supported by the process of obtaining answers. Thus, the teacher will have difficulty in analysing the extent of students' concept understanding because the answers presented do not describe students' abilities as a whole.

In the research conducted, researchers provided numeracy literacy-oriented problem exercises to support the acculturation of numeracy literacy in learning. The numeracy literacy questions given are contextual questions that can support the development of critical thinking skills. Agree with (Kolar & Hodnik, 2021) that giving contextual problems related to everyday life can help mathematical literacy skills. Acculturation is also done by facilitating students with controlled exercises before students practice working on problems independently. controlled exercises on the assessment sheet help students think systematically in understanding the process to solve literacy problems (Sutama, et al., 2022). Thus, after being given treatment and retested, student learning outcomes and students' critical thinking disposition improved. This is because the habituation of students to do numeracy literacy exercises in learning can help students develop their critical thinking skills (Elvina & Setyaningsih, 2023). Continuous practice can also meet the needs of students facing difficulties in solving literacy and numeracy problems (Singh et al., 2023).

What distinguishes this study from other studies is the presence of critical thinking dispositions that can be seen when students are given numeracy literacy questions.

Disposition as the way students view learning will affect their learning outcomes, if they have a high disposition towards learning (Kamid et al., 2021). In high school students who were used as research respondents, their critical thinking disposition at the beginning of the study showed a medium category. After being given numeracy literacy questions, their critical thinking disposition increased to the high category. In secondary school students, the cognitive stage experienced by students has entered the formal operational stage (Ardiningtyas et al., 2023). At this stage, students are able to think abstractly. However, to be able to understand abstract material in mathematics, especially those that support the mastery of numeracy literacy skills, an appropriate learning method or media is needed (Meliana et al., 2025; Listiaji et al., 2025).

4. Conclusion

The acculturation of numeracy literacy that occurs in one of the schools in Surakarta is still not optimal. The questions presented by teachers as assessments are still at the level of basic understanding of the material. To support numeracy literacy acculturation, teachers can develop appropriate learning methods or media such as numeracy literacy-oriented assessment sheets. This is because continuous practice of numeracy literacy-oriented questions can train their critical thinking skills. This habit can be started from providing facilities for students through basic concept development, controlled practice, and independent practice.

The presentation of material related to everyday life can increase students' knowledge of the benefits of learning abstract mathematical material. Providing contextual problems can help improve students' perspectives on mathematics. This can be seen from the results of the critical thinking disposition questionnaire which increased after numeracy literacy habituation. The information in the literacy questions can

increase students' curiosity in the application of abstract mathematics material. This new knowledge can increase students' *open-mindedness*. The facility of controlled practice before independent practice makes students practice *Analyticity* and *Systematicity*. Providing numeracy literacy exercises can also increase *Critical-Thinking Self Confidence* and *Cognitive Maturity* due to habituation.

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