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# Effectiveness of Traditional Game-Based Learning: using *Panjat Pinang* Context to Improve Students' Mathematical Modelling Skills

**Nadiati Amarta[1], Darmawijoyo[1*], Yusuf Hartono[1]**
[1]Department of Mathematics Education, Sriwijaya University, Indonesia
darmawijoyo@unsri.ac.id

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**ABSTRACT**

This study aims to develop a context-based Learner Worsheet (LKPD) on comparison material using the traditional game of panjat pinang to enhance the mathematical modelling skills of seventh-grade junior high school. The research employed a design research approach with the Tessmer model, consisting of preliminary and formative evaluation stages. Instrument included expert validation sheets (to assess content, construct, and language), practicality questionnaires, and a mathematical modelling ability test (covering understanding tasks, mathematising, working mathematically, and explaining results). Data analysis involved calculating percentage scores for validity and practicality, along with descriptive analysis of students' mathematical modelling performance. The results indicate that the LKPD achieved high validity with an average score of 84,77% and good practicality with an average score of 81,25%. Field testing demonstrated its potential to improve students' performance in all four stages of mathematical modelling. In conclusion, integrating panjat pinang as a cultural context creates meaningful learning experiences, making the concept of comparison more accessible and engaging. The LKPD can serve as an effective alternative mathematics teaching material and a reference for developing other culturally relevant resources.

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## A. INTRODUCTION

Mathematics is regarded as a fundamental science, playing a pivotal role in numerous facets of life and education (Mahanani & Murtiyasa, 2016). One of the fundamental concepts in mathematics that learners must master is comparison, which serves as the foundation for understanding proportion, ratio, and other advanced mathematical ideas (Puriasih & Rati, 2022). To address challenges in learning comparison, context-based learning is a promising approach. Contexts that resonate with learners' experiences have been shown to improve comprehension and engagement (Zulkardi & Putri, 2019).

One relevant context is traditional games, such as *panjat pinang*, which can serve as an effective learning medium for comparison concepts. The game inherently involves comparative elements, such as the relationship between the height of the pole and the number of participants needed to reach the top (Windarto et al., 2019). Several studies have reported that incorporating traditional games into mathematics learning can enhance students' understanding and their ability in mathematical modelling (Maulida, 2020; Setiyadi, 2021; Setyawati et al., 2023; Wahid & Samta, 2022).

However, most of these studies have emphasized the general effectiveness of traditional games as learning media, without systematically integrating all stages of mathematical modelling. Prior research has often overlooked crucial aspects such as understanding tasks, mathematising, working mathematically, and explaining results (Fajri et al., 2022; Khusna & Ulfah, 2021; Nur Hasanah et al., 2023). This indicates a significant research gap in the development of learning tools that comprehensively support students' mathematical modelling processes using culturally relevant contexts, such as *panjat pinang*.

Comparison is also theoretically important as a foundation for building mathematical models. In modelling, students often use the concepts of ratio, proportion, and scale to simplify and represent real-world situations into mathematical form. These concepts enable learners to analyze relationships between quantities and make informed estimates and predictions. For example, understanding how the distance on a map corresponds to actual distances in the real world (scale). Conversely, situations such as the relationship between the number of workers and time taken to complete a task involve inverse proportional reasoning, which is equally vital in many practical contexts (Risdiyanti et al., 2024; Weiland et al., 2021).

Research has shown that students who are proficient in interpreting proportional and inverse proportional relationships demonstrate greater flexibility in solving real-world problems (Lesh & Doerr, 2003). These skills are not only essential in academic settings but are also integral to various fields such as science, engineering, and economics, where mathematical models often begin with identifying and quantifying comparative relationships (Karim, 2012). Furthermore, comparison-based reasoning forms a crucial part of students' development in quantitative literacy, which includes the ability to reason about ratios, percentages, and proportional changes in various formats, including graphs and tables (Roohr et al., 2014). Therefore, strengthening students' understanding of comparisons is a critical step toward enhancing their overall modelling competence.

