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Effectiveness of Ethnomathematics-Based Project Learning in Rumah Bubungan Tinggi

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Abstract

The aim of this research is to describe the effectiveness of project-based learning and discovery learning methods based on ethnomathematics at the Bubungan Tinggi house in terms of the ability to understand concepts, mathematical representation, and self-regulated learning. This research is a quasi-experimental study with a sample of two class VIII MTsN 2 Tanah Regency Seas for the 2022/2023 academic year selected using purposive sampling. The instruments used are concept understanding ability test questions, mathematical representation test questions, and self-regulated learning questionnaires. The validity of the pretest and posttest instruments carried out by two experts obtained valid and suitable results. The reliability of the instrument in the concept understanding ability test was 0.791, in the mathematical representation ability test it was 0.732, and in the self- regulated learning ability it was 0.909 in the very high category. The results of the research show that the project- based learning method based on ethnomathematics at the Bubungan Tinggi house is more effective than the discovery learning method based at the Bubungan Tinggi house in the ability to understand concepts.

Keywords*:* Bubungan Tinggi house, ethnomathematics, concept understanding, discovery learning, project-based learning, self-regulated learning.

Introduction

Education is an effort to make humans intelligent, moral, responsible, and independent. As stated in Indonesian Government Regulation No. 57 of 2021 concerning National Education Standards, education is a conscious and planned effort to create a learning atmosphere and learning process so that students actively develop their potential to have religious spiritual strength, self-control, personality, intelligence, noble character, and the skills needed by themselves, the community, the nation, and the state. Mathematics learning is closely related to everyday life, especially in developing the ability to calculate, measure, and find patterns. Tampubolon et al. (2019) state that building basic mathematical concepts is very important because of their usefulness in everyday life, whether social, cultural, economic, political, or natural, and even in technological advances based on mathematics. The objectives of teaching mathematics in schools based on Permendikbud No. 22 of 2016 concerning Basic and Secondary Education Process Standards are: (1) to improve intellectual abilities, especially the higher-level abilities of students, (2) to develop students' abilities to solve problems systematically, (3) to achieve high learning outcomes, (4) to train students in communicating ideas, especially in writing scientific papers, and (5) to develop students' character. Therefore, the learning process in educational units is conducted in an interactive, inspiring, enjoyable, and challenging manner, motivating students to participate actively, and providing sufficient space for initiative, creativity, and independence in accordance with the talents, interests, and physical and psychological development of students.

Permendikbud Number 37 of 2018 states that the core competency of knowledge in secondary schools is understanding knowledge based on curiosity about science, technology, arts, and culture related to visible phenomena and events. Meanwhile, the core competency of skills is trying, processing, and presenting in the concrete and abstract realms (writing, reading, calculating, drawing, and composing) in accordance with what is learned in school and other sources from the same perspective/theory. Based on the above process standards and core competencies of knowledge, the basic abilities that students must have when they learn mathematics include the ability to understand mathematical concepts and representations. Santrock (2011) explains that conceptual understanding in mathematics is a key aspect of mathematics as a whole and as preliminary knowledge for understanding more advanced material. A good conceptual understanding will encourage students to explore topics in depth. Students who have an understanding of mathematical concepts will find it very easy to solve mathematical problems (Radiusman, 2020). Therefore, mathematics learning needs to be directed towards understanding mathematical concepts and not just solving mathematical problems.

The five standards of mathematical ability possessed by students are problem-solving skills, communication skills, connection skills, reasoning skills, and representation skills (NCTM, 2000). Hwang & Chen (2007) explain that mathematical representation is the process of modeling realistic content into mathematical symbols. Mathematical representation is categorized into five types, namely realistic objects, concrete representations, arithmetic symbols, verbal representations, and images or graphs. Kartini (2009) states that mathematical representation is an expression of mathematical ideas and concepts intended to show the work of students in a certain way as a representation of their thoughts. Mathematical representation skills are important for students to help stimulate their thinking so that they can expand their capacity for systematic thinking (Mulyati, 2016). Representation skills also make it easier for students to understand mathematical concepts and the connections between topics.

