



Analysis of Students' Numeracy Literacy in Terms of Self-Efficacy through Problem-Based Learning (PBL) Supported by Flipbooks with an Ethnomathematics Approach

Anggun Filisia Acuna^{1*}, Zaenuri¹ 

¹Mathematics Education Study Program, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang

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ABSTRACT

Students' numeracy skills in Indonesia remain relatively low due to a lack of attention to the aspect of self-efficacy. In addition, there is a need for instructional models and media capable of improving numeracy skills. This study aims to analyze students' numeracy skills in terms of self-efficacy following the implementation of an ethnomathematics-based Problem-Based Learning (PBL) model aided by a flipbook. This study employed a mixed-methods approach with an explanatory sequential design, involving 32 eighth-grade students at SMP Negeri 13 Semarang during the 2025/2026 academic year. Instruction focused on the topic of function relationships, integrating the ethnomathematics of Semarang City. The research instrument consisted of a numeracy literacy test that met validity criteria (a significance value of $< 0,05$ for each item) and was deemed reliable based on a Cronbach's Alpha coefficient of 0,640. The data were analyzed using descriptive and inferential statistics through normality tests, individual achievement tests, class achievement tests, simple linear regression tests in the experimental class, and descriptive analysis based on self-efficacy categories. The results of the study indicate that there was an increase in numeracy literacy skills in the class taught using Problem-Based Learning with an ethnomathematics approach aided by a flipbook ($M_{pre} = 69,97$ to $M_{post} = 92,13$), and that self-efficacy had a positive and significant effect on numeracy literacy skills with a coefficient of determination (R^2) of 40,5%. We also found that students with high self-efficacy met all numeracy literacy indicators, whereas students with moderate and low self-efficacy met only some of the indicators. These findings indicate that the implementation of ethnomathematics infused Problem Based Learning supported by flipbooks effectively improves students' numeracy literacy skills, as evidenced by a higher N-Gain of 0,74 in the experimental class which falls into the high category compared to the control class's N-Gain of 0,59, which falls into the moderate category.



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Introduction

Numeracy literacy is one of the essential competencies that students need to possess in order to face the challenges of the 21st century (Ambarwati & Kurniasih, 2021). Numeracy is a skill that focuses not only on calculation but also on the application of mathematical concepts, procedures, facts, and tools to solve problems in various everyday situations (Sholeh & Supriadi, 2021). This skill plays a crucial role in helping students think logically, critically, and systematically when making decisions based on quantitative information. Therefore, improving numeracy skills has become a primary focus in mathematics education in schools. Nevertheless, various assessment results indicate that students' numeracy skills in Indonesia still need improvement. According to the 2022 Programme for International Student Assessment (PISA) results, Indonesian students' numeracy achievement remains below the average of OECD countries (Arrofit & Dwi, 2025). This situation indicates that students still struggle to formulate, apply, and interpret mathematical concepts to solve contextual problems (Winata et al., 2021). Low numeracy literacy skills are also evident in the school learning process, where students tend to be accustomed to solving routine problems and lack learning experiences that require higher-order thinking skills (Disi et al., 2025).

The results of preliminary observations, interviews with mathematics teachers, and a pretest at SMP Negeri 13 Semarang indicate that students' numeracy literacy skills regarding function relationships are still not optimal. Based on the results of the pretest administered to 32 students, the average score was 69,97, while 22 students (68,75%) had not yet met the learning objective achievement criterion (KKTP), which was set at 75. Observation results showed that students still struggled to interpret information presented in the form of tables, diagrams, or contextual problems, and were not yet accustomed to connecting mathematical concepts with real-life situations. Interviews with teachers also revealed that the learning process is still dominated by routine problem-solving, limiting students' opportunities to develop their reasoning skills and solve contextual problems. Furthermore, the use of digital learning media and local cultural contexts in mathematics instruction has not been optimized.

One factor that influences numeracy literacy is an affective factor, namely self-efficacy. Self-efficacy is defined as an individual's belief in their ability to perform the actions necessary to achieve a specific goal (Bandura, 1997). Students with high levels of self-efficacy tend to be more confident in tackling math problems, demonstrate persistence when encountering difficulties, and continue to try until they find an appropriate solution (Salsabilah & Kurniasih, 2022). Conversely, students with low levels of self-efficacy tend to give up easily and avoid tasks they consider difficult (Subaidi, 2016). Therefore, self-efficacy is viewed as one of the psychological factors related to numeracy literacy because it can influence self-confidence, perseverance, and strategies for solving mathematical problems (Hardiyanto, 2018).

Efforts to improve numeracy skills require a learning model that actively engages students in the problem-solving process. One model considered appropriate is Problem-Based Learning (PBL) (Yumnia & Maknun, 2024). The Problem-Based Learning model uses contextual problems as the starting point for learning, encouraging students to identify problems, seek information, analyze data, and find solutions—either independently or through group work (Knopfel et al., 2024). These characteristics align with numeracy literacy indicators that require the ability to formulate, apply, and interpret mathematics in various situations (Disi et al., 2025). However, the effectiveness of contextual problems in PBL heavily depends on how closely the context used relates to students' life experiences and environments. Therefore, an approach is needed that can provide an authentic learning context closely related to students' lives, such as through ethnomathematics.

To provide a more authentic context in Problem-Based Learning, the implementation of this model can be integrated with the ethnomathematics approach. Ethnomathematics is an approach that links mathematical concepts to culture and various activities that take place in the lives of local communities (Dominikus, 2021). Integrating local culture into mathematics learning allows students to understand concepts more contextually because the material they study is closely tied to their life experiences (Pratiwi & Pujiastuti, 2020). Ethnomathematics not only plays a role in enhancing students' understanding of mathematical concepts but also fosters an appreciation for local culture while strengthening cultural identity (Rohmatin, 2020). Thus, the integration of ethnomathematics can enrich contextual problems in problem-based learning through situations drawn from students' cultural environments. However, to ensure that these cultural contexts are presented in an engaging, systematic, and accessible manner during the problem-solving process, appropriate instructional media are required.

These needs can be met through the use of digital flipbooks as a learning medium. A flipbook is an interactive learning medium capable of integrating text, images, animations, videos, and exercises into a single digital platform (Widianto et al., 2021). The use of flipbooks allows students to have a more engaging and flexible learning experience, thereby increasing their motivation and engagement during the learning process (Bunari et al., 2024). Additionally, presenting cultural contexts through ethnomathematics-based flipbooks can help students connect mathematical concepts to real-world phenomena found in their surroundings (Arrofit & Dwi, 2025). Therefore, flipbooks can serve as a medium that bridges the application of PBL and ethnomathematics by providing culturally-based problems in a visual and interactive format. The integration of PBL, ethnomathematics, and flipbooks is further aimed at creating contextual learning experiences that support the development of students' numeracy literacy skills.

Improving numeracy skills requires instruction that develops problem-solving abilities, connects mathematical concepts to real life, and makes optimal use of educational technology. Therefore, the integration of the Problem-Based Learning (PBL) model, the ethnomathematics approach, and flipbook media is viewed as a unified and mutually complementary learning framework (Portuna et al., 2025). Problem Based Learning uses contextual problems as the starting point for learning, encouraging students to identify problems, gather information, analyze various solution alternatives, and communicate their findings (Amidi et al., 2025). These characteristics align with the goals of numeracy literacy, which emphasize the ability to formulate, apply, and interpret mathematical concepts in various real-life contexts (Sakdiyah, 2025). Various studies indicate that the implementation of Problem-Based Learning can enhance students' mathematical and numeracy literacy skills by providing them with opportunities to construct knowledge through meaningful problem-solving activities. An analysis of numeracy literacy skills based on self-efficacy categories is necessary because students' level of confidence in their abilities influences their choice of learning strategies, persistence, and responses when facing difficulties (Bandura, 1997). Analysis based on self-efficacy categories allows researchers to identify the characteristics of numeracy literacy skills in each group of students, thereby providing a more comprehensive picture of learning outcomes (Schunk & DiBenedetto, 2021).

