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Optimization of Mathematical Literacy through the Development of Information Literacy-Based Inquiry Learning in Secondary Education

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ABSTRACT

The low level of students' mathematical literacy in Indonesia, as indicated by the results of the Minimum Competency Assessment and various previous studies, highlights the need to improve the instructional models used in schools. This study examines the validity, practicality, and effectiveness of developing Information Literacy-Based Inquiry Learning. The development model used in this study is adapted from Plomp which consists of five phases: (1) the preliminary investigation phase, (2) the design phase, (3) the realization/construction phase, (4) the testing, evaluation, and revision phase, and (5) the implementation phase. The subjects in this study were 63 grade X high school students in Madiun district. Data collection techniques used in this study were validation sheets, response questionnaires, and students' mathematical literacy tests. The average score from the teaching module validation was 3.86, categorized as good, and all validators confirmed that the developed mathematical literacy test instrument was valid. In the trial, the average score from the student response questionnaire was 4.02, which was also in the good category. The average student's mathematical literacy score in this trial was 79.5. Therefore, it can be concluded that the development of the model is valid, practical, and effective.

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1. INTRODUCTION

Mathematical literacy refers to an individual's ability to formulate, apply, and interpret mathematics in various situations, including the ability to think mathematically and use facts, concepts, and procedures to describe and explain a phenomenon or event (Aningsih, 2018; Niss & Jablonka, 2020). Mathematical literacy also helps individuals recognize the role of mathematics in real life and as a foundation for decision-making processes needed by society. This highlights the importance of mathematical literacy for students, not only to master the material but also to apply reasoning, concepts, facts, and mathematical tools in solving real-life problems, and to require students to communicate and explain the problems they encounter using mathematical concepts (Cameron, Kim, Duncan, Becker, & McClelland, 2019; Fointuna, 2021; Vera D. Susanti, Sukestriyarno, Kharisudin, & Agoestanto, 2022).

Enhancing mathematical literacy aims to improve learning outcomes and the learning process in educational institutions across Indonesia. One of the efforts involves using the Minimum Competency Assessment (MCA) to measure and evaluate the quality of education. This assessment focuses on evaluating students' basic competencies in reading and numeracy (Dwi Lestari, Wijayanti, Susilawati, & Insan Budi Utomo, 2023).

The 2022 Programme for International Student Assessment (PISA) revealed that only 36% of Indonesian students reached at least Level 2 in mathematical literacy, indicating a basic ability to apply simple mathematical concepts in real-life contexts (OECD, 2023). Furthermore, data from the 2023 Education Report released by the Indonesian Ministry of Education showed that 34.57% of senior high school students demonstrated low proficiency in reading literacy (Ilham Pratama Putra, 2023). These findings highlight that literacy among secondary-level students in Indonesia remains a significant challenge that must be urgently addressed.

A study by Setianingsih, Ekayanti, & Jumadi (2022) found that out of 15 students who took the MCA test, 11 demonstrated low numeracy skills. Previous research has also shown that Indonesian students across educational levels still tend to score low in mathematical literacy (Astuti, Fahinu, & Masuha, 2019; Setiani, Waluya, & Wardono, 2018; Wijayanti, Waluya, & Masrukan, 2018). Pakpahan (2017) also emphasized that students' mathematical literacy at the secondary education level remains low, despite the adaptation of the international test design to the Indonesian context. Based on the results of the Minimum Competency Assessment (MCA) measurement for mathematical literacy, as reported on https://pusmendik.kemdikbud.go.id/an/simulasi_akm, it shows that the mathematical literacy scores of students at the researcher's school are still below 60%.

Poor mathematical literacy contributes to several challenges in learning mathematics, such as (1) misinterpreting mathematical problems, which leads to difficulty in planning and solving problems effectively (Maslihah, Waluya, Rochmad, & Suyitno, 2020), and (2) lack of students' critical thinking skills when dealing with real-world issues (Maslihah et al., 2020; Rizki & Priatna, 2019; Sukestiyarno, Cahyono, & Pradnya, 2019). Inappropriate instructional models used in classrooms are also identified as contributing factors to students' low mathematical literacy (Sulfayanti, 2023).