However, based on the results of the Programme for International Student Assessment (PISA) survey in 2018 (OECD, 2018), only 28% of Indonesian students reached level 2 in mathematics. This figure is still relatively low when compared to the average across all OECD countries, where 76% of students achieved at least proficiency in mathematical concept and representation understanding. The average score obtained by PISA participants was 479, while Indonesia only obtained a score of 379, which shows that Indonesia is below the average score. This score is derived from the level of mathematical literacy, which includes the ability of students to analyze, give reasons, and convey ideas effectively, formulate, solve, and interpret mathematical problems in various forms and situations. Johar & Subianto (2013) stated that Indonesia's low performance in PISA is inseparable from the school curriculum, in which students are not accustomed to solving problems that require them to analyze, reason, argue, represent problems in various situations, and solve problems related to everyday life.

Putra et al. (2016) stated that based on the PISA results, students are still weak in geometry content, especially shapes and space, because they have difficulty understanding basic geometric concepts. Sholihah & Afriansyah (2017) mention several factors that cause students to have difficulties in geometry, especially quadrilaterals, namely a lack of understanding of the concepts and properties of quadrilaterals, a weak prior understanding of quadrilateral flat shapes, a lack of skills in using geometric ideas to solve mathematical problems related to quadrilaterals, and classroom conditions that are not conducive to learning. Afrilianto & Rohaeti (2018) mention that students experience difficulties in mastering the concepts of cubes and blocks, finding the formula for the surface area of cubes and blocks, and using the formula for the surface area of cubes and blocks because students only memorize ready-made formulas, so they often forget the formulas. Fauzi & Arisetyawan (2020) mention that students face difficulties in answering geometry questions in the use of concepts, the use of principles, and solving verbal problems. Based on interviews with teachers, it was found that students' understanding of flat-sided shapes was still lacking, as they were unable to distinguish between flat-sided shapes and flat shapes. In addition, students only remembered the formulas provided in the book to solve problems involving the surface area and volume of flat-sided shapes without understanding the concepts of surface area and volume, making it difficult for them to solve non-routine problems.

After the Covid-19 pandemic, the *online* learning model has changed the learning patterns of students, where they must manage themselves to study independently However, the unpreparedness of students in facing the pandemic and technological limitations have caused online learning to be ineffective. Purwanto et al. (2020) mentioned that there were several obstacles in the online process, one of which was unlimited working hours for teachers because they had to coordinate with students and parents outside of working hours. Students' unpreparedness in facing online learning caused them to not complete their assignments on time (Zahro et al., 2021). Students showed a lack of independence and dependence on others in completing the tasks given. Even though learning activities were conducted face-to-face again, their sense of responsibility for the tasks given was still lacking. Students submitted their assignments after the deadline, and often their work was the same as that of their friends. Therefore, it is important for students to manage themselves in their learning activities, which is better known as *self-regulated learning*.

Self-regulated learning is an ability whereby a person can activate and encourage thoughts (cognition), feelings (affection), and actions (actions) that have been planned systematically and repeatedly with the aim of achieving a goal in their learning. *Self-regulated learning* plays an important role in increasing students' motivation and metacognition in order to improve learning achievement (Zimmerman, 1989; Vrieling et al., 2012). This is reinforced by Pratama's (2017) research, which mentions the importance of SRL in moderating learning with a scientific approach to the learning outcomes of junior high school students.Teachers' professionalism in carrying out their roles as educators and instructors is very important to improve students' conceptual understanding and mathematical representation skills, which is reflected in the selection of appropriate learning methods that are in line with the material being studied, the characteristics of the students, and the objectives to be achieved.

An effective learning method to be presented to students that will build their conceptual understanding and representation skills is constructivist learning. Yulia (2019) states that the role of teachers in helping students understand the mathematical concepts taught is very much needed. Regulation of the Minister of Education and Culture Number 22 of 2016 concerning Standards for Primary and Secondary Education Processes states that the characteristics of learning in each education unit are different and are influenced by graduate competency standards and content standards at each level. Discovery/inquiry learning needs to be applied to strengthen the scientific approach, integrated thematic (interdisciplinary) approach, and thematic (within a subject) approach. It is highly recommended to use a learning approach that produces problem-solving-based work (*project-based learning)* to encourage students' ability to produce contextual work, both individually and in groups. The *discovery learning* method is a method that is oriented towards the cognitive development of students. In this method, the material is not given in its entirety to students with the expectation that they will organize the material independently.