Furthermore, mathematical modelling is also one of the key competencies measured in international assessments such as PISA (OECD, 2023a). This approach aligns with the Curriculum Standards and Educational Assessment Agency of the Ministry of Education and Culture on Learning Outcomes for Junior High School in the Merdeka Curriculum, which asserts that the objective of mathematics education is to cultivate students' proficiency in problem-solving, encompassing the ability to comprehend problems, formulate mathematical models, and solve or interpret the solutions obtained (Kemendikbudristek, 2022). This finding indicates that the ability to engage in mathematical modelling enables learners to translate real-world problems into mathematical language (Raharjanti et al., 2016; Saputri & Zulkardi, 2019).

However, based on PISA 2022 results, the mathematical modelling ability of Indonesian students remains limited, with only 18% of students attaining level 2 (OECD, 2023b). This finding underscores the necessity for the development of teaching materials that are not only contextual but also foster higher-order thinking skills, including the capacity to transform real-world problems into mathematical forms. Therefore, the objective of this research is to develop a valid and practical students' worksheet (LKPD) on comparison material using the context of panjat pinang, to support the mathematical modelling abilities of seventh-grade junior high school students.

## B. METHODS

This study adopted a design research approach using the Tessmer formative evaluation model, which consists of two primary phases, namely the preliminary phase and the formative evaluation phase (Tessmer, 2013). The goal was to develop a valid, practical, and potentially effective Learner Worksheet (LKPD) using the context of the traditional game panjat pinang to enhance seventh-grade students' mathematical modelling skills, particularly in the topic of comparison. The overall research procedure is depicted in Figure 1, which outlines the iterative process followed throughout the study.

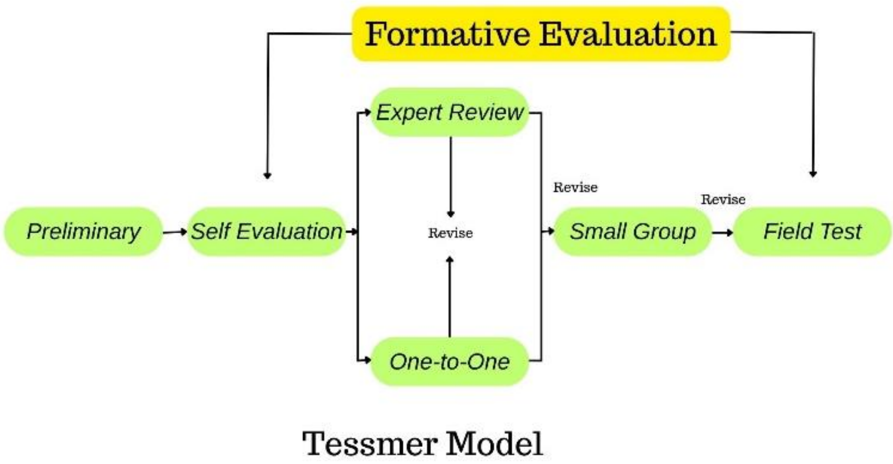


**Figure 1**. Research process

The preliminary phase focused on identifying student needs, defining learning objectives, and designing the initial prototype of the LKPD. The development integrated the modelling stages with culturally relevant contexts, in this case, the traditional game of *panjat pinang* to increase students' engagement and contextual understanding. The formative evaluation phase comprised the following sequential stages, namely: (1) self-evaluation: internal review by the researchers to refine LKPD structure, content flow, and alignment with modelling stages; (2) an expert review; assessment experts focusing on the validity of content, construct, and language; (3) a one-to-one evaluation: conducted with three students of varying ability levels to evaluate readability and clarity of tasks.; (4) a small group evaluation: involving six students, this stage assessed the practicality of the LKPD when used classroom setting; and (5) a field test: administered to 29 students to examine the potential effect of the LKPD on mathematical modelling skills. The modelling skills targeted through the LKPD follow four key stages, summarized in Table 1, which also served as a reference for designing the mathematical modelling test.