One approach that can address low literacy levels is information literacy, which equips students with the ability to define problems, search for and evaluate information, and use it to solve problems logically and responsibly (Duke, Purcell-Gates, Hall, & Tower, 2006). Information literacy not only strengthens academic skills but also fosters independent learning and critical thinking, which are essential foundations for facing the challenges of 21st-century education.

On the other hand, Inquiry-Based Learning (IBL) is a learning approach that emphasizes active student involvement in constructing knowledge through investigation and problem-solving, where students build conceptual understanding by exploring and discovering new cause-and-effect relationships, including formulating hypotheses and testing them through experiments or observation. (Pedaste, Mäeots, Leijen, & Sarapuu, 2012; Pedaste et al., 2015). Wang et al. (2022) stated that IBL enhances students' understanding, reasoning, confidence, and collaboration, while Kang (2022) emphasized that its success relies on strong teacher-student interaction and constructive feedback. Therefore, it is necessary to integrate Inquiry-Based Learning (IBL) with Information Literacy (IL) to address these challenges. Information literacy can serve as a foundational step for students to understand and manage information before engaging in the inquiry stages that require in-depth analysis and synthesis of information.

The concept of information literacy, according to Banik & Kumar (2019), is the ability to recognize the need for information, as well as to locate, evaluate, and effectively use that information in the context of problem-solving. This process involves six steps: defining the task, designing an information search strategy, identifying access and information locations, using the information, synthesizing the information, and evaluating the results (Shamila et al., 2023). This ability is highly relevant to be applied in inquiry-based learning processes, as it supports students' foundational skills in navigating complex information.

Based on the above explanation, this study develops a learning model that combines the syntax of Inquiry-Based Learning (IBL) with the steps of information literacy (IL) into a new model called ILBIL (Information Literacy-Based Inquiry Learning). The ILBIL model retains the five main phases of IBL—orientation, conceptualization, investigation, discussion, and conclusion. However, the orientation phase is specifically enhanced by integrating information literacy components, so that students gain initial skills in accessing, evaluating, and using information before proceeding to scientific inquiry and problem-solving. This integration is expected to overcome the limitations of IBL and strengthen students' mathematical literacy through a more systematic and in-depth approach.

2. METHOD

This study is development research. The development model used in this study is adapted from Plomp, (1997), which consists of five phases: (1) the preliminary investigation phase, (2) the design phase, (3) the realization/construction phase, (4) the testing, evaluation, and revision phase, and (5) the implementation phase. This study involved high school students in Madiun Regency who were learning mathematics using the Independent Curriculum (Kurikulum Merdeka). The subjects of this study were 10th-grade students from SMAN 1 Geger and SMA Basyariah Madiun, with a total of 63 students. The data collection techniques used by the researcher in this study were observation, interviews, questionnaires, and mathematical literacy tests.

The data analysis in this study consists of two types: qualitative and quantitative data. Qualitative data were obtained through observations, questionnaires, and interviews regarding the activities of teachers and students during the learning process using the learning model, while quantitative data were obtained through the analysis of students' work on the final learning test. The validity analysis is based on the achievement of scores and criteria met by the product and the development instruments. The product is considered valid if it meets the minimum valid score in this study. This research on the development of the ILBIL involved 3 experts as validators. The following formula is used to determine the average validation score.

$$V = \frac{V_1 + V_2 + V_2}{3}$$

Table 1. Validity Criteria

No	Score range	Description
1	85,01% - 100,00%	Very Valid, or can be used without revision
2	70,01% - 85,00%	Sufficiently Valid, or can be used but needs minor revision
3	50,01% - 70,00%	Less Valid, it is recommended not to use it because it needs major revision
4	01,00% - 50,00%	Invalid, or may not be used

The Information Literacy-Based Inquiry Learning is declared valid if the combined validity results show more than 70% results (Vera Dewi Susanti, Suprapto, & Wardani, 2022).

