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# Development of E-Comics in PBL-Ethnomathematics on Critical Thinking Skills

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## Abstract

Indonesia's average scores in mathematics, literacy, and science declined in the PISA 2022 study compared to its 2018 results. In the 21st century, several important competencies must be mastered by students, one of which is critical thinking skills. One suitable learning model for improving critical thinking skills is PBL. This study aimed to determine the development process of e-comics in PBL-Ethnomathematics on critical thinking skills. The research employed an R&D methodology, utilizing the 4D model modified into 3D, which includes the Define, Design, and Develop phases. The data collection technique in this study used an eligibility test questionnaire. After the eligibility test was carried out by the final assignment supervisor, the eligibility aspect of the content has a percentage score of 98.96% which means very eligible, the eligibility aspect of the presentation has a percentage score of 96.67% which means very eligible, the linguistic aspect has a score of 100% which means very eligible, and the learning innovation aspect has a score of 92.86% which means very eligible. The percentage of the final score was 97.92% with comments and suggestions to focus on critical thinking, so that it was e-comics in PBL-Ethnomathematics on critical thinking skills included in the category of very eligible to use.

**Keywords:** e-comics, PBL, ethnomathematics, critical thinking

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## 1. Introduction

The level of education in Indonesia, particularly in mathematics, remains a serious concern. The Programme for International Student Assessment (PISA) 2022 study (OECD, 2023) demonstrated a decline in Indonesia's average scores in mathematics, literacy, and science when compared to the results obtained in 2018. Specifically, 15-year-old students scored 366 points in mathematics, significantly below the average score for OECD countries, which is 472 points. This indicates that the level of education, especially in mathematics, in Indonesia remains relatively low.

In the 21st century, several important competencies must be mastered by students, one of which is critical thinking skills. According to Fisher (2011) and Paul (1990) in Sukma & Priatna, (2021), critical thinking is the ability to consider problems based on students'

experiences or knowledge, as well as the ability to use rational thinking in decision-making processes, behavior, and beliefs. Critical thinking skills are crucial for students to master because they are essential for decision-making. One effective learning model for improving critical thinking skills is Problem Based Learning (PBL). Through PBL, students are encouraged to be actively involved, analyze difficult problems, think deeply, generate new ideas, and practice collaboration skills while working in small groups. This PBL model is open and structured, significantly enhancing higher-order thinking skills compared to conventional learning (Herman, 2007). According to Nur et al., (2016), the syntax of PBL includes: (1) student orientation to the problem; (2) organizing students; (3) guiding group investigations; (4) developing and presenting work; and (5) analyzing and evaluating the problem-solving process.

Meanwhile, an appropriate approach for PBL learning is ethnomathematics. Ethnomathematics is a term referring to the study of mathematics linked to culture. According to D'Ambrosio (1985), ethnomathematics is the study of mathematics that takes cultural considerations into account, where mathematics emerges through understanding the reasoning and mathematical systems used. Previous research by Zahar (2021) showed that ethnomathematics can increase student learning motivation and develop critical and creative thinking skills. This study indicates that the students became more motivated in learning mathematics and more diligent in exploring and analyzing geometric concepts related to their cultural context.

Learning using the PBL model will be more engaging and easier to understand when using problems that are local to their environment, particularly their local culture, so students do not feel bored during mathematics learning activities Abdullah et al. (2015). The PBL model with an ethnomathematics approach was chosen because it is considered appropriate for developing students' critical thinking skills.

Comics have become a favorite among young people, including school students. Easy access makes e-comics popular among all groups in Indonesia. In addition to entertainment, comics are used as a medium for conveying education. Comics have become a favorite among young people, including school students. Easy access makes e-comics popular among all groups in Indonesia. In addition to entertainment, comics are used as a medium for conveying education. Based on data from the *LINE WEBTOON Company Profile (2019)*, e-comic readers in Indonesia are 65% female and 35% male; 70% are aged 13-24. Previous research by Fadella et al. (2018) found that PBL assisted math comics were effective in improving problem solving skills and curiosity in grade VII students on comparison topics.