The *discovery learning* method is effective in improving student learning outcomes (Hasanah et al. 2020; Rozak & Shodiqin, 2021) and students' mathematical abilities (Amalia, 2018; Ningsih & Pramaeda, 2020; Hanum et al., 2019; Juliani et al., 2022). Teachers act as mentors, providing guidance only when necessary and not fully guiding the learning process so that students are actively involved in the learning process. The *discovery learning* method also increases student activity in the classroom (Amalia, 2018). Apart from *discovery learning,* another method that has a student-oriented learning approach that is currently being developed is *project-based learning* (PjBL). Project-based learning provides opportunities for students to acquire important knowledge, skills, and dispositions by investigating open-ended questions to "make meaning" that they convey in a certain way. In project-based learning, students are directly involved in learning and create a more interesting and meaningful learning experience (Maya, 2016).

Project-based learning, according to (Barron & Hammond, 2008; Thomas et al., 1991) in Chen & Yang (2019), states that *project-based learning* is a systematic teaching and learning method that involves students in complex real-world tasks that produce products or presentations to an audience, enabling them to acquire knowledge and skills that improve their lives. *Project-based learning* can also improve students' conceptual understanding, mathematical representation, and *self-regulated learning* abilities. This can be seen in several research results, such as those conducted by Tampubolon & Nurdalilah (2021), which state that the project-based learning process requires students to have self-regulation abilities in learning. Learners who have self-regulation in learning will be interested in the material being taught, prepare for the learning process, and participate by asking questions or expressing ideas in class discussions. One aspect that can be developed in *project-based learning* is combining mathematics with culture (Marsigit et al., 2014).

According to Shirley (2001), ethnomathematics is a science used to understand mathematics in a cultural context. The ethnomathematics-based learning method makes it possible for material learned from their culture to motivate learning and make it easier for students to understand the material because it is directly related to their culture, which is their daily activity in society (Mahendra, 2017). Applying ethnomathematics-based *project-based learning* can create a more interesting and easier-to-understand learning atmosphere because it is related to the students' culture. There are similarities in the learning process using the *project-based learning* and *discovery learning* methods, such as student-centered activities, the investigation process, and learning objectives. However, in *project-based learning*, students are involved in real projects that include investigation, collaboration, and the application of concepts in a practical context (Thomas, 2000), while *discovery learning* encourages students to "discover" ideas or learning principles through independent exploration and experimentation (Bruner, 1961). Interviews with teachers revealed that learning using the *project-based learning* method had been implemented but was ineffective due to limited learning time and too much material being taught.

Learning using ethnomathematics has also not been widely applied in classrooms. Fajriah et al. (2023) mentioned that wetland ethnomathematics has only been used as the context for the questions given, but no illustrations describing the actual situation have been provided. The material in this study is flat-sided shapes taught in grade VIII. Ethnomathematics of Bubungan Tinggi houses will be used as the basis for the project learning applied. The shape of the Bubungan Tinggi house makes it a suitable medium for learning flat-sided shapes (Yuniar et al., 2022). Therefore, the researchers were interested in investigating the effectiveness of ethnomathematics-based *project-based learning* in terms of conceptual understanding, mathematical representation, and *self-regulated learning.*

Method

This study was conducted as a *quasi-experimental study*. A quasi-experimental study was used because it was not possible to control all relevant variables. The experimental research design was *a nonequivalent control group design* (Creswell, 2012). The population of this study was all eighth-grade students at MTsN Tanah Laut in the 2022/2023 academic year, consisting of eight classes with a total of 200 students. Sampling was conducted using purposive sampling, which is a non-random sampling technique in which the researcher has certain characteristics to become a research sample. Students in classes VIIIA and VIIIB were selected as samples, with class VIIIA being given the Bubungan Tinggi ethnomathematics-based *project-based learning* method and class VIIIB being given the Bubungan Tinggi ethnomathematics-based *discovery learning* method. The independent variables in this study were Bubungan Tinggi ethnomathematics- based *project-based learning* and *discovery learning*. The dependent variables were mathematical abilities influenced by the treatment given, namely conceptual understanding, mathematical representation, and *self-regulated learning.* The control variables in this study were the duration of learning, the teacher who delivered the learning method, the material taught, and the facilities, which were the same in both experimental classes.