In the practicality analysis, the data used to evaluate the practicality of the learning model were gathered through a student response questionnaire regarding the implementation of the model that had been tested. The questionnaire was distributed after the students participated in the learning session. To calculate practicality, the following formula is used:

$$\text{Average score} = \frac{\text{Total score obtained}}{\text{Number of respondents} \times \text{Number of statements}}$$

The model's practicality category was determined by matching the average total score with the following criteria:

Table 2. Practicality Category

No	Score range	Description
1	4.5 ≤ score ≤ 5	Very good
2	3.5 ≤ score < 4.5	Fairly good
3	2.5 ≤ score < 3.5	Not good
4	1.5 ≤ score < 2.5	Poor

Mathematical literacy, as defined by OECD (2019), consists of seven indicators: (a) communication, (b) mathematizing, (c) representation, (d) reasoning and argument, (e) devising strategies for solving problems, (f) using symbols, formal and technical language, and operations, and (g) using mathematical tools. In the effectiveness analysis, the level of learning success was determined based on the percentage of correct responses on the mathematical literacy test, which consisted of 5 questions and was analyzed using SPSS. The learning model is considered to meet the practicality criteria if 70% or more of the students provide a positive response. (Saputro, 2011).

3. FINDINGS AND DISCUSSION

The results of this study are based on the stages of the development model adapted from Plomp (1997), which consists of five phases: (1) the preliminary investigation phase, (2) the design phase, (3) the realization/construction phase, (4) the testing, evaluation, and revision phase, and (5) the implementation phase. The results obtained from each phase are presented as follows:

3.1 Investigation Phase

The initial investigation was conducted through direct observation at the school and interviews with subject teachers. It was found that the school implements the Merdeka Curriculum for Grade X and the 2013 Curriculum for Grades XI and XII. Most of the instructional materials used are still based on references provided by the Ministry of Education. Results from the Minimum Competency Assessment (AKM) revealed that students' numeracy skills remain low, consistent with national findings indicating that mathematical literacy among Indonesian students is still inadequate. At the research site, students' mathematical literacy levels were also found to be below 60%. In addition, teachers have not yet developed learning tools specifically aimed at enhancing mathematical literacy. The teaching process remains teacher-centered, utilizing PowerPoint presentations and commercially published textbooks.

In response to this situation, the study developed the ILBIL model (Information Literacy-Based Inquiry Learning), an adaptation of the Inquiry-Based Learning (IBL) model designed to enhance students' mathematical literacy. The development of the model focused particularly on the orientation phase by integrating components of information literacy, aiming to equip students with the skills to access, evaluate, and use information effectively as a foundation for scientific thinking and mathematical problem-solving.

3.2 Fase Desain

In this phase, the researcher begins to design the ILBIL (Information Literacy-Based Inquiry Learning) model both conceptually and operationally. The design process takes into account the core syntax of Inquiry-Based Learning (IBL), which includes orientation, conceptualization, investigation, discussion, and conclusion. The ILBIL model retains these five main phases as the primary framework of inquiry-based instruction. However, the orientation phase is specifically enhanced by integrating components of information literacy, allowing students to develop initial skills in accessing, evaluating, and using information effectively before moving on to the stages of scientific inquiry and problem-solving.