A preliminary study with grade VIII math teachers at SMP Negeri 1 Bergas revealed that the learning resources used were limited to student worksheets and textbooks. The teacher also occasionally displayed instructional videos on an LCD projector. However, students sometimes encountered problems they hadn't yet covered in either the worksheets or textbooks. Consequently, students needed to seek other learning resources to deepen their understanding and knowledge. After further questioning, three of the five students interviewed stated that they enjoyed reading comics and were interested in learning through them.

Given the above, researchers developed an e-comic integrating PBL and Ethnomathematics for critical thinking. The study's objective is thus to identify the steps in its development process.

## 2. Methods

The research approach used is Research and Development (R&D). This study adapts the 4D model (Define, Design, Develop, and Disseminate), which is then modified into the 3D model (Define, Design, and Develop).

The instrument used to collect data in this study is a questionnaire. This questionnaire is in the form of a product eligibility test which includes aspects of content eligibility, presentation eligibility, language, and learning innovation. The development of this e-comic will be validated by an expert, namely the final assignment supervisor. The types of data used are quantitative data (obtained from eligibility test scores) and qualitative data (in the form of suggestions and input from expert lecturers).

The eligibility data in this research was analyzed using a Likert scale, as detailed in Table 1. (Sugiyono, 2015).

**Table 1.**  
*Assessment Criteria Using the Likert Scale*

Score	Information
4	Very Good/Very Suitable/Very Interesting
3	Good Enough/Good Enough/Interesting Enough
2	Not good/less appropriate/less attractive
1	Very Poor/Very Inappropriate/Very Unattractive

(Table Adaptation: Sugiyono, 2015)

The formula used to determine the final value of the questions in the questionnaire is as follows.

$$P = \frac{\text{total score}}{\text{maximum score}} \times 100\%$$

P is the percentage score (Arifin, 2013). The results of the eligibility test are then described by the percentage of scoring results achieved according to table 2 (Ardiansyah & Pratama, 2021).

**Table 2.**  
*Criteria for the Level of Eligibility of E-Comic Modules*

Eligibility Level	Criteria
$25\% < P \leq 43,75\%$	Not Eligible
$43,75\% < P \leq 62,5\%$	Quite Eligible
$62,5\% < P \leq 81,25\%$	Eligible
$81,25\% < P \leq 100\%$	Very Eligible

(Table Adaptation: Ardiansyah & Pratama, 2021)

Based on table 2, e-comics in PBL-Ethnomathematics towards critical thinking skills are said to meet the eligibility test if they obtain a percentage score of more than 81.25%. If the

percentage score is less than or equal to 81.25% then the e-comic module needs to be revised and revalidated.

### **3. Results and Discussion**

#### **3.1 Define**

At the define, several analyses were conducted. First, the initial-final analysis, obtained the problem, namely the low PISA score results in Indonesia. Another problem is the limited learning resources used by students are not complete so that students need to find other learning resources. Second, student analysis based on interviews, a problem with interest was revealed, as some students were less fond of mathematics, although others were motivated when they succeeded in getting the correct answer. Meanwhile, information from the mathematics teacher confirmed that the availability of learning resources was limited only to worksheets and textbooks. Occasionally teachers also look for other learning resources from YouTube. Therefore, it is necessary to develop e-comics in PBL-Ethnomathematics for critical thinking skills.

Third, concept analysis. The material selected in this study is Probability, which is covered in the Learning Outcomes (CP) for Phase D, Grade VIII (data analysis and probability elements). Specifically, this material enables students to explain and use the concept of probability and relative frequency to determine the expected frequency of a single event in a simple experiment (assuming all experimental outcomes are equally likely to occur). The description of the material in this e-comic will be adapted to the stages of the PBL.