**Table 1.** Stages of Mathematical Modelling

| Stages of Mathematical Modelling | Descriptors |
|---|---|
| Understanding task | The identification of the salient information contained within the problem is presented. |
| Mathematising | The process of translating real-world problems into mathematical models is an essential step in the scientific method. |
| Working Mathematically | The utilisation of a predetermined mathematical model is a methodology employed in order to ascertain a solution to the problem. |
| Explaining Results | The following steps are to be taken to provide an explanation related to the mathematical solution obtained and to interpret the solution in terms of real-world applications. |

The research was conducted at SMP Negeri 11 Palembang, involving a total of 29 seventh-grade students. Each instrument contributed to answering the research objectives related to validity, practicality, and potential effectiveness of the LKPD product in supporting mathematical modelling ability.

## C. RESULT AND DISCUSSION

This study was conducted at SMPN 11 Palembang to develop and evaluate a contextual Learner Worksheet (LKPD) based on the traditional game of *panjat pinang* for enhancing students' mathematical modelling skills on the topic of comparison. The development and testing process followed the Tessmer formative evaluation model, including stages of self-evaluation, expert review, one-to-one, small group, and field test. The results are discussed in three main subsections: validity, practicality, and potential effectiveness.

### 1. Preliminary Stage

In the preliminary stage of the study, the researcher requested recommendations from teaching staff regarding the selection of students based on their level of mathematical ability, but in different classes. Following the completion of the validation process with the designated validator, the researcher proceeded directly to the one-to-one stage. This stage involved the researcher conducting three individual sessions with students and six small group sessions with students, as per the teacher's instructions (Tessmer, 2013).

The researcher furnished LKPD with comparison material concerning the stages of mathematical modelling within the context of *panjat pinang*. Moreover, the presentation of answers and the facilitation of joint discussions. The primary objective of this study is to develop a student worksheet (LKPD) based on the context of the traditional game of *panjat pinang*. The development of this worksheet aims to enhance students' mathematical modelling abilities in a valid, practical, and potentially impactful manner.

### 2. Formative Evaluation

a. Self-Evaluation

Initially, the researcher conducted an evaluation, assessing three characteristics: content, construct, and language used as an assessment. Following a comprehensive evaluation of the pertinent factors, a meticulous resolution of the identified issues, and a precise alignment with the overarching context of *panjat pinang*, the subsequent steps have been determined. The creation of Figure 2, an initial prototype, was the final stage of the research process. The researcher will also validate the data with the validator.

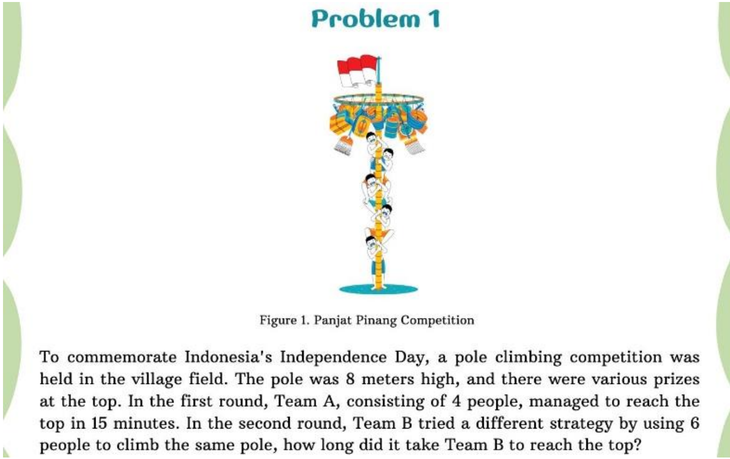
Problem 1

Figure 1. Panjat Pinang Competition

To commemorate Indonesia's Independence Day, a pole climbing competition was held in the village field. The pole was 8 meters high, and there were various prizes at the top. In the first round, Team A, consisting of 4 people, managed to reach the top in 15 minutes. In the second round, Team B tried a different strategy by using 6 people to climb the same pole, how long did it take Team B to reach the top?