The integration of information literacy in the orientation phase includes steps such as defining tasks, designing search strategies, and identifying sources and access points for information. This enhancement is intended to address some of the limitations of conventional IBL, particularly in terms of students' readiness to think critically, synthesize information, and construct evidence-based arguments. Overall, the ILBIL model is designed to strengthen mathematical literacy through a more systematic, in-depth, and 21st-century-relevant learning approach. The integration of syntax in the ILBIL model can be illustrated as follows:

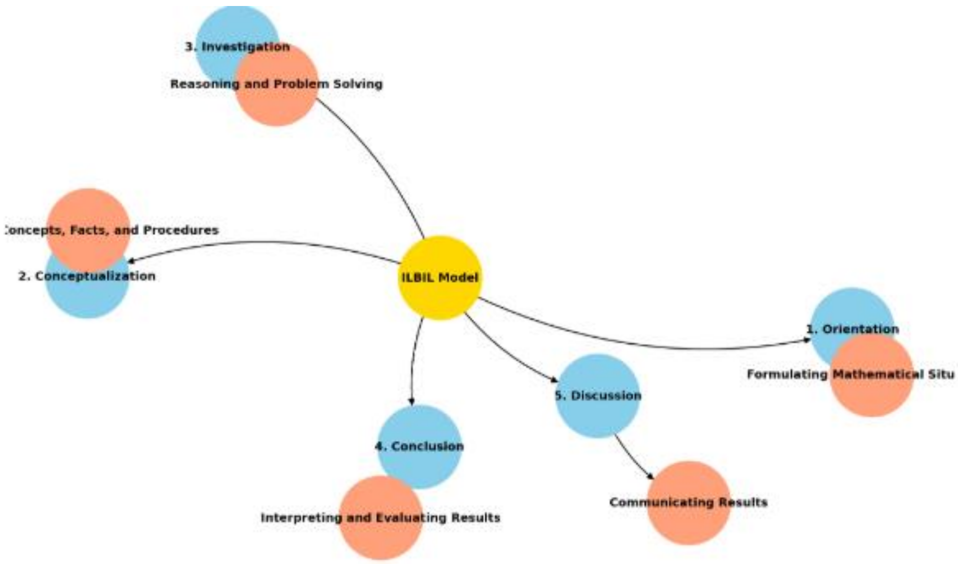

Figure 2 Integration of Inquiry-Based Learning, information literacy model, and mathematical literacy

The design of the Inquiry Learning Based on Information Literacy (ILBIL) model was also developed by considering aspects of book design that are by academic standards and have been registered with an ISBN. The description of the book can be seen as follows.

Figure 1 ILBIL Model Book Design

3.3 Realization/Construction Phase

The realization phase results in the development of the ILBIL learning model syntax, which consists of five stages: orientation, conceptualization, investigation, conclusion, and discussion. The syntax outlined in the design stage is as follows.

Introduction

1. The teacher prepares the classroom environment to ensure students are ready for learning.
2. The teacher conducts an apperception activity.
3. The teacher communicates the learning objectives and explains the activities to be carried out during the lesson.

Orientation

1. The teacher provides students with appropriate and relevant problems related to the topic.
2. The teacher organizes students into heterogeneous groups.
3. The teacher gives students the opportunity to clarify the problems, gather information, and engage in discussions to plan and manage complex tasks (*task definition*).
4. The teacher facilitates students in identifying relevant information sources, whether from the internet, books, or other resources (*information seeking strategies*).
5. The teacher guides students to access the selected sources, read or watch the content, and select the most useful information to solve the problem (*use information*).
6. The teacher facilitates students in organizing the gathered information, taking notes on key points, and summarizing their findings (*information synthesis*).

Conceptualization

The teacher facilitates students in identifying and organizing the information they have obtained and in formulating a plan or strategy to solve the problem.

Investigation

1. The teacher facilitates group discussions as students work to solve the problem.
2. The teacher assists students/groups in overcoming difficulties in implementing problem-solving strategies.

Discussion

1. The teacher gives students/groups the opportunity to present the results of their discussions.
2. The teacher allows students/groups to respond or ask questions about the presentations given by other groups.

Conclusion

The teacher guides students/groups to evaluate and draw conclusions based on the answers they have developed.

Closure

1. The teacher directs students to summarize the key concepts from the lesson.
2. The teacher reinforces understanding through Q&A or feedback.
3. The teacher motivates students to stay enthusiastic about learning.
4. The teacher assigns follow-up tasks for deeper understanding.
5. The teacher conducts reflection with students and self-reflection on the lesson implementation.