The meaningfulness of learning increases when the problems used in PBL are linked to local culture through an ethnomathematics approach. Ethnomathematics utilizes local activities, artifacts, and wisdom as a learning context, thereby bringing mathematical concepts closer to students' experiences (Munthahana et al., 2023). In this study, the cultural context used was the culture of Semarang, such as Lawang Sewu, Tugu Muda, Kampung Batik Semarang, and Johar

Market, which were integrated into the teaching of function relations (Rusminati et al., 2025). These contexts are not merely used as illustrations but are embedded within learning problems and activities to help students identify relationships between two sets or objects found in these cultural settings. An illustration of the ethnomathematics used in the learning process is presented in Figure 1. The use of these cultural contexts is expected to help students understand the relationship between mathematical concepts and real-world phenomena while also fostering an appreciation for local culture (Resi et al., 2025). A number of studies indicate that the integration of ethnomathematics can strengthen numeracy literacy, improve conceptual understanding, and create more contextual and meaningful learning.

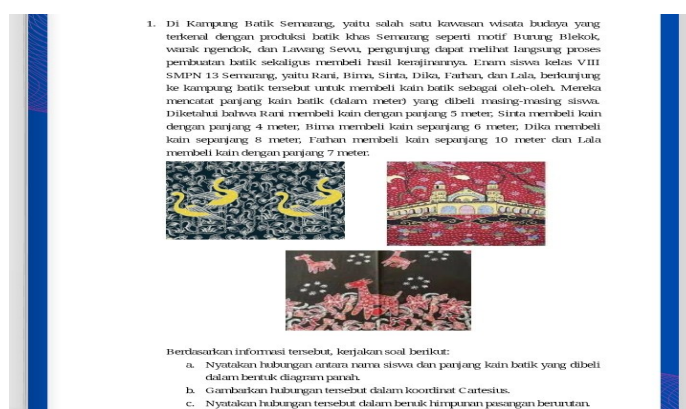


Figure 1. An example of how Semarang's traditional batik is incorporated into the "Relasi" concept

Several previous studies have shown that Problem-Based Learning has a positive effect on improving students' numeracy skills (Awami et al., 2022). Other studies have also shown that the ethnomathematics approach can improve students' understanding of mathematical concepts by presenting cultural contexts that are relevant to their daily lives (Disi et al., 2025). Additionally, the use of interactive digital media such as flipbooks has been shown to enhance motivation and learning outcomes in mathematics. On the other hand, a number of studies have revealed that self-efficacy has a positive relationship with problem-solving skills and mathematics achievement (Nugraha & Wardono, 2025). Nevertheless, research examining students' numeracy skills in terms of self-efficacy following the implementation of ethnomathematics-infused Problem-Based Learning supported by flipbooks remains relatively limited.

Based on the above discussion, there is still a limited body of research that integrates the Problem-Based Learning model, the ethnomathematics approach, and flipbooks as a unified learning framework for function relations, while also examining numeracy literacy skills based on self-efficacy categories. Therefore, this study was conducted to address this gap. This study aims to test the effectiveness of applying an ethnomathematics-infused Problem-Based Learning model supported by flipbooks on students' numeracy literacy skills in the topic of function relationships; to analyze the influence of self-efficacy on students' numeracy literacy skills in the experimental class; and to describe students' numeracy literacy skills based on self-efficacy categories after participating in the learning process.

Method

Settings

The research approach used in this study is mixed methods. The type of research used in this study is explanatory sequential. The explanatory sequential design was carried out in two main stages: the quantitative stage and the qualitative stage. This study was conducted at SMP Negeri 13 Semarang during the even semester of the 2025/2026 academic year, specifically from late April through late May 2026. The study population consisted of eighth-grade students during the even semester of the 2025/2026 academic year. Cluster random sampling was used to select the research sample. Cluster random sampling is a sampling technique in which the population is divided into several groups, and then one or more clusters are selected at random, so that all members of the selected clusters become the sample (Sugiyono, 2021). The selection process was conducted randomly by the supervising teacher to ensure the objectivity of the sample selection. The teacher wrote down the class codes (VIII F through VIII I), then selected them at random, resulting in the selection of two classes: Class VIII G as the control class and Class VIII I as the experimental class. The experimental class received instruction using Problem-Based Learning (PBL) supported by a flipbook with an ethnomathematics theme focused on the city of Semarang, while the control class used conventional instruction. The total number of students from the selected classes was 64 (32 students in each class), and all students in both classes were included in the research sample.

The pretest-posttest control group design was implemented using a pretest administered before the intervention and a posttest administered after the intervention during the learning activities. The structure of the pretest-posttest control group design, as described by (Sugiyono, 2021), is shown in Table 1 below.

Table 1. Control group design

<i>Sample</i>	<i>Pretest</i>	<i>Interpretation</i>	<i>Posttest</i>
E	O_1	X	O_2
K	O_3	C	O_4

Research Subject

The subjects of this qualitative study were selected using purposive sampling, a method of sample selection based on specific criteria (Sugiyono, 2021). The criterion used by the researcher was the students' level of self-efficacy. The subjects in this qualitative study consisted of 2 students with high levels of self-efficacy, 2 students with moderate levels of self-efficacy, and 2 students with low levels of self-efficacy. The classification of students' self-efficacy is presented in Table 2 below (Samsuddin & Retnawati, 2022).

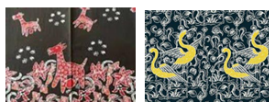
Table 2. Classification of Self-Efficacy

Interval ($\bar{x}$ = Mean, SD = Standar Deviation)	Category
$x > \bar{x} + SD$	High
$\bar{x} - SD < x \leq \bar{x} + SD$	Moderate
$x \leq \bar{x} - SD$	Low

Instruments

The research instruments consisted of a numeracy literacy test and a self-efficacy questionnaire. The numeracy literacy test was developed based on numeracy literacy indicators, which include the ability to formulate problems, apply mathematical concepts and procedures, interpret results, and evaluate solutions in the context of daily life. The test instruments were administered before instruction (pretest) and after instruction (posttest) to measure improvements in students' numeracy literacy skills. The self-efficacy questionnaire was used to measure students' level of confidence in their ability to complete math tasks based on the dimensions of magnitude, strength, and generality. The questionnaire used a five-point Likert scale, and the results were categorized as high, moderate, and low self-efficacy.

2. Menjelang kegiatan perpisahan kelas Ana, Adi, Viona dan Reza berencana membuat seragam sederhana dari kain batik bermotif khas pesisir, seperti motif warak ngendog yang menjadi ikon budaya Semarang yang dibeli langsung di Pasar Johar Semarang. Mereka memilih berbelanja di pasar tersebut karena harganya lebih terjangkau dan bisa membeli sesuai kebutuhan. Ana bersama teman-temannya mengunjungi salah satu pedagang kain. Pedagang tersebut menjelaskan bahwa harga kain tergantung pada panjang kain yang dibeli. Untuk memudahkan perhitungan, pedagang memberikan aturan harga dalam bentuk model matematika (dalam ribuan rupiah) dengan fungsi $f(x) = 6x - 4$. Karena setiap siswa memiliki kebutuhan yang berbeda, mereka mempertimbangkan beberapa pilihan panjang kain, yaitu 6 meter, 8 meter, 10 meter, dan 12 meter. Tentukan.