The data collection instruments consisted of tests and questionnaires. The test instruments were used to measure conceptual understanding and mathematical representation abilities. Meanwhile, the questionnaire instruments were used to measure students' *self-regulated learning* abilities before and after the treatment, as well as observation sheets to determine how the learning activities were carried out. The validity of the instruments was assessed by two expert lecturers, and the validation results were analyzed using Gregory, which showed that the instruments were suitable for use in the study. The construct analysis of the *self-regulated learning* questionnaire yielded *KMO and Bartlett's test* values of 0.762 > 0.5. This value indicates that the factor analysis sample was sufficient for the study. Meanwhile, the reliability value *using Cronbach's alpha* obtained a concept understanding of 0.791 > 0.70, mathematical representation of 0.732 > 0.70, and *self-regulated learning* of 0.909 > 0.70. Therefore, it can be concluded that the instruments used in this study are reliable. The data analysis techniques used in this study consisted of descriptive analysis and inferential analysis.

Results

Students' Conceptual Understanding

The results showed significant improvements in students' conceptual understanding after treatment. As presented in Table 1, the ethnomathematics-based Project-Based Learning (PjBL) class increased from 61.90 (low) to 87.03 (high), while the ethnomathematics-based Discovery Learning (DL) class improved from 62.86 to 81.17 (medium). The gain in the PjBL class ($\Delta = 25.13$) was higher than in DL ($\Delta = 18.31$), indicating that PjBL provided greater benefits in conceptual development.

Table 1. Pretest and Posttest Scores of Conceptual Understanding

Group	Pretest Mean	Posttest Mean	Gain	Category

PjBL	61.90	87.03	25.13	High
DL	62.86	81.17	18.31	Medium

These results confirm that PjBL better supports students in constructing mathematical concepts through problem-solving and contextual projects. This is consistent with Amalia (2018) and Chen & Yang (2019), who highlighted PjBL's ability to enhance engagement and understanding.

Students' Mathematical Representation

Students' ability to represent mathematical ideas also improved in both groups (Table 2). The PjBL class improved from 70.45 to 84.87 ($\Delta = 14.42$), while the DL class improved from 70.21 to 83.14 ($\Delta = 12.93$). Although both reached the high category, PjBL still showed slightly greater improvement.

Table 2. Pretest and Posttest Scores of Mathematical Representation

Group	Pretest Mean	Posttest Mean	Gain	Category
PjBL	70.45	84.87	14.42	High
DL	70.21	83.14	12.93	High

This finding demonstrates that both models successfully facilitated students' abilities to use multiple representations, in line with NCTM (2000) and Hwang & Chen (2007). The relatively small difference between PjBL and DL suggests that representation skills are enhanced as long as students actively explore problems, regardless of the learning model.

Students' Self-Regulated Learning (SRL)

SRL scores improved in both groups, though the gains were moderate (Table 3). The PjBL class increased from 104.32 to 112.74 ($\Delta = 8.42$), while the DL class increased from 100.31 to 106.86 ($\Delta = 6.55$). Both remained in the high category.

Table 3. Pretest and Posttest Scores of SRL

Group	Pretest Mean	Posttest Mean	Gain	Category
PjBL	104.32	112.74	8.42	High
DL	100.31	106.86	6.55	High

These results indicate that both PjBL and DL support student independence and responsibility in learning. This aligns with Zimmerman (1989), who emphasized SRL as a key factor in motivation and academic performance.

Comparison Between Groups

Normality and homogeneity tests confirmed that assumptions were met, allowing the use of parametric analysis. One-sample t-tests showed that posttest scores in both groups were significantly above the minimum learning criteria ($p < 0.05$). Independent sample t-tests further revealed significant differences between groups in conceptual understanding, but not in representation and SRL (Table 4).