After formulating the syntax, the next step is to define the social system, reaction principles, support system, and instructional and nurturing effects to support the ILBIL model syntax (Joyce, Weil, & Calhoun, 2011). The realization activities include the development of all these components, as presented in the following table.

Table 3. Components of the ILBIL Model Development

Component	Description
Syntax	The stages in the ILBIL model begin with orientation, conceptualization, investigation, discussion, and conclusion. In the orientation stage, the integration of information literacy components helps enhance mathematical literacy, enabling students to be equipped with skills to effectively access, evaluate, and use information as a foundation for scientific thinking and solving mathematical problems.
Social System	Emphasizes collaboration among students in diverse groups and between students and teachers as facilitators. Students work together to identify problems, seek information, and develop evidence-based solutions. Teachers guide them in formulating questions, understanding concepts, and evaluating results. Discussion and reflection are key components.
Reaction Principle	Teachers do not provide direct answers but encourage students to explore information sources, propose hypotheses, and test their ideas. They offer constructive feedback that fosters critical thinking, encourages consideration of different perspectives, and helps students build logical, evidence-based arguments. This approach promotes independent learning, analytical thinking, and problem-solving skills.
Support System	Consists of resources such as books, journals, online articles, and expert interviews. Learning tools include digital documents, mind maps, educational apps, as well as communication tools like online forums and interactive presentations. This system supports inquiry-based learning and deepens students' understanding of concepts.
Instructional effects and nurturing effects	The ILBIL model impacts the enhancement of students' mathematical literacy by integrating critical thinking and problem-solving processes through inquiry-based steps. The orientation phase helps students access and organize information, preparing them to tackle complex mathematical problems. During the conceptualization, investigation, and discussion phases, students become more skilled at connecting mathematical concepts and formulating evidence-based arguments. The conclusion phase ensures deep understanding by reconstructing the mathematical knowledge that has been learned.

3.4 *Testing, Evaluation, and Revision Phase*

In this phase, the focus is on the validation and field testing of Prototype I, which includes the ILBIL learning model and its instructional tools. The specific activities carried out in this phase are as follows.

Table 4 Validation Results of the ILBIL Model

No	Statement	Validator Value			Total	Average
		I	II	III		
A	Assessment of the Rationalization Aspect of the Development of the ILBIL Model					
	Rationalization of the development of the ILBIL model	4	3	3	10	3,33
B	Assessment of Aspects of the Theoretical Basis for the Development of the ILBIL Model					
	Theoretical basis of mathematical literacy	4	3	4	11	3,67
	Theoretical basis for developing the ILBIL model	3	3	3	9	3
C	Assessment of Aspects of the Development Phase of the ILBIL Model					

	ILBIL model development phase	4	4	3	10	3,33
	Activities in each phase of developing the ILBIL model	4	4	4	12	4
	Validity of the ILBIL model	4	4	4	12	4
D	Assessment of Syntax Aspects of the ILBIL Model					
	Phases of activities in the syntax of the ILBIL model	4	4	3	11	3,67
	Implementation of the syntax of the ILBIL model in the classroom	4	4	4	12	4
E	Assessment of Social System Aspects of the ILBIL Model					
	Social system of ILBIL model	5	4	4	13	4,33
	Implementation of the social system of the ILBIL model in the classroom	4	4	5	13	4,33
F	Assessment of the Reaction Principle Aspect of the ILBIL Model					
	ILBIL model reaction principle	4	4	4	12	4
	Implementation of the reaction principle of the ILBIL model in the classroom	4	5	4	13	4,33
G	Assessment of Support System Aspects of the ILBIL Model					
	ILBIL model support system	4	4	3	11	3,63
	Implementation of the ILBIL model support system in the classroom	4	4	4	12	4
H	Instructional Impact and Accompanying Impact of Learning Models					
	Instructional impact and accompanying impact of the ILBIL model	4	4	4	12	4
	Achievement of instructional impact and accompanying impact of the ILBIL model in the classroom	4	4	4	12	4
I	ILBIL Model Assessment					
	ILBIL model Assessment	4	4	4	12	4
J	Completeness of ILBIL Model Implementation					
	Completeness of teaching modules with the ILBIL model	4	4	4	12	4
	Completeness of teaching material development with the ILBIL model	4	4	3	11	3,67
	Completeness of assessment using the ILBIL model	4	4	4	12	4
Total					232	77,29
Average						3.86