- Hitunglah harga kain untuk masing-masing panjang kain 6 meter, 8 meter, 10 meter, dan 12 meter.
- Sajikan hasil tersebut dalam bentuk tabel.
- Tentukan dan Jelaskan daerah hasil (range) dari fungsi tersebut berdasarkan data yang ada.

In preparation for their class farewell event, Ana, Adi, Viona, and Reza plan to make simple uniforms from batik fabric featuring distinctive coastal motifs, such as the *warak ngendog* motif, a cultural icon of Semarang. The fabric is sold at Johar Market in Semarang.

They choose to shop at this market because the prices are more affordable and they can purchase the amount of fabric they need. Ana and her friends visit a fabric vendor, who explains that the price depends on the length of fabric purchased. To simplify the calculations, the vendor provides a pricing rule expressed as a mathematical model, in thousands of rupiah $f(x) = 6x - 4$.

Since each student has different needs, they consider several fabric lengths: 6 meters, 8 meters, 10 meters, and 12 meters. Complete the following tasks:

- Calculate the price of the fabric for each length: 6 meters, 8 meters, 10 meters, and 12 meters.
- Present the results in a table.
- Determine and explain the range of the function based on the given data

Figure 2. Examples of Numeracy Literacy Assessment Instruments

The numeracy literacy test instrument consists of three open-ended questions designed based on three numeracy literacy indicators (see Figure 2). Each question is assessed using a scoring rubric with a range of 0–10, resulting in a maximum total score of 30, which is then converted to a scale of 0–100. The self-efficacy questionnaire consists of 24 questions using a five-point Likert scale. All instruments were validated by one mathematics education lecturer and two mathematics teachers. They were then pilot-tested on students outside the research sample. The results of the validity test were based on the hypothesis that if the significance value (*sig.*) is < 0.05 , then H_0 is rejected and the instrument is deemed valid, and vice versa.

Table 3. Validity Test for the Literacy Skills Test

		Correlations			
		task1	task2	task3	total
task1	Pearson Correlation	1	.418*	.599**	.614**
	Sig. (2-tailed)		.022	.000	.000
	N	30	30	30	30
task2	Pearson Correlation	.418*	1	.810**	.748**
	Sig. (2-tailed)	.022		.000	.000
	N	30	30	30	30
task3	Pearson Correlation	.599**	.810**	1	.885**
	Sig. (2-tailed)	.000	.000		.000
	N	30	30	30	30
total	Pearson Correlation	.614**	.748**	.885**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	30	30	30	30

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Based on the results in Table 3 under the “Correlations” section, the significance values for each item were $< 0,05$; thus, H_0 is rejected. Consequently, all items are deemed valid and suitable for use as a research data collection tool.

Table 4. Reliability Test for Numeracy Literacy Tests

Reliability Statistics	
Cronbach's Alpha	N of Items
.640	3

Based on the results in Table 4 under “Reliability Statistics,” the instrument’s reliability falls into the “fairly good” category, with a Cronbach’s alpha value of 0.640 for the numeracy literacy test.

Data Collection

Data collection was conducted in two stages: the first (quantitative) stage and the second (qualitative) stage. In the first (quantitative) stage, the study employed a true experimental design using a pretest–posttest control group design. The research subjects were divided into an experimental group and a control group. The experimental group received instruction using a Problem-Based Learning model supported by a digital flipbook incorporating the ethnomathematics of Semarang, while the control group received conventional instruction. The intervention in the experimental class was implemented over four sessions covering the topic of function relationships. The instruction applied the Problem-Based Learning model integrated with the ethnomathematics approach of Semarang, supported by a digital flipbook. The cultural contexts used included Lawang Sewu, Tugu Muda, Kampung Batik Semarang, and Pasar Johar as sources of contextual problems related to the concept of function relationships. The flipbook used contained learning objectives, content, illustrations of local culture, images, instructional videos, worksheets, numeracy-based practice problems, and assessments.

Phase Two (qualitative): A qualitative approach was used to analyze students’ mathematical literacy skills in relation to their self-efficacy. Students in the experimental group were given a questionnaire to assess their self-efficacy. The results will be categorized into three groups: high, moderate, and low mathematical literacy. From each category, two subjects

will be selected for interviews regarding their mathematical literacy. This will be followed by an analysis of the test results, questionnaires, and interviews on mathematical literacy in relation to students' self-efficacy. The following is an overview of the process (Figure 3).

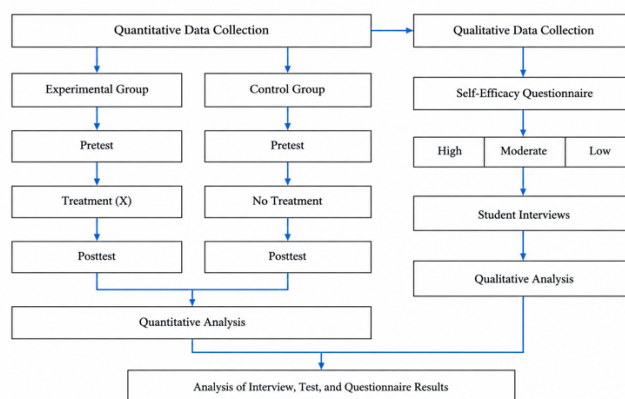


Figure 3. Research process

Quantitative and qualitative data were integrated during the results interpretation phase in accordance with the explanatory sequential design. The results of the quantitative analysis were used as the basis for determining the subjects of the qualitative study by grouping them into high, moderate, and low self-efficacy categories. Next, the results of the numeracy literacy tests, interviews, and student work samples were analyzed qualitatively to provide a more in-depth explanation of the quantitative findings regarding the relationship between self-efficacy and numeracy literacy skills. Thus, the qualitative data served to reinforce and provide an explanation for the statistical analysis results obtained in the quantitative stage.

Data Analysis

Data analysis in this study was conducted using both descriptive and inferential methods. Descriptive analysis was used to provide an overview of students' numeracy literacy skills before and after instruction. The descriptive statistics used included the number of subjects (N), minimum score, maximum score, mean, and standard deviation of the pretest and posttest scores in the experimental and control classes. In addition, descriptive analysis was also used to describe students' self-efficacy scores based on high, moderate, and low categories, as well as the N-Gain values for each class.

Inferential analysis included a normality test using the Kolmogorov–Smirnov test and a test of homogeneity of variances using Levene's test. Next, an independent two-sample t-test was conducted on the posttest scores of the experimental and control classes to determine differences in the mean numeracy literacy scores after the intervention. Individual mastery was tested using a one-sample t-test (right-tailed) against a passing score of 75 on the KKTP, while class-level mastery was tested using a one-tailed proportion test (right-tailed) with a criterion that at least 70% of students achieved mastery. The effectiveness of the instruction was also analyzed by comparing the gains (N-Gain) between the experimental and control classes using an independent two-sample t-test. Additionally, a simple linear regression analysis was conducted to determine the effect of self-efficacy on numeracy literacy skills.

To test the effectiveness of implementing an ethnomathematics-infused Problem-Based Learning (PBL) model supported by a flipbook, an analysis was conducted on the improvement in students' numeracy literacy skills using the Normalized Gain (N-Gain) score. The results of

the analysis showed that the average N-Gain in the experimental class was 0.74, while the average N-Gain in the control class was 0.59. Based on the N-Gain interpretation criteria, the experimental class showed a high level of improvement, while the control class showed a moderate level of improvement. These findings indicate that learning using the ethnomathematics-infused Problem-Based Learning model supported by a flipbook results in a greater improvement in numeracy literacy skills compared to conventional learning. Thus, the learning model implemented in the experimental class can be deemed more effective in improving students' numeracy literacy skills.