Next, task analysis to determine the assessment in the e-comic that is adjusted to the learning objectives. The questions in this e-comic contain problems that are related to the nuances of ethnomathematics. The e-comic that is developed also contains activities that encourage students to analyze, evaluate, and compile arguments to train students' critical thinking skills. According to Elder (2007) there are five characteristics of someone who has critical thinking skills, including: (1) can raise important questions and problems and formulate them clearly and precisely, (2) can collect and assess relevant information and use abstract ideas to interpret it effectively, (3) can conclude and provide good solutions, and test them based on relevant standard criteria, (4) has an open mind to other thoughts, recognition, and values, (5) can communicate effectively with others to solve complex problems. The indicators of critical thinking skills include: (1) students are able to formulate what is known and what is asked and the conclusion of the question (Interpretation), (2) students are able to create a mathematical model of the question that has been given and provide a correct and complete answer (Analysis), (3) use the right strategy in solving the question (Evaluation), (4) draw the right conclusion, according to the complete context of the question (Inference).

Finally, the analysis of learning objectives yielded the goal for developing this e-comic: through PBL-Ethnomathematics based learning, students are expected to be able to explain the concept of probability and relative frequency, and to be able to determine the value of probability, relative frequency, and expected frequency in real contextual problems.

#### **3.2 Design**

This stage yielded several findings. The first result was the selection of e-comics as the medium, based on the consideration that the medium is easily accessible. This e-comic was specifically designed by combining the PBL model with Ethnomathematics nuances. The title of the e-comic created is "Si Paling Hoki". It is hoped that this developed e-comic will be able to enhance or contribute positively to critical thinking skills.

Both results of format selection. The display format of the developed e-comic is almost the same as the comic format uploaded to the Webtoon platform. The fonts used are CC Wild Word Roman for sentences and Roboto for equations. The application used to create this e-comic is ibisPaint X. The paper size used is  $1440 \times 2560$  (9:16). The composition of the e-comic is adjusted to the PBL syntax. The contents of the e-comic are associated with the nuances of ethnomathematics which will be the attraction of this e-comic. This e-comic contains three parts, namely introduction, content, and closing. The introduction consists of a cover, learning outcomes, learning objectives, and instructions for using the comic. The contents contain stories that are integrated with PBL learning, exploration, and experiments. The closing consists of practice questions, reflections, and literature reviews.

Finally, the initial draft results, obtained the initial design results of the developed e-comic. The initial draft of the e-comic is presented in Figure 1.

**Figure 1.**

*Initial Draft of E-Comic*



### 3.3 Develop

The next stage is development. At this stage, an eligibility test is carried out on the initial draft of the developed e-comic. The eligibility test of e-comics in ethnomathematics is carried out by the researcher's final assignment supervisor. In this eligibility test, there are several

aspects that are assessed, including aspects of content eligibility, aspects of presentation eligibility, linguistic aspects, and aspects of learning innovation. The developed e-comic is declared eligible if it meets the criteria of very eligible. The results of the e-comic eligibility test can be seen in table 3. The final result obtained from the eligibility test by the expert was 97.92% which is very eligible.

**Table 3.**

*Results of E-Comic Eligibility Test by Experts*

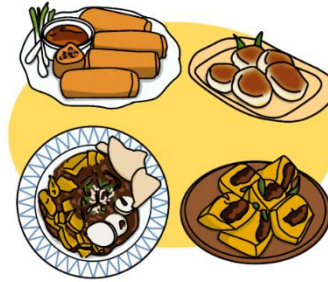
No	Eligibility Aspect	Percentage (%)	Criteria
1	Contents	98.96	Very Eligible
2	Presentation	96.67	Very Eligible
3	Linguistics	100	Very Eligible
4	Learning Innovation	92.86	Very Eligible
The final result		97.92	Very Eligible
Comments and Suggestions		Focus on critical thinking.	

It can be seen that the developed e-comic has a final result of 97.92% which means very eligible. Based on the eligibility aspect, it can be seen that the eligibility aspect of the content has a percentage score of 98.96% which means very eligible, the eligibility aspect of the presentation has a percentage score of 96.67% which means very eligible, the linguistic aspect has a score of 100% which means very eligible, and the learning innovation aspect has a score of 92.86% which means very eligible.

Revisions to the developed e-comic were made based on the validation results, as well as comments and suggestions provided by the expert lecturers. The revisions can be seen in Figure 2.