**Figure 2.** LKPD Before Revision

b. Expert Review

The researcher conducts the expert review stage after conducting a self-evaluation. At this stage, the initial prototype will be validated by the validator. The validator will assess and evaluate the content, construction, and language of the designed LKPD. After the validation process, the researcher undertakes a rapid remediation of any issues identified in the LKPD, utilising the suggestions or comments provided by the validator. Please refer to Table 2, based on this, the LKPD was revised as shown in Figure 3, following the initial prototype in Figure 2.

**Table 2.** Comments and Suggestions by Expert Review

| Comments or Suggestions | Revision |
|---|---|
| 1. Redesigned the image | The image must be redesigned |
| 2. Question | The question sentence and the information provided in the question must be corrected. The problem should be made more congruent with the real situation |

Table 3 shows the average validity score of 84.77% categorized as "valid". Content validity was ensured by aligning tasks with the four stages of mathematical modelling: understanding task, mathematising, working mathematically, and explaining result, consistent with frameworks by Niss & Blum (2020).

**Table 3.** Validity Assessment by Expert Review

| Aspect | Indicator | Persentase |
|---|---|---|
| Content | The LKPD is predicated on mathematical modelling, which has been formulated by Learning Achievements and Learning Objectives. | 83,3% |
| | The present study will examine the suitability of problems in LKPD with comparative material. | 83,3% |
| | The issues encountered in LKPD have a detrimental effect on students' mathematical modelling abilities, | 83,3% |

| Aspect | Indicator | Persentase |
|---|---|---|
| Construct | The identification of significant and pertinent information by students is facilitated by issues in LKPD, which can then be utilised to solve problems. | 83,3% |
| | The presence of issues in LKPD has been demonstrated to encourage students to adopt systematic and logical problem-solving methodologies. | 83,3% |
| | Questions 1 and 2 are indicative of the initial stages of understanding tasks. | 83,3% |
| | Questions 3 and 4 are indicative of the process of mathematising. | 83,3% |
| | Question 5 is indicative of a stage in the process of working mathematically. | 75% |
| | Question 6 is intended to explaining results. | 75% |
| | The order of the question structure in LKPD is correct according to the stages of mathematical modelling. | 83,3% |
| Language | Selection of a contrasting background so that it is easy to read. | 100% |
| | The LKPD design has an attractive appearance to read. | 83,3% |
| | It is imperative to employ language that is by the Enhanced Spelling (EYD). | 83,3% |
| | The sentence structure of the LKPD is transparent. | 91,6% |
| | The sentences employed in the LKPD are unambiguous. | 91,6% |
| | The sentences employed I the LKPD are characterised by a high degree of intelligibility. | 83,3% |
| | The punctuation employed in the LKPD is accurate. | 91,6% |
| | Total | 84,77% |

The assessment encompasses various criteria, including the alignment of content with the curriculum, the clarity of language, the comprehensive structure of the modelling activity, and the precision of contextual illustrations. Subsequently, the group will engage in a series of exercises designed to reinforce the concepts discussed.

c. One-to-One

After the expert review stage, the researcher proceeded to the one-to-one stage. At this stage, three students were selected based on teacher recommendations: ABS (low ability), RO (middle ability), and IO (high ability). They were asked to work on the problems in the LKPD and provide comments or suggestions. During the students' work process, the researcher asked about and confirmed each content and language issue, as well as the students' responses to the problems, the obstacles they encountered, and their understanding of them. Table 4 displays the students' comments or suggestions about the LKPD.

**Table 4.** Comments and Suggestions by Students (One-to-One)

| Comments or Suggestions | Revision |
|---|---|
| Question literacy | Slight revision of words related to the problem to help students understand what information is needed to find a solution |

The researcher will revise the questions in Table 2 and Table 4 based on the expert reviews and student feedback. Figure 3 shows that the prototype is valid after revision.