Results

Instruction in the experimental class was conducted using a Problem-Based Learning (PBL) model supplemented by an ethnomathematics-themed flipbook on the topics of relations and functions. The instruction took place over four sessions, with each session allocated 2 and 3 JP. The flipbook served as the primary medium for presenting the material, problem information, images of cultural contexts, inquiry activities, and exercises for students to complete. The ethnomathematics contexts used were drawn from the culture of Semarang, such as Kampung Batik Semarang, Johar Market, Lawang Sewu, and Tugu Muda. These contexts were not merely used as illustrations but were integrated into the mathematical problems that students had to solve through the PBL stages.

The implementation of instruction in the experimental class followed the five stages of learning based on the PBL syntax, namely: 1) orienting students to the problem; 2) organizing students for learning; 3) facilitating independent and group investigations; 4) developing and presenting work products; and 5) analyzing and evaluating the problem-solving process (Junaidi, 2020). Each stage was applied throughout all sessions with activities tailored to the material and the level of complexity of the problems. Details of the material and main activities for each session are presented in Table 5.

Table 5. Implementation of Problem-Based Learning (PBL) Supported by an Ethnomathematics-Based Flipbook

Session	Topic	Main Activities
1	Relation	Definition of Relations and Representations of Relations (Arrow Diagrams, Sets of Ordered Pairs, and Cartesian Coordinates)
2	Function	Definition of Functions and Representations of Functions: Arrow Diagrams and Sets of Ordered Pairs.
3	Function	Presentation of Functions: Function equations, tables, and graphs.
4	Relation dan Function	Problem-Solving and Evaluation

In the first session, students explored the concept of relations through the cultural context of Semarang. During the problem-orientation phase, students examined a problem presented in a flipbook regarding the relationship between a student's name and the length of batik fabric purchased. Students identified known information and the problem to be solved. Next, students were divided into groups and organized the information they had gathered. During the investigation phase, students determined the relationship between two sets and presented it in the form of arrow diagrams, Cartesian coordinates, and ordered pairs. The results were then presented and evaluated together to ensure the accuracy of the relationship representations.

In the second session, instruction focused on understanding the concept of a function as an extension of the concept of a relation previously studied. Students examined contextual problems through a flipbook, then identified the characteristics of relationships that satisfy the definition of a function. In groups, students conducted investigations using various representations, such as arrow diagrams and sets of ordered pairs. Each group presented their solutions along with the reasoning supporting their determination that a given relationship was a function. The teacher and students then analyzed these results to reinforce their understanding of the characteristics of functions.

In the third session, students applied the concept of functions in the form of equations, tables, and graphs through contextual problems related to the culture of Semarang. One of the problems used involved determining the price of batik fabric at Johar Market, expressed as the function $f(x) = 6x - 4$. Using a flipbook, students gather information about the length of the fabric and the pricing rules, then determine the value of the function, present the results in a table, identify the range, and interpret the results in the context of purchasing batik fabric. This activity guides students to apply mathematical concepts to real-life situations while also developing their ability to analyze information and interpret results.

In the fourth session, students integrated the concepts of relations and functions through more complex problems. Students worked in groups to analyze information, identify appropriate mathematical concepts, develop solution strategies, and communicate their results. During the presentation phase, students explained their strategies and solutions to other groups. Next, students and the teacher jointly analyze and evaluate the problem-solving process, including the appropriateness of the strategies, the accuracy of the calculations, and the relevance of the answers to the problem context. Thus, these four sessions form a learning sequence that gradually develops students' understanding of the concepts of relations and functions, as well as their ability to apply mathematics in cultural and everyday contexts.

The integration of ethnomathematics into learning is achieved by using the cultural activities and objects of Semarang as the context for mathematical problems. For example, Semarang's Batik Village is used as a context for understanding the relationship between students and the length of batik fabric, while Johar Market is used as a context for applying function rules to determine the price of fabric. Thus, local culture is not merely included as a backdrop to the story but is used as a source of information that must be analyzed and modeled using the concepts of relations and functions (Figure 4, Figure 5, and Figure 6).



Figure 4. Flipbook



Figure 5. Using Flipbook



Figure 6. Student Presentation

After the entire learning sequence was completed, students' numeracy literacy skills were assessed through posttests administered to the experimental and control classes. Pretest scores were used to assess students' initial proficiency, while posttest scores were used to determine their numeracy literacy proficiency after the instruction. Subsequently, the data were analyzed descriptively and inferentially to determine improvements in numeracy literacy proficiency, differences in outcomes between the experimental and control classes, learning achievement, and the relationship between self-efficacy and numeracy literacy proficiency.

In the control class, a pretest was administered before the learning activities began; the research sample took the pretest to measure students' initial numeracy literacy skills. Subsequently, the learning process was conducted using the teaching methods typically employed by the teacher, without utilizing either the ethnomathematics-based flipbook or the problem-based learning model. After the entire series of activities was completed, students took a posttest to measure their final numeracy literacy skills. The pretest and posttest data from the control class were then compared with those from the experimental class to determine the effect of implementing an ethnomathematics-based Problem-Based Learning model aided by a flipbook on students' numeracy skills.

Table 6. Analysis of Pretest and Posttest Data on Students' Numeracy Literacy Skills

	N	Minimum	Maximum	Mean	Std. Deviation
<i>Pretest</i> Experimental	32	51	90	69,97	10,18
<i>Posttest</i> Experimental	32	75	100	92,13	8,79
<i>Pretest</i> Control	32	57	92	79,38	10,31
<i>Posttest</i> Control	32	72	100	91,56	6,92

The results of the calculations based on Table 6 show that the minimum pretest score for the experimental class was 51, the maximum was 90, the mean was 69.97, and the standard deviation was 10.18, while the minimum posttest score for the experimental class was 75, the maximum was 100, the mean was 92.13, and the standard deviation was 8.79. The minimum pretest score for the control class was 57, the maximum was 92, the mean was 79.82, and the standard deviation was 10.31. Meanwhile, the minimum posttest score for the control class was 72, the maximum was 100, the mean was 91.15, and the standard deviation was 6.92. Based on the results of the calculations, the numeracy literacy skills of students in the experimental class after learning using an ethnomathematics-based Flipbook with problem-based learning had higher minimum, maximum, mean, and standard deviation values compared to the control class that used the conventional model.

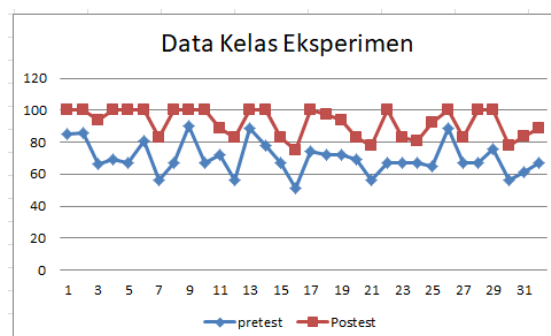


Figure 7. Graph of the experimental class's progress

Based on the results of the calculations, the numeracy literacy scores of students in the experimental class ranged from a posttest high of 100 to a low of 75. Meanwhile, the pretest scores ranged from a high of 90 to a low of 51. The average pretest score for the experimental class using the ethnomathematics-based Flipbook with problem-based learning was 69.97, and the average posttest score was 92.13; this indicates a 74% increase from the pretest to the posttest, as visualized Figure 7.