**Figure 2.**  
*Question in “Eksplorasi”*

## EKSPLORASI



SEMARANG ADALAH IBU KOTA PROVINSI JAWA TENGAH YANG TERLETAK DI PESISIR UTARA PULAU JAWA. KOTA INI TIDAK HANYA DIKENAL KARENA SEJARAH DAN BUDAYANYA YANG KAYA, TETAPI JUGA KARENA KEKAYAAN KULINERNYA YANG UNIK DAN MENGGUGAH SELERA. SEBAGAI KOTA PELABUHAN YANG SEJAK LAMA MENJADI TEMPAT PERSINGGAHAN BERBAGAI BANGSA, SEMARANG MEMILIKI KULINER YANG MERUPAKAN PERPADUAN BUDAYA LOKAL, TIONGHOA, DAN KOLONIAL BELANDA. ADAPUN BEBERAPA MAKANAN KHAS SEMARANG YANG TERKENAL, ANTARA LAIN LUMPIA SEMARANG, WINGKO BABAT, TAHU GIMBAL, DAN TAHU PETIS.

LINTUK MENGETAHUI MAKANAN KHAS MANA YANG PALING DISUKAI MASYARAKAT, SEORANG PENELITI KULINER MELAKUKAN SURVEI TERHADAP 100 ORANG RESPONDEN. IA MEMINTA MEREKA MEMILIH SATU DARI EMPAT MAKANAN KHAS SEMARANG YANG MEREKA SUKAI.

**Figure 3.**  
*Revision of Addition of Instructions for Completion with Critical Thinking Indicators*

HASIL VOTING YANG DILAKUKAN DIPEROLEH HASIL SEBAGAI BERIKUT:

- 38 ORANG MEMILIH LUMPIA
- 19 ORANG MEMILIH WINGKO BABAT
- 27 ORANG MEMILIH TAHU GIMBAL
- 16 ORANG MEMILIH TAHU PETIS

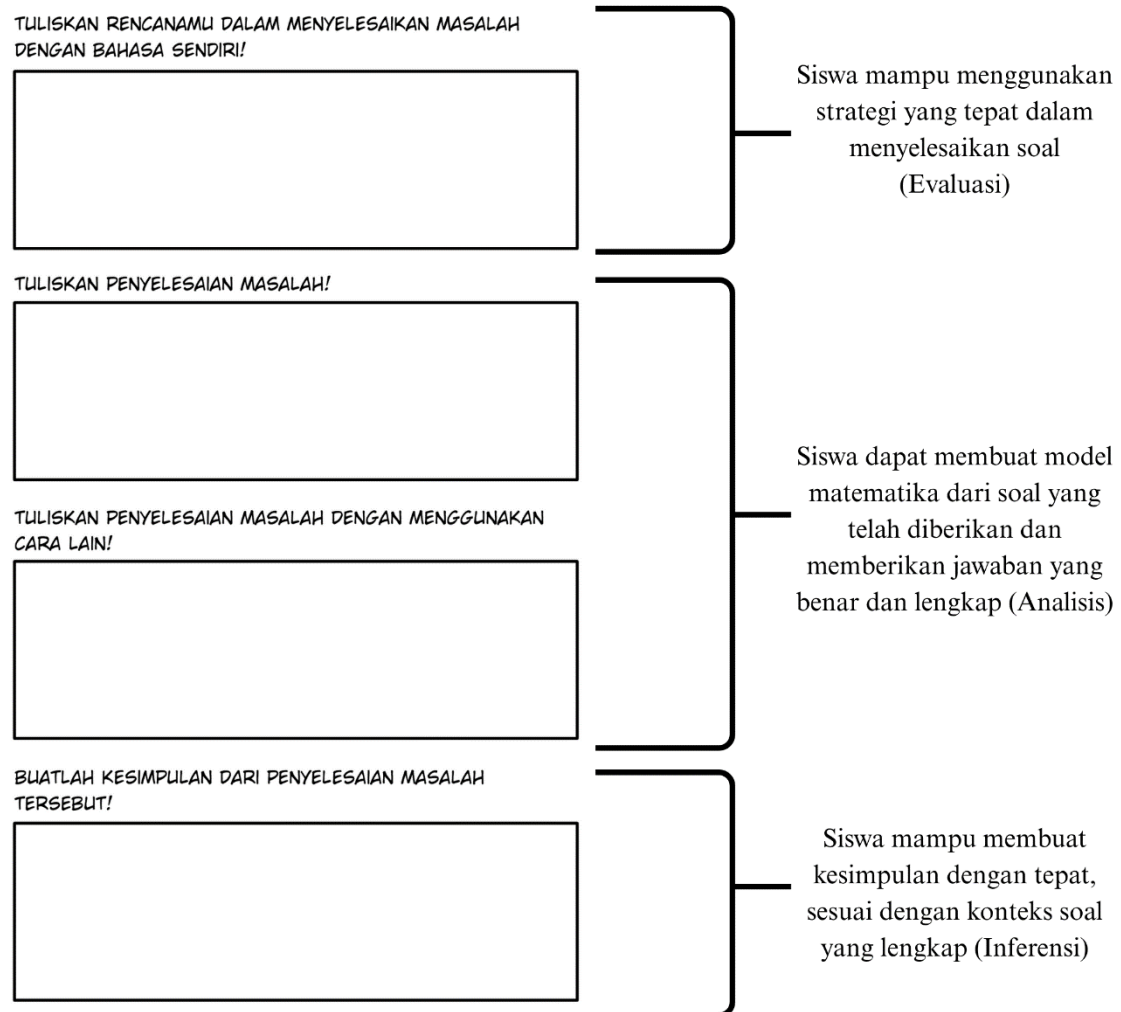
BERDASARKAN DATA TERSEBUT, TENTUKAN PELUANG EMPIRIK TERPILIHNYA LUMPIA DAN PELUANG TEORITIK TERPILIHNYA TAHU GIMBAL!