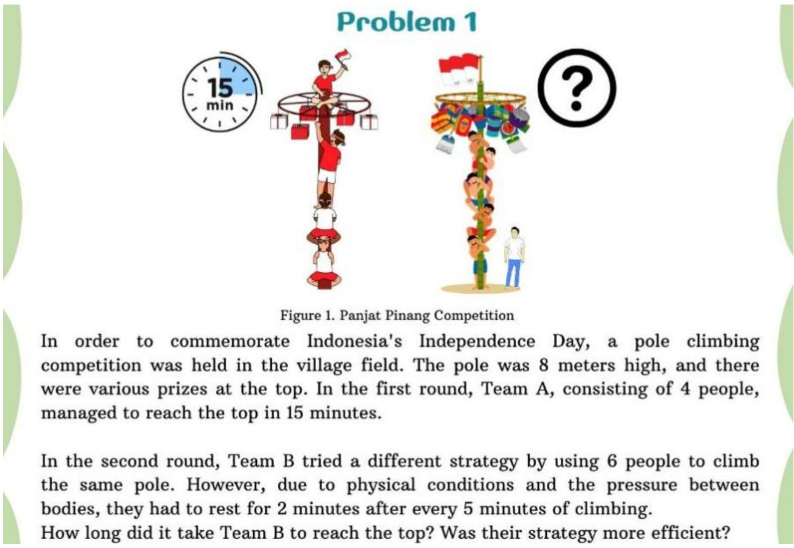


**Figure 3.** LKPD After Revision

d. Small Group

In the course of working on or presenting questions, small groups are formed to discuss the LKPD. At this stage, the task will be carried out by six seventh-grade students, who have been divided into two groups. The first group is as follows: The categories employed in this study are QA (high ability), IFG (middle ability), and SCU (low ability). The second group consists of AA (high ability), FN (middle ability), and BY (low ability). The practicality test, administered through small group evaluation, demonstrated that students demonstrated a strong aptitude for comprehending the instructions and exhibited a high level of enthusiasm in completing the LKPD activities. The results of the questionnaire demonstrated that 81,25% of students reported that they felt assisted in comprehending the concept of comparison due to the utilisation of the accessible, engaging, and enjoyable context of *panjat pinang*.

e. Field tests

The activity was conducted with a sample of 29 seventh-grade students from SMPN 11 Palembang, who had not participated in the one-to-one and small group stages. The selection of students was conducted based on teacher assessment, which encompassed categories of high, middle, and low ability. The implementation process was conducted throughout two meetings, each with a duration of 80 minutes, and was integrated into regular mathematics lessons. The teachers employed LKPD that had been validated and revised based on comparison material with the context of the traditional game of *panjat pinang*. The learning process was focused on four stages of mathematical modelling: understanding tasks, mathematising, working mathematically, and explaining results.

Before the initiation of the learning process, students were administered a preliminary test to assess their initial competencies in mathematical modelling. Following the conclusion of the learning process, students completed a post-test comprising a parallel question structure, the purpose of which was to measure increased abilities. Furthermore, data were collected using student engagement observation sheets, teacher reflection notes, and student worksheets as part of data triangulation.