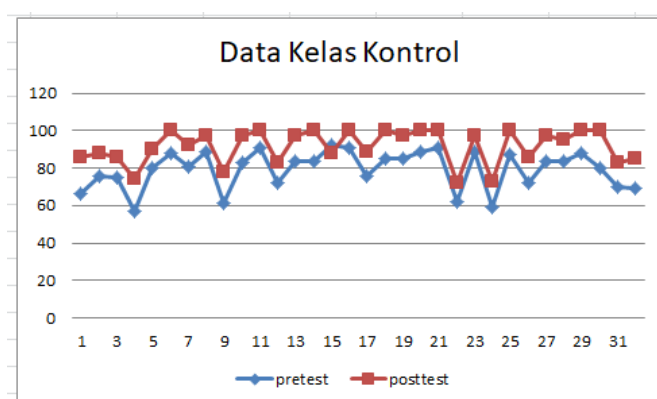


Figure 8. Graph of the increase in the control class

Based on the results of the calculations, the numeracy literacy scores of students in the control class ranged from a high of 100 to a low of 72 on the posttest. Meanwhile, the pretest scores ranged from a high of 92 to a low of 57. The average pretest score for the experimental class using the conventional model was 79.38, and the average posttest score was 91.56. This indicates a 59% increase from the pretest to the posttest (see Figure 8).

Table 7. results of the normality test
One-Sample Kolmogorov-Smirnov Test

		litnum
N		64
Normal Parameters ^{a,b}	Mean	75.84
	Std. Deviation	11.625
Most Extreme Differences	Absolute	.106
	Positive	.086
	Negative	-.106
Test Statistic		.106
Asymp. Sig. (2-tailed)		.072 ^c

a. Test distribution is Normal.

b. Calculated from data.

c. Lilliefors Significance Correction.

Based on the results in Table 7, in the Kolmogorov-Smirnov column, both the experimental and control groups yielded a Sig. value of $0.072 > 0.05$. Therefore, H_0 is accepted. Thus, the data on the numeracy proficiency scores of students in the experimental and control groups come from a normally distributed population.

The criteria for the right-tailed t-test (individual achievement test) based on the KKTP used in this study are to reject H_0 if $t \geq t_{(1-\alpha);(n-1)}$ or $t_{hitung} \geq t_{tabel}$ with $dk = n - 1$, using the following formula:

$$t = \frac{\bar{x} - \mu_0}{\frac{s}{\sqrt{n}}}$$

A $t = 11,02$ was obtained; at a 5% significance level, $t_{(1-\alpha);(n-1)} = 1,696$. Based on the calculations, $t_{hitung} = 11,02 \geq 1,696 = t_{tabel}$. Therefore, H_0 is rejected. Thus, the mean numeracy literacy score of students after learning through Problem-Based Learning with an ethnomathematics approach aided by a flipbook exceeded the minimum passing score of 75. The criteria for the right-tailed proportion test (classical significance test) used in this study are to reject H_0 if $z \geq z_{(0,5-\alpha)}$ or $z_{hitung} \geq z_{tabel}$, using the following formula:

$$z = \frac{\frac{\bar{x}}{n} - \pi_0}{\sqrt{\frac{\pi_0(1 - \pi_0)}{n}}}$$

A $z = 2,68$ was obtained; at a 5% significance level, $z_{(0,45)} = 1,65$. Based on the calculations, $z_{hitung} = 2,68 \geq 1,65 = z_{tabel}$. Therefore, H_0 is rejected. Thus, the proportion of students who achieved classical learning mastery in the implementation of the ethnomathematics-infused Problem-Based Learning model aided by Flipbook is more than 70%.

Table 8. Regression test results

Coefficients ^a							
Model	Unstandardized Coefficients		Standardized Coefficients Beta	t	Sig.	95,0% Confidence Interval for B	
	B	Std. Error				Lower Bound	Upper Bound
1 (Constant)	49.323	8.074		6.109	.000	32.835	65.812
selfefficacy	.550	.122	.636	4.518	.000	.301	.798

a. Dependent Variable: litnum

Based on [Table 8](#), the following regression equation was obtained: $Y = 49,323 + 0,550X$. The variable X represents self-efficacy, and Y represents students' numeracy skills.

Table 9. Model Summary regression test result

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.636 ^a	.405	.385	4.501

a. Predictors: (Constant), selfefficacy

Based on [Table 9](#), the correlation coefficient was found to be $R = 0,636$ and $R^2 = 0,405 = 40,5\%$. This means that self-efficacy accounts for 40.5% of students' numeracy literacy skills, while 59.5% is influenced by other variables. To provide a more detailed picture of students' levels of self-efficacy, a descriptive analysis was then conducted by grouping self-efficacy scores into three categories—high, moderate, and low—based on the mean and standard deviation. The criteria for these groupings are presented in [Table 10](#).

Table 10. Classification of Students by Self-Efficacy Level

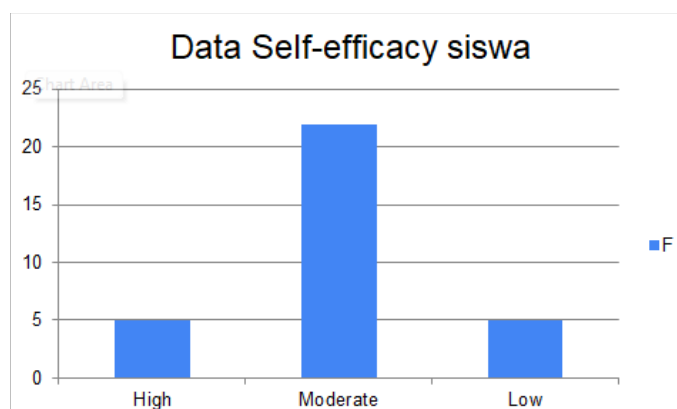
Criteria	Category
$x \geq 76,34$	High
$62,35 < x < 76,34$	Modetare
$x \leq 62,35$	Low

Subject to the following conditions $\bar{x} = 69,34$; $SD = 6,99$; $\bar{x} + SD = 76,34$; $\bar{x} - SD = 62,35$. Based on the self-efficacy grouping criteria established in Table 10, the self-efficacy scores of each student were then grouped into high, moderate, and low categories. The results of this grouping were then analyzed to determine the frequency distribution and percentage of students in each category. The results of the students' self-efficacy distribution are presented in Table 11.

Table 11. Distribution of Students by Self-Efficacy

No	Category	Frequency	Persentase
1.	High	5	15,625%
2.	Moderate	22	68,75%
3.	Low	5	15,625%
	Total	32	100%

To clarify the distribution of students' self-efficacy across each category, the data presented in Table 11 is further visualized in the form of a bar chart. This visualization is intended to help readers easily compare the number of students in the high, moderate, and low categories. The distribution of students' self-efficacy is presented in Figure 9.

**Figure 9.** Self-Efficacy Distribution Diagram

In accordance with the explanatory sequential mixed-methods research design, the qualitative phase was conducted after the quantitative data analysis was completed. Interview subjects were selected based on the self-efficacy categories derived from the questionnaire results, namely high, moderate, and low. In addition to the interviews, an analysis was also conducted on the students' work to gain insight into the thought processes and problem-solving strategies used in solving the numeracy literacy problems found in the flipbook. The results of the analysis for each category are presented in the following discussion (see Figure 10 for the practice Problems).

1. Pada kegiatan wisata edukasi di kawasan Kota Lama Semarang, rombongan siswa menyewa sepeda ontel untuk berkeliling area wisata. Tempat penyewaan menetapkan biaya tetap sebesar Rp 10.000 sebagai biaya administrasi dan tambahan Rp 5.000 untuk setiap jam pemintajaman sepeda. Jika x menyatakan lama penyewaan sepeda (dalam jam) dan $f(x)$ menyatakan total yang harus dibayar:
 - a. Tentukan Bentuk fungsi dari permasalahan tersebut.
 - b. Hitunglah biaya yang harus dibayar jika sepeda disewa selama 3 jam, 5 jam dan 7 jam.
 - c. Nyatakan hasil tersebut dalam bentuk tabel dan dan grafik.