The assessment results from three expert validators showed that the average score for the ILBIL model was 3.86, which falls within the range of 3.5 < score ≤ 4.5 and is categorized as "good." All three expert validators stated that the ILBIL learning model developed is good and can be used with minor revisions. Student response assessment in the ILBIL learning model was conducted by all students after the completion of the learning process using a student response sheet. The results of the student response questionnaire in the trial are summarized in the following table.

Table 5 Student Response Results

No	Statement	Number of Evaluators					JM	RT
		1	2	3	4	5		
A	Response to ILBIL model learning activities							
	Preliminary Activities							
1	Condition yourself to be ready to follow the learning			14	22	27	265	4.21
2	Asking questions related to prerequisite knowledge			20	34	9	241	3.83
3	Conveying learning objectives and activities to be carried out				35	28	280	4.44
	Core activities							
1	Providing problems/questions				50	13	265	4.21
2	Forming heterogeneous groups				56	7	259	4.11
3	Searching for relevant information from the internet, books or other sources (information seeking strategies)			17	42	4	239	3.79
4	Summarize material from teaching materials/learning videos by identifying information (use of information and synthesis)			8	45	10	254	4.03
5	Identifying and organizing the information obtained and making plans or strategies to solve problems (conceptualization)			23	28	12	241	3.83
6	Group discussion in solving problems by directing students to reason			12	35	16	256	4.06
7	Implementing problem solving strategies			16	40	7	243	3.86
8	Evaluation of answer results			22	32	9	239	3.79
9	Making Conclusions				57	6	258	4.10
10	Group presentation			13	44	6	245	3.89
11	Students give their opinions to their friends/groups who are presenting			15	46	2	239	3.79
	Closing Activities							
1	Responding to feedback from teachers				48	15	267	4.24
2	Motivate students to be enthusiastic				45	18	270	4.29
3	In-depth material assignment				56	7	259	4,11
4	Reflection on learning activities					63	315	5
B	The importance of using ILBIL models to improve mathematical literacy							
1	Learning activities using the ILBIL model to improve mathematical literacy			15	46	2	239	3.79
C	Interest in implementing the ILBIL model							
1	Learning using the ILBIL model			14	46	3	241	3.83
2	I feel optimistic that if learning uses the ILBIL model, I will learn well.			28	33	2	226	3.59
3	Learning using the ILBIL model needs to be applied to other subjects			25	32	6	233	3.7
Average								4.02

The average score of the student response questionnaire was 4.02, which falls within the interval 3.40 < x ≤ 4.20, categorized as good. The mathematical literacy assessment was conducted after four learning sessions in one trial phase. The average score of students' mathematical literacy in the trial was 79.5, which is ≥ 70 and falls within the interval 70 ≤ score < 90, categorized as good academic achievement.