Table 4. Independent Sample t-Test Results

Variable	t-value	Sig. (p)	Interpretation
Conceptual Understanding	3.481	0.001	Significant
Mathematical Representation	1.243	0.219	Not significant
Self-Regulated Learning	1.857	0.068	Not significant

The findings suggest that ethnomathematics-based PjBL is significantly more effective than DL in improving conceptual understanding, while both models are equally effective in developing representation and SRL. This result strengthens previous research on the role of contextual and project-based approaches in mathematics education (Mahendra, 2017).

Discussion

This study examined the effectiveness of ethnomathematics-based project-based learning (PjBL) using the Bubungan Tinggi cultural context compared with ethnomathematics-based discovery learning (DL). The findings revealed that both approaches significantly improved students' conceptual understanding, mathematical representation, and self-regulated learning (SRL). However, PjBL demonstrated superior effectiveness in enhancing conceptual understanding, while representation and SRL improvements did not differ significantly between the two groups.

The superiority of PjBL in conceptual understanding can be explained by its emphasis on active construction of knowledge through projects. When students design, create, and present cultural-based mathematical models, they engage in deeper cognitive processes that strengthen their conceptual frameworks (Linda, 2015; Sarwoedi et al., 2018). This aligns with Widakdo (2017), who highlighted the role of problem-solving in developing students' mathematical representations. Similarly, integrating ethnomathematics provides contextual relevance, enabling students to relate mathematical concepts to local culture (Nugraha, 2022).

Both PjBL and DL contributed positively to representation skills, supporting earlier studies showing that meaningful problem exploration enhances students' ability to use diagrams, tables, and models to communicate mathematical ideas (NCTM, 2000; Muhamad, 2015). The non-significant difference between groups indicates that representation ability can be effectively fostered through either active discovery or project-oriented learning, as long as students are given opportunities to externalize their thinking.

Regarding SRL, both groups achieved high scores, suggesting that ethnomathematics-based tasks inherently encourage independence and responsibility. PjBL students slightly outperformed DL, which may be attributed to the requirement of time management, teamwork, and reflective evaluation throughout the project cycle (Zimmerman, 1989; Serin, 2019). However, as Apriandinata (2016) noted, SRL development is influenced by prior knowledge—students with weaker foundations may still struggle despite engaging methods.

The integration of Bubungan Tinggi ethnomathematics not only contextualized mathematics but also increased student motivation and cultural appreciation. Classroom observations confirmed that students were enthusiastic, actively discussed problems, and even extended collaboration beyond class hours through digital platforms. These findings demonstrate the potential of ethnomathematics as a meaningful bridge between cultural heritage and modern mathematics learning.

Based on the results of observations, classroom research, data analysis, and discussion, this study found the following results: (1) The ability of students to understand concepts and *self-regulated learning* in the Bubungan Tinggi ethnomathematics-based *project-based learning* class was superior, influenced by the high enthusiasm of students in that class, as seen in their active discussions even outside of mathematics class hours; (2) Students' conceptual understanding after being taught using both learning methods is described as follows: a) Most students were able to correctly state the definitions and elements of a flat shape, but a small number answered that the elements of a flat shape were incomplete; b) Students were confused by the shape of the Bubungan Tinggi roof, which is a horizontal triangular prism; some students answered that the roof was pyramid-shaped; c) Some students were still mistaken in determining the area of the vertical surface when calculating the surface area of a pyramid; and (3) In terms of representation skills, students were able to draw the flat-sided shapes given in the questions. However, a small number of students answered the questions incorrectly.

Conclusion

Based on the results of the study, it can be concluded that the Bubungan Tinggi ethnomathematics-based *project-based learning* approach is effective in terms of conceptual understanding, mathematical representation, and *self-regulated learning* abilities. The Bubungan Tinggi ethnomathematics-based *discovery learning* approach is effective in terms of conceptual understanding based on t-values, mathematical representation, and *self-regulated learning* abilities. Meanwhile, the Bubungan Tinggi ethnomathematics-based *project-based learning* approach is superior to the Bubungan Tinggi ethnomathematics-based *discovery learning* method in terms of conceptual understanding based on the t_{hitung} = 