During an educational trip to Semarang's Old Town, a group of students rents bicycles to explore the tourist area. The bicycle rental service charges a fixed administrative fee of Rp 10,000, plus an additional Rp 5,000 for each hour of rental. Let x represent the rental duration in hours and $f(x)$ represent the total amount to be paid. a. Determine the function that models this situation. b. Calculate the total cost of renting a bicycle for 3 hours, 5 hours, and 7 hours. c. Present the results in a table and a graph

Figure 10. Practice problems in the flipbook

High self-efficacy category

An analysis of numeracy skills among participants in the high self-efficacy category was conducted on two subjects, ST1 and ST2. Based on the results of the analysis of answer sheets and interviews, both subjects demonstrated relatively consistent abilities in understanding information, forming mathematical models, performing calculations, and interpreting the results of their solutions. The following discussion focuses the analysis on ST1 as one of the subjects representing the high self-efficacy category. In the initial stage, ST1 identified information related to additional costs. This was confirmed through the following interview (Tabel 12) and students work (Figure 11, Figure 12, and Figure 13).

Table 12. ST1 Interview Results, Part 1

Researcher: How did you solve this problem?
 ST1: First, I read the information provided in the problem. I saw that there was a fixed fee of 10.000 rupiah and an additional fee of 5.000 rupiah per hour. So, I set up the mathematical model first: $f(x) = 10.000 + 5.000x$. After that, I simply plugged the values of x is 3, 5, and 7 into the model.

This statement indicates that ST1 first identifies relevant information before performing calculations. The student is able to distinguish between fixed information and information that changes based on the rental period. Next, this information is used to construct a mathematical model. This shows that ST1 does not merely use the numbers provided in the problem but is able to understand the relationship between contextual information and the concept of a function. ST1's ability to use mathematical models is also evident from the problem-solving strategy chosen. When asked why they created a mathematical model first, ST1 explained as follows in the interview.

Table 13. ST1 Interview Results, Part 2

Researcher: Why did you choose to create the formula first?
 ST1: To make the calculations easier, once I've found the formula, I can plug the value of x into it and present the results in the form of a table and a graph.

This response indicates that ST1 understands the function of mathematical models as a means of obtaining the necessary values. ST1 then uses the calculation results to create representations in the form of tables and graphs. Thus, there is an interconnection between the processes of understanding information, constructing models, performing calculations, and presenting results in the form of mathematical representations. ST1's work also supports the

findings of the interviews, as the student was able to complete the problem-solving steps systematically. During the interpretation stage, ST1 was able to connect the graph to the context of the problem. When asked about the conclusions drawn from the graph, ST1 explained as follows.

Table 14. ST1 Interview Results, Part 3

Researcher: What conclusions do you draw from the graph? ST1: The graph keeps rising because the longer you rent a bike, the higher the cost. The rate increases by Rp5.000 per hour.

This answer demonstrates that ST1 is not only able to produce a graph but also understands the meaning of the graph in the context of the problem. The student was able to explain that the upward trend in the graph indicates an increase in cost as the rental period increases. In addition, ST1 was able to identify the pattern of a Rp5,000 increase in cost for each additional unit of rental time.



Figure 11. interview ST1

UK 2 Hal 11

1. Diketahui : Administrasi = Rp. 10.000
 Tambahan = Rp. 5.000
 x lama sewa (jam)
 $F(x)$ total biaya

Ditanya : a. Bentuk Fungsi
 b. biaya 3 jam, 5 jam, 7 jam
 c. tabel & grafik

Figure 12. work results ST1, part 1

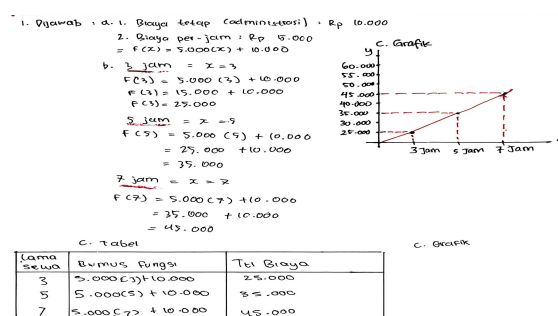


Figure 13. Work result ST1, part 2

Based on the results of the assignments and interviews, ST1 demonstrated proficiency in all three numeracy literacy indicators used in this study. Regarding the indicator of using numbers and mathematical symbols, ST1 was able to use numerical information to construct a function model. Regarding the indicator of analyzing information, ST1 was able to identify key information and determine the relationship between cost and rental duration. Regarding the “interpretation of results” indicator, ST1 was able to explain the meaning of tables and graphs and relate them to the problem context. Thus, for ST1, who represents the high self-efficacy category, numeracy skills were evident through a systematic problem-solving process, the ability to explain the rationale for using specific strategies, and the ability to connect mathematical results to the problem context.

Moderate self-efficacy category

In the moderate self-efficacy category, the analysis focused on two subjects: SS1 and SS2. The results of the analysis indicate that subjects in this category possess the basic ability to understand information and apply functional concepts, but their problem-solving process is not yet fully developed. Difficulties were particularly evident when students had to determine the position of fixed costs in the mathematical model and when they had to interpret the graph. The following discussion uses SS1 as one of the subjects representing the moderate self-efficacy category. Below are the results of the interview with SS1 (Tabel 15) and their work result (Figure 14, Figure 15, and Figure 16).

Table 15. SS1 Interview Results, Part 1

Researcher: How do you solve this problem?

SS1: I know there's an initial fee of 10.000 rupiah, plus 5.000 rupiah per hour. I came up with the formula, but I was confused about whether the 10.000 rupiah should be multiplied by x or not.

This question indicates that SS1 is able to identify important information but does not yet fully understand the role of each piece of information in the mathematical model. The student still has difficulty distinguishing between constant values and values that depend on variables. However, when encountering difficulties, SS1 tries to review the available information.

Table 16. SS1 Interview Results, Part 2

Researcher: So, how did you finally find the answer?

SS1: I read the question again and looked at the examples in the flipbook; finally, I realized that Rp10,000 is a fixed fee.

This response indicates that SS1 was able to improve their understanding after rereading the question and using the examples in the flipbook. This means that the student has the ability to continue the problem-solving process after encountering difficulties, but still needs assistance or reinforcement to confirm the strategies used. During the representation stage, SS1 was able to plot points on the Cartesian plane based on the table. However, this ability was not yet fully accompanied by the ability to interpret the graph.

Table 17. SS1 Interview Results, Part 3

Researcher: What do you do when you create a graph?

SS1: I can plot the data points from the table, but I'm still not sure how to explain what the graph means.

This statement indicates a difference between the ability to perform procedures and the ability to interpret results. SS1 has been able to use tables as a basis for creating graphs, but is still unsure when it comes to explaining the relationships shown in the graphs. The students' work also shows that most of the steps in the problem-solving process have been completed, although the interpretation of the results is not yet optimal.