The application of the ILBIL model is said to be effective if more than 75% of students get a mathematical literacy score above the minimum completeness criteria, which is 70 (reaching the applied completion limit), and more than 75% of students experience an increase in mathematical literacy at least in the moderate category. A normality test was first carried out for the final mathematical literacy test data to test completeness. The normality test was carried out using SPSS. The results of the analysis can be seen in the following table

Table 6 Normality Test for the Final Mathematical Literacy Test

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	Df	Sig.
Pretest	.103	63	.091	.976	63	.265
Posttest	.093	63	.200*	.953	63	.018

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Based on the results of the normality test in Table 3 using the SPSS program, the significance value (sig.) for the Kolmogorov-Smirnov test is 0.200, which is greater than the 0.05 significance level. Therefore, H_0 is accepted, and it can be concluded that the data follows a normal distribution. The Kolmogorov-Smirnov test was used because the sample size in this study is large, and this test is suitable for assessing the fit of data to a normal distribution with larger sample sizes. Thus, the data meet the normality assumption and can be further analyzed using parametric statistical techniques. This means that the variable of students' mathematical literacy scores is normally distributed. The completion test is used to determine the achievement of individual and classical student completion. The individual completion test is used to determine whether the average student's mathematical literacy has reached more than 75 or not. The calculation is done using SPSS. The results of the analysis can be seen in Table 4.

Table 7 Analysis of Mathematical Literacy Completeness Test

	Test Value = 75					
					95% Confidence Interval of the Difference	
	T	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Pretest	-1.918	62	.060	-3.016	-6.16	.13
Postest	5.868	62	.001	8.095	5.34	10.85

From the calculation results in the pretest, sig. 0.060 was obtained, where sig. 0.060 > 0.05, then H_0 was accepted. This means the average mathematical literacy of students who received learning using the ILBIL model was < 75. While the calculation results in the posttest obtained sig. 0.001, where sig. 0.001 < 0.05, then H0 was rejected. This means the average mathematical literacy of students who received learning using the ILBIL model was > 75. This means that students, after being treated with learning with the ILBIL model, had an average mathematical literacy above the minimum completeness criteria.

3.5 Implementation Phase

At this stage, it is carried out with a subject-teacher deliberation meeting (called MGMP) workshop in Madiun. The implementation of the workshop and guidance for participants in preparing learning devices using the ILBIL model. In general, the implementation of the workshop can be seen in the following Figure.

Figure 3 Introduction to the ILBIL model

Figure *4* Assistance in preparing ILBIL model learning tools

Discussion

Information literacy refers to the ability to seek necessary information, organize library resources, become familiar with available sources, and possess knowledge in information retrieval (Juditha, 2019; Yusup & Saepudin, 2017). The objectives of information literacy include: (1) providing the skills to access and retrieve information; (2) supporting decision-making processes; and (3) fostering responsibility (Catts, R. & Lau, 2008). This type of literacy is essential before students attempt to solve problems. The theoretical review indicates that the stages of conceptualization and investigation require problem-based learning, while the discussion and conclusion stages require evaluation. Preliminary research also highlights the need for a learning approach that offers students the opportunity to express ideas, encounter real-world problems, utilize all their abilities to find solutions, prepare themselves in advance, review their work, and evaluate their outcomes.

Problem posing is also a part of problem solving that involves mathematical inquiry beyond basic problem-solving skills (Gonzales, 1988; Silver, E. A., & Cai, 2005). Researchers have pointed out that problem-solving and problem-posing skills are interrelated and support the development of mathematical thinking (Lowrie, 2002; Shriki, 2013). Other studies also emphasize that the inquiry learning method—a student-centered approach that allows learners to generate questions and construct knowledge—is widely used (Hammerman, 2006; Llewellyn, 2002).

Discovery learning emphasizes student engagement in identifying problems, understanding the characteristics of solutions, and applying chosen strategies (Borthick & Jones, 2000). This approach helps students develop a habit of problem-solving. As students become accustomed to solving problems, their problem-solving abilities are expected to improve. In producing discoveries, students must be able to connect their mathematical ideas. They are given the freedom to represent these ideas through visuals, graphs, symbols, or words that are simpler and easier for them to understand.

During the design phase, a framework for the ILBIL learning model was developed based on the theoretical review and preliminary studies conducted. This framework was further developed during the construction phase into Prototype 1, which included the model book, teaching modules, and test instruments. The prototype was then validated by experts, who declared the ILBIL model valid with a few suggestions for improvement. After refinement, it became Prototype 2, which was tested in schools to assess its practicality and effectiveness.