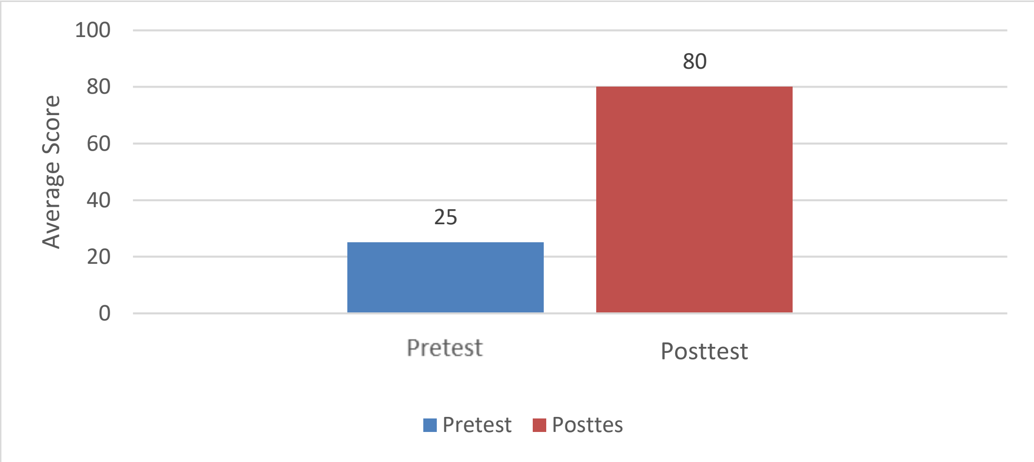


**Figure 4.** Comparison of Pretest and Posttest Scores

As illustrated in Figure 4, a comparison analysis of the mean pretest and posttest scores obtained by students before and after the implementation of LKPD is presented, with the analysis conducted within the context of the *panjat pinang* paradigm. The findings of the investigation demonstrated a substantial enhancement in the mathematical modelling competencies of the students. The mean score increased from 25 (pretest) to 80 (posttest), with 85% of students achieving the Minimum Completion Criteria (KKM). This increase in score is indicative of the development of students' abilities in understanding and solving comparative problems through a structured mathematical modelling approach. These results also indicate that the LKPD developed is not valid and practical, but also has a potential effect in improving students' mathematical thinking skills, especially in the four stages of mathematical modelling integrated into learning activities.

The results of the observations demonstrated that students exhibited a high level of enthusiasm in participating in learning activities, particularly in situations involving real-life scenarios with which they were familiar. Furthermore, teachers reported an enhancement in student participation, particularly among those who had previously tended towards passivity or a deficiency in mathematical confidence. In consideration of the findings, it can be concluded that contextual LKPD, grounded In the traditional game of *panjat pinang*, harbours potential efficacy in enhancing students' mathematical modelling competencies. This LKPD is also considered to be applicable in a classroom setting with the potential to offer a learning experience that is both enjoyable and meaningful for students, while also being relevant to their real-life experiences.

## 3. Result

Demonstrated a substantial increase in the mean posttest score from 25 to 80, with a completion rate 85%. This finding indicates that the developed LKPD is capable of assisting students in comprehending and resolving contextual issues through the four stages of mathematical modelling. The finding aligns with the conclusions of previous research, which demonstrated that learning mathematics based on cultural contexts and traditional games can enhance critical thinking and problem-solving skills (Maulida, 2020; Ramadanti et al., 2023; Saputri & Zulkardi, 2019). The *panjat pinang* context has been demonstrated to facilitate the exploration of mathematical concepts in a concrete and meaningful manner, thereby supporting the contextual learning approach that is advocated in the Merdeka Curriculum.

## D. CONCLUSION AND SUGGESTIONS

The findings of this study indicate that the development of the Learner Worksheet (LKPD) on comparison material using the context of *panjat pinang* meets the criteria of validity, with an average expert validation score of 84.77% (valid category), and practicality, with an average student response score of 81.25% (practical category). It has also proven effective in supporting seventh-grade students' mathematical modelling skills at SMP Negeri 11 Palembang, particularly in understanding tasks, mathematising, working mathematically, and explaining results. The integration of the *panjat pinang* facilitates meaningful learning by connecting abstract concepts to real-life experiences, thereby enhancing students' comprehension of comparison material.

These results imply that the LKPD can be effectively applied in classroom settings as an alternative learning medium, especially for improving mathematical modelling competencies. Furthermore, it offers a practical reference for teachers, teaching material developers, and future researchers to design culturally relevant and engaging mathematics learning resources. The development model used in this research also opens opportunities for further innovation in integrating local culture into curriculum materials across different topics and levels.

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