Figure 14. Interview SS1

Dik = H. Sewa = 10.000
 H. Administrasi = 5.000
 Dit = a. Tent. fungsi
 b. Hitung biaya jika sepeda disewa selama 3 jam, 5 jam, 7 jam
 c. Buat tabel & grafik

Jawab
 a. $f(x) = 5.000x + 10.000$
 b. $f(3) = 5.000(3) + 10.000$
 $f(3) = 15.000 + 10.000$
 $f(3) = 25.000$
 $f(5) = 5.000(5) + 10.000$
 $f(5) = 25.000 + 10.000$
 $f(5) = 35.000$
 $f(7) = 5.000(7) + 10.000$
 $f(7) = 40.000 + 10.000$
 $f(7) = 50.000$

Figure 15. Work results SS1, part 1

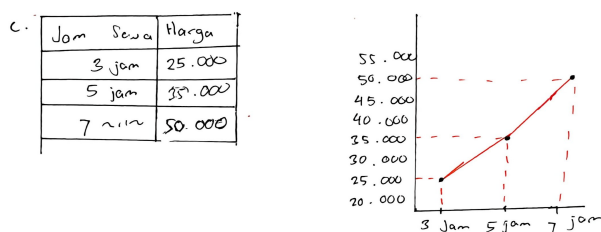


Figure 16. Work results SS1, part 2

Based on the results of the interviews and the students' work, SS1 demonstrated the ability to identify information and apply mathematical procedures, but still exhibited uncertainty in constructing models and interpreting results. Thus, for SS1, who represents the moderate self-efficacy category, numeracy skills were evident in most stages of problem-solving, but interpretation skills and confidence in explaining results still need to be strengthened.

Low self-efficacy category

For the **low self-efficacy** category, the analysis was conducted on two subjects, namely SR1 and SR2. The results showed that the subjects' difficulties did not only emerge at the final stage of the solution process but had already appeared at the initial stage, when the students were required to determine strategies for understanding and modeling the problem. The following discussion uses SR1 as one of the subjects representing the **low self-efficacy** category (Tabel 18), confirmed by the interview (Figure 17) and work result (Figure 18).

Tabel 18. SR1 Interview Results, Part 1

Researcher: What did you do first when you read this problem?
 SR1: I read the problem first, but I was confused about where to start.

This statement indicates that SR1 had read the information presented in the problem but was unable to determine an appropriate solution strategy. This difficulty continued when the student was asked to construct a mathematical model.

Table 19. SR1 Interview Results, Part 2

Researcher: Which part did you find the most difficult?
 SR1: I was confused about how to formulate the equation. I knew there were Rp10.000 and Rp5.000, but I didn't know how to write them mathematically.

The response indicates that SR1 was able to identify the numbers or basic information provided in the problem but was unable to connect the information to construct a function

model. In other words, the student's difficulty was not merely in performing calculations but also in the process of modeling the relationship between the variables.

Tabel 20. SR1 Interview Results, Part 3

Researcher: Were you able to create a table or graph?

SR1: I tried calculating it one by one, but I still couldn't create the table or graph.

This statement indicates that SR1 tended to perform calculations directly and was unable to use the function model to produce mathematical representations. The inability to construct the model subsequently affected the student's difficulty in presenting the results in the form of a table and graph. In addition, SR1 had not yet understood the relationship between the variables in the context of the problem.

Tabel 21. SR1 Interview Results, Part 4

Researcher: Why do you think this problem is difficult?

SR1: Because I do not yet understand the relationship between the rental duration and the cost that must be paid.

This indicates that the student was not yet able to interpret the relationship underlying the function problem. SR1's work also shows difficulties in using mathematical symbols, analyzing information, and interpreting the results.



Figure 17. Interview SR1

$$\begin{aligned}
 &2. \text{Dik: 14. Sisa} = 10.000 \\
 &\quad \text{H. Administrasi} = 5.000 \\
 &\text{Dit: a. Tent fungsi} \\
 &\quad \text{b. Hitung biaya jika sepeda di sewa selama 3 jam, 5 jam, 7 jam} \\
 &\quad \text{c. Buat tabel dan grafik} \\
 &\text{Jawab: a. } f(x) = 5000x + 10.000 \\
 &\quad \text{b. } -f(x) = 5000x + 10.000 \\
 &\quad \quad f(3) = 5000(3) + 10.000 \\
 &\quad \quad f(3) = 15.000 + 10.000 \\
 &\quad \quad f(3) = 25.000 \\
 &\quad \quad -f(x) = 5000x + 10.000 \\
 &\quad \quad f(5) = 5000(5) + 10.000 \\
 &\quad \quad f(5) = 25.000 + 10.000 \\
 &\quad \quad f(5) = 35.000 \\
 &\quad \quad -f(x) = 5000x + 10.000 \\
 &\quad \quad f(7) = 5000(7) + 10.000 \\
 &\quad \quad f(7) = 40.000 + 10.000 \\
 &\quad \quad f(7) = 50.000
 \end{aligned}$$

Figure 18. Work results SS1

Based on the interview results and the student's work, SR1 demonstrated the ability to identify some basic information but was not yet able to transform the information into a mathematical model, represent the relationship in the form of a table or graph, or interpret the results. Thus, for SR1, who represents the low *self-efficacy* category, the barriers to numeracy literacy skills were evident from the planning stage of the solution and continued through the representation and interpretation stages.

Discussion

The research findings show that students' numeracy literacy skills in the experimental class, which received learning through Problem Based Learning assisted by an ethnomathematics-based flipbook, improved after the treatment. In the experimental class, the average pretest score for numeracy literacy was 69.97, increasing to 92.13 on the posttest. Meanwhile, the control class, which received conventional instruction, had an average pretest score of 79.38, which increased to 91.56 on the posttest. Thus, the increase in the average numeracy literacy score was greater in the experimental class than in the control class, namely

22.16 points in the experimental class and 12.18 points in the control class, although the experimental class had a lower initial ability based on its average pretest score.

The improvement in numeracy literacy in the experimental class was also evident in students' ability to solve problems related to relations and functions. Students were able to identify the information provided in problems, represent relationships between sets using arrow diagrams, sets of ordered pairs, Cartesian diagrams, and tables, as well as determine and interpret relations as functions in the context of everyday problems. The problems presented through the ethnomathematics-based flipbook incorporated the cultural context of Semarang City as situations for problem solving. These findings indicate an improvement in students' ability to use mathematical representations and solve contextual problems after participating in Problem Based Learning assisted by an ethnomathematics-based flipbook.

In this study, the context was realized through an ethnomathematics-based flipbook containing various local cultural activities as learning resources. The problems presented in the flipbook were associated with community activities so that the concepts of relations and functions were not learned abstractly, but rather through real-life situations that were familiar to students. For example, the relationship between types of batik motifs and their regions of origin, the relationship between traditional musical instruments and their areas of distribution, and the relationship between traditional foods and their producing regions can be modeled as relations and analyzed to determine whether they satisfy the conditions of a function. The presentation of these cultural contexts helped students understand the meaning of mathematical concepts while also recognizing that mathematics is part of community cultural activities. This finding is consistent with (Dominikus, 2021), who stated that ethnomathematics connects mathematical concepts with cultural practices, making learning more contextual. This finding is also supported by (Pratiwi & Pujiastuti, 2020) and (Rohmatin, 2020), who explained that integrating local culture into mathematics learning can improve conceptual understanding while fostering appreciation of regional culture.

In addition to the use of cultural contexts, the digital flipbook provided a more interactive learning experience than conventional teaching materials. The flipbook used in this study integrated text, images, cultural illustrations, animations, instructional videos, and problem-based exercises, allowing students to learn the concepts of Relations and Functions gradually and independently. Through this medium, students obtained clearer visualizations of relationships between sets and function representations, making the process of abstracting mathematical concepts easier. The engaging presentation of the material also increased students' attention, motivation, and engagement during Problem Based Learning. This condition supported students' success in solving numeracy literacy problems because they had opportunities to explore information, discuss with peers, and develop solutions based on the problems presented in the flipbook. These findings are consistent with Bunari et al. (2024), who stated that flipbook-based learning media have a positive effect on students' motivation and learning outcomes. The findings are also supported by Widiyanto et al. (2021), who explained that digital learning media can improve learning effectiveness through more interactive and accessible material presentation.