The effectiveness of a learning model depends on how the instructor manages the learning process. The initial trial showed that the ILBIL model was practical and effective. However, several aspects of Prototype 2 required improvement, leading to a revised version. In the second trial, the ILBIL learning model again proved to be practical and effective, with no further revisions needed. This resulted in the final prototype, ready for dissemination. The final version of the ILBIL learning model consists of five phases: orientation, conceptualization, investigation, conclusion, and discussion.

In the orientation phase, the teacher presents a problem for students to investigate and assigns them to heterogeneous groups. The initial inquiry questions are designed to challenge students' thinking. Before starting the investigation, the teacher helps clarify the problem, gather relevant information, and engage students in planning and managing the complex task (task definition). Students then seek relevant information from sources such as the internet, books, or experts, and determine which are most useful (information seeking strategies). They access, read, or watch content from these sources and select the most useful information (use information). Next, students organize the gathered information, take notes, and summarize their findings using tools like documents or spreadsheets (synthesis).

Before beginning the learning process, it is essential to assess students' readiness. Several studies have shown that learning readiness positively affects academic achievement (Mulyani, 2013). In mathematics education, Kearney & Garfield (2019) suggest that learning readiness contributes significantly to student performance.

In the ILBIL learning model, apperception is also used to check prerequisite knowledge before instruction. This is assessed through diagnostic tools. Researchers argue that mastery of prerequisite material in math education impacts learning outcomes (Nursalam, Anita, & Sri, 2014). Communicating the learning objectives is essential so students understand what they will learn and its benefits. Putri, Angelina, Claudia, & Mujazi, (2017) stated that learning goals influence students' performance and interest. Objectives also serve as a form of motivation from teacher to student. Hannula (2006) emphasized the importance of motivation in learning mathematics.

In the orientation phase, the teacher presents problems related to the concepts being studied to help students mentally prepare for the lesson. Students are expected to construct knowledge based on their prior understanding. This aligns with Blackburn (2015), who stated that presenting problems encourages students to apply theories, seek additional information, and develop critical and analytical thinking. The conceptualization phase of ILBIL guides students in identifying and organizing information from the problem and planning its solution. Understanding the problem involves identifying and recording key information. To guide problem-solving, the teacher provides questions that help students formulate strategies.

The investigation phase involves students solving mathematical problems through discovery learning. Based on the plans made in the conceptualization phase, students now implement those strategies in written form. After identifying the relevant concepts, students are encouraged to freely express their findings. The conclusion phase is when students summarize what they have learned. Teachers also provide motivational feedback to encourage persistence and self-confidence. This phase includes learning evaluation. According to Magdalena (2022), evaluation is a systematic process of collecting and interpreting information to assess goal achievement. Soeprianto, Sarjana, & Hapipi, (2018) added that evaluation is crucial in measuring the success of instructional implementation.

4. CONCLUSION

Based on the results of the study, it can be concluded that the ILBIL (Information Literacy-Based Inquiry Learning) model developed is feasible to be implemented in improving students' mathematical literacy in senior high schools. The validation results by three expert validators showed that the teaching module achieved an average score of 3.86, which falls into the "good" category, indicating that the model meets the criteria for validity. In terms of practicality, students' responses to the implementation of the model were also highly positive, with an average response score of 4.02, which is categorized as good. Regarding effectiveness, the average score of students' mathematical literacy tests after learning using the ILBIL model reached 79.5, which lies in the "good" achievement category ($70 \leq RHB < 90$). Furthermore, the developed model consists of five structured phases—orientation, conceptualization, investigation, conclusion, and discussion—each designed to encourage students to develop critical thinking skills, organize information, solve problems, and evaluate learning outcomes both independently and collaboratively. Therefore, the ILBIL learning model is declared valid, practical, and effective, and can serve as an alternative model to enhance mathematical literacy in senior high school education.

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