**PETUNJUK PENYELESAIAN:**

TULISKAN MASALAH YANG DITANYAKAN PADA PERMASALAHAN DI ATAS!

TULISKAN INFORMASI APA SAJA YANG KAMU KETAHUI DARI PERMASALAHAN DI ATAS!

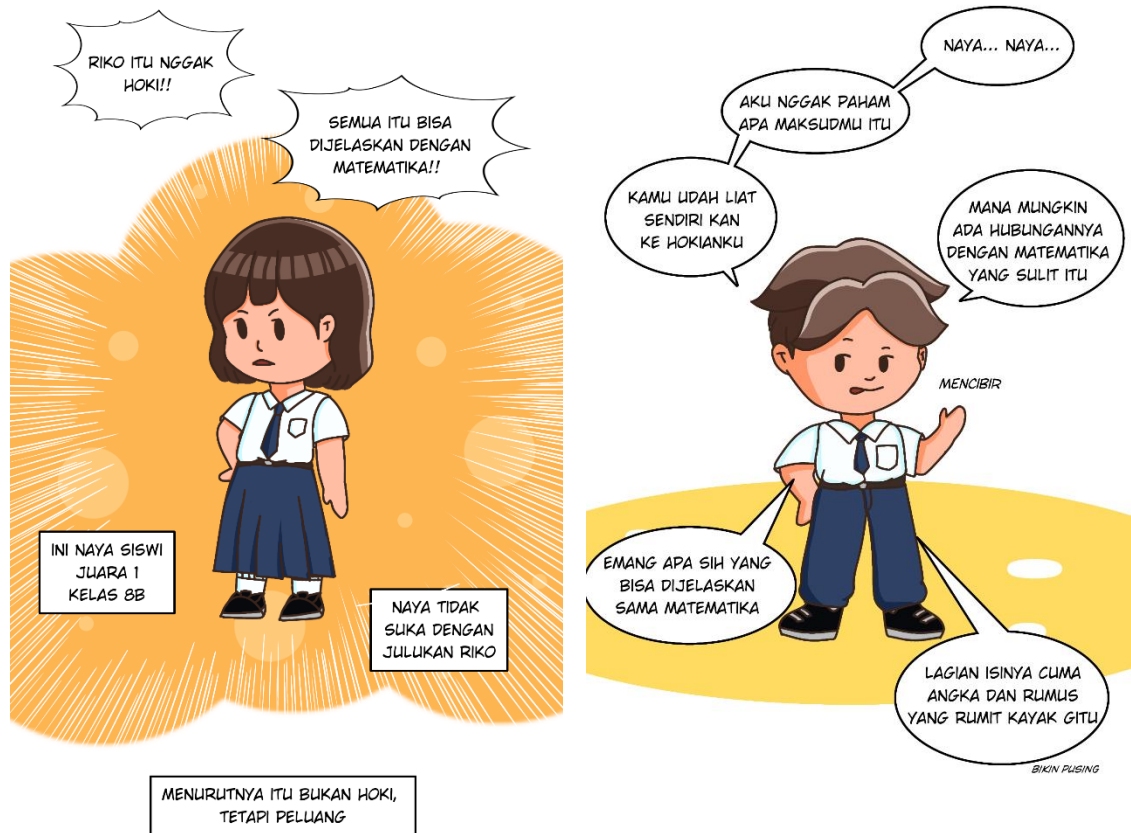
Siswa mampu merumuskan apa yang diketahui dan apa yang ditanyakan dan kesimpulan soal tersebut (Interpretasi)



The addition of these solution instructions aims to improve students' critical thinking skills. The given instructions have been adjusted to the indicators of critical thinking skills. For instance, as can be seen in Figure 2, students are asked to write down what the problem is in the question and what information they know in the problem (Interpretation). Furthermore, students are asked to write a problem-solving plan (Evaluation). Then, students are asked to write down the solution to the problem and find other alternative solutions (Analysis). Finally, students write down the conclusion of the solution to the problem (Inference).

In the developed e-comic, the PBL learning process is applied to the storyline. The story begins with a morning at school. Riko, a grade VIII student, has just won the lottery, again. Because he wins so often, his classmates call Riko "si paling hoki," or someone who often has good luck. Naya, Riko's classmate, thinks that it's not luck, but chance. Because of their different opinions, they argue. Luckily, their homeroom teacher, Mr. Hery, intervenes. Since it's already class time, Mr. Hery finally explains to the students about chance.

**Figure 4.**  
*E-Comics “Si Paling Hoki”*





Students are faced with problems originating from the surrounding environment, namely the game "Cublak-Cublak Suweng" (Figure 5). This aligns with the first syntax of the PBL model, which is student orientation to the problem.

**Figure 5.**  
*Problem Orientation*

KALIAN PASTI TAU  
PERMAINAN "CUBLAK-CUBLAK  
SUWENG" KAN?

CUBLAK CUBLAK SUWENG ADALAH SEBUAH PERMAINAN  
TRADISIONAL ANAK-ANAK YANG BERASAL DARI JAWA,  
KHUSUSNYA JAWA TENGAH DAN YOGYAKARTA

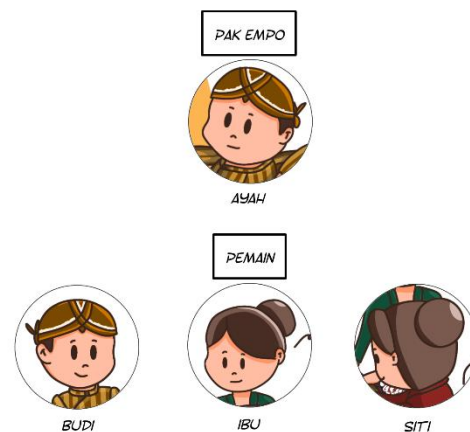


PERMAINAN INI MELIBATKAN LAGU  
DAN GERAKAN TANGAN,  
DI MANA SALAH SATU PEMAIN  
AKAN MENJADI "PAK EMPO"  
DAN BERTUGAS MENEBAK

SEMENTARA ITU, PEMAIN  
LAINNYA SECARA BERGANTIAN  
MENYEMBUNYIKAN BENDA KECIL,  
ATAU YANG DISEBUT "SUWENG",  
SAMBIL MEREKA MENYANYIKAN  
LAGU KHAS PERMAINAN INI

SI "PAK EMPO" HARUS FOKUS  
MENEBAK DI TANGAN SIAPA  
"SUWENG" ITU DISEMBUNYIKAN

BERDASARKAN ILLUSTRASI DI ATAS  
AYAH BERPERAN SEBAGAI "PAK EMPO"  
SEDANGKAN IBU, BUDI, DAN SITI  
BERTUGAS UNTUK MENYEMBUNYIKAN "SUWENG"



Students are given trigger questions regarding the relationship between the game "Cublak-Cublak Suweng" and the material on opportunities. Furthermore, students are given directions to form groups to discuss problems in the "Eksplorasi" and "Eksperimen" activities with teacher guidance, according syntax 2 PBL organizing students. As for the further activities, including guiding group investigations, developing and presenting work, and analyzing and evaluating the problem-solving process, their execution is handed over and adjusted according to the instructions given by the respective class teacher.

**Figure 6.**  
*Organizing Students*



E-Comics in PBL-Ethnomathematics that are developed are learning resource innovations that provide a different atmosphere for learning in class and outside the classroom. Students not only learn and understand mathematical concepts, but also get to know the culture around them at the same time. The ease of access to digital e-comics provides the advantage of unlimited accessibility for students to carry out learning. Based on the e-comic validity test by experts, a final result of 97.92% was obtained, which means very eligible. This means that the PBL-ethnomathematics e-comic is very worthy of being tested in mathematics learning to improve students' critical thinking skills. There are several preliminary studies by previous researchers that can strengthen this hypothesis. Research conducted by Tambunan et al. (2025) entitled "The Effectiveness of the Problem-Based Learning Model on Students' Mathematical Creative Thinking Ability" obtained the results of data analysis using the t-test, producing a significance value of  $0.00 < 0.05$  and a calculated tvalue of  $9.922 > t_{table}$  value of 2.03. Based on these findings, it can be concluded that the PBL model has a positive and significant effect on students' mathematical creative thinking abilities on the topic of circles. Research conducted by Fahrunnisa et al. (2021) entitled "Pendekatan Etnomatematika: Bagaimana Pengembangan Media Komik Dalam Pemecahan Masalah Pada Pembelajaran Matematika SD?" The

assessment results from subject matter experts, mathematics teachers, and media experts showed an average score of 4.12, categorized as adequate. The average student response score was 4.24, categorized as adequate. The development test, conducted using a pre-test and post-test, yielded a 14.5% increase, indicating a significant improvement in student understanding.

The development of this PBL-Ethnomathematics-based e-comic is strongly supported by cognitive theory, particularly the thinking of Vygotsky and Piaget. Vygotsky's theory, which emphasizes learning as a social and culturally mediated process (Huang, 2021), serves as the philosophical foundation for the ethnomathematics approach, which focuses on cultural factors (Amir & Risnawati, 2015). Similarly, the PBL model is supported by Piaget's idea that cognitive development results from individual interactions in an effort to understand the surrounding environment (Waseso, 2018). The relationship between these two theories is explained structurally through five stages of PBL syntax (Nur et al., 2016) starting from student orientation to the problem and organizing students, which carries a cognitive scheme (Piaget); continued with guiding group investigations that utilize the ZPD (Vygotsky); to the final stage of developing and presenting the results of the work, as well as analyzing and evaluating the problem-solving process. This entire process encourages students to process their experiences and local cultural context into more structured complex thinking skills.

#### 4. Conclusion

This research produces a new product, namely e-comics in PBL-Ethnomathematics towards critical thinking skills. The material chosen is the probability material of phase E of grade VIII. The e-comic created is entitled "Si Paling Hoki". This e-comic is suitable for use as an alternative media during classroom learning, and of course with teacher guidance. Based on the results of the e-comic eligibility validation by expert lecturers, the following percentage scores were obtained: the content eligibility aspect received a score of 98.96% (very eligible), the presentation eligibility aspect received a score of 96.67% (very eligible), the linguistic aspect received a score of 100% (very eligible), and the learning innovation aspect received a score of 92.86% (very eligible). The final result of the eligibility test obtained a percentage score of 97.92% which means very eligible. The validation results state that the development of e-comics in PBL-Ethnomathematics towards critical thinking skills is very eligible to be tested. Future research needs to conduct field trials to prove the effectiveness of the PBL-Ethnomathematics e-comic in improving students' critical thinking skills.

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