Based on the results of the tests conducted, learning using an ethnomathematics-based flipbook combined with Problem Based Learning demonstrated potential in improving students' numeracy literacy. This finding is consistent with Nugraha & Wardono (2025), who reported that PBL is effective in improving students' numeracy literacy skills when viewed from their self-efficacy. The regression analysis showed that self-efficacy was positively associated with students' numeracy literacy, with an explanatory contribution of 40.5% ($R^2 =$

0.405) with the equation $Y = 49,323 + 0,550X$ and a correlation coefficient of $R = 0,636$ indicating a moderately strong relationship. This finding is consistent with [Yang et al. \(2024\)](#), who found a positive relationship between mathematics self-efficacy and mathematical achievement across various educational levels. The finding is further supported by [Salsabilah & Kurniasih \(2022\)](#), who reported a positive relationship between self-efficacy and students' numeracy literacy. The results of this study also support [Disi et al. \(2025\)](#), who showed that self-efficacy plays an important role in students' numeracy literacy. Students with high self-efficacy tend to be more confident when facing and solving mathematical problems, particularly when PBL is integrated with ethnomathematics. In a systematic review, [Arrofit & Dwi \(2025\)](#) emphasized that self-efficacy is closely related to students' numeracy literacy skills, indicating that higher self-efficacy tends to be associated with better numeracy literacy skills, and vice versa. This finding is consistent with [Bandura \(1997\)](#) theory and is further supported by [Schunk & DiBenedetto \(2021\)](#), who explained that self-efficacy influences how students respond to challenges and regulate their efforts toward achieving desired outcomes.

Although the results of the study indicate that the implementation of Problem Based Learning (PBL) with an ethnomathematical approach assisted by a flipbook was able to improve students' numeracy literacy skills, these findings need to be interpreted by considering several limitations of the study. In this study, the ethnomathematical context was not only used as a cultural illustration but was integrated into learning activities through the presentation of contextual problems directly related to the topic of relations and functions. For example, students analyzed the relationship between Semarang batik motifs and their philosophical meanings, the relationship between traders and types of goods sold at Johar Market, and the relationship between historical buildings and their locations. These activities required students to construct relations, determine ordered pairs, and interpret mathematical relationships arising from cultural practices. Thus, culture was not merely presented as a visual example but functioned as an authentic context that helped students construct mathematical concepts through cultural experiences that were familiar to them. This approach is consistent with the perspective of [Natalia et al. \(2025\)](#), who view ethnomathematics as the study of mathematical practices embedded in cultural activities, and is supported by [Bakar et al. \(2025\)](#), who stated that ethnomathematics-based learning can connect school mathematics concepts with students' cultural experiences. In addition, a literature review by [Munthahana et al. \(2023\)](#) showed that the integration of ethnomathematics into learning contributes to improving conceptual understanding, problem-solving skills, and numeracy literacy.

On the other hand, the findings of this study need to be interpreted by considering several limitations. First, the average initial abilities of students in the experimental and control classes differed based on the pretest results, and this condition may have affected the magnitude of the improvement in numeracy literacy skills following the treatment. Second, the study was conducted at only one school, so the relatively homogeneous characteristics of the students and learning environment limit the generalizability of the findings. Third, the treatment involved an integration of the Problem Based Learning model, ethnomathematical approach, and flipbook media; therefore, this study cannot identify the contribution of each learning component separately. Fourth, the qualitative analysis involved only six subjects, consisting of two students from each self-efficacy category: high, moderate, and low. Therefore, the qualitative findings are intended primarily to provide an in-depth understanding of the subjects' thinking processes rather than to generalize the findings to all students within each self-efficacy category.

The integration of Problem Based Learning, ethnomathematics, and flipbook media resulted in a complementary learning process. Problem Based Learning served as a model for

developing critical thinking and problem-solving skills, ethnomathematics provided a meaningful cultural context, while the flipbook functioned as a medium that facilitated the interactive presentation of learning materials. The combination of these three components enabled students to develop a deeper understanding of the concepts of Relations and Functions, increase their confidence in solving mathematical problems, and develop numeracy literacy skills through situations that were closely connected to their everyday lives. Thus, the improvement in numeracy literacy skills in the experimental class was not solely associated with the implementation of the Problem Based Learning model, but also with the use of local cultural contexts and flipbook media, which contributed to creating a more meaningful learning experience.

Conclusion

Based on the findings of the study, it can be concluded that the implementation of Problem Based Learning (PBL) with an ethnomathematical approach assisted by a flipbook was able to improve students' numeracy literacy skills more effectively than conventional learning. This was indicated by the increase in the average numeracy literacy score in the experimental class from 69.97 on the pretest to 92.13 on the posttest, with a greater improvement than that of the control class. These findings indicate that learning that integrates contextual problem-solving, local culture, and interactive learning media can provide a more meaningful learning experience, thereby supporting the improvement of students' numeracy literacy skills. The results of the simple linear regression analysis showed that self-efficacy was positively and significantly associated with students' numeracy literacy skills. The coefficient of determination (R^2) of 0.405 indicates that self-efficacy explained 40.5% of the variance in students' numeracy literacy skills, while the remaining 59.5% was not explained by the regression model. The regression equation obtained was $Y = 49,323 + 0,550X$ indicating that every one-unit increase in the self-efficacy score was associated with an increase of 0.550 units in numeracy literacy skills. In terms of self-efficacy levels, subjects in the high self-efficacy category tended to fulfill all indicators of numeracy literacy skills. Subjects with moderate self-efficacy were able to fulfill most of the indicators but still experienced difficulties in interpreting results and drawing conclusions, whereas subjects with low self-efficacy were only able to fulfill a limited number of numeracy literacy indicators. These findings indicate that students with higher levels of self-efficacy tended to demonstrate better numeracy literacy skills when solving contextual mathematical problems.

The qualitative analysis showed that the two subjects in the high self-efficacy category tended to fulfill all indicators of numeracy literacy skills, whereas the two subjects in the moderate self-efficacy category and the two subjects in the low self-efficacy category still demonstrated limitations in several indicators. Therefore, these qualitative findings provide a description of the characteristics of the subjects studied and are not intended to generalize the findings to all students in each self-efficacy category. This study has several limitations, including differences in initial ability between the experimental and control classes, the implementation of the study at only one school, the use of a combined treatment involving PBL, ethnomathematics, and flipbook, which means that the contribution of each component could not be isolated, and the limited number of qualitative subjects. Future research is recommended to use larger samples, involve multiple schools, control students' initial abilities more rigorously, and examine the contribution of each learning component separately.

Declarations

- Conflict of Interest** : The authors declare that there are no conflicts of interest.
- Auhor Contributions** : A.F.A.: Conceptualization, Methodology, Investigation, Formal analysis, Project administration, Writing – original draft.
Z.: Conceptualization, Validation, Writing – review & editing.
All authors have read and agreed to the published version of the manuscript.
- Data Availability Statement** : The authors declare that the data supporting the findings of this study will be made available by the corresponding author, [A.F.A.], upon reasonable request.

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Authors Biography



Anggun Filisia Acuna is an undergraduate student in the Mathematics Education Study Program, Faculty of Mathematics and Natural sciences, Universitas Negeri Semarang, Central Java, Indonesia.

✉ acunaanggunfilisia@students.unnes.ac.id



Zaenuri is a lecturer and researcher at the department of mathematics education, faculty of mathematics and natural science, Universitas Negeri Semarang, Central Java, Indonesia. His research interests include ethnomathematics in various countries, with a particular emphasis on cross-cultural mathematical practices, culturally responsive mathematics education, and the integration of local wisdom into mathematics learning.

✉ zaenuri.mipa@mail.unnes.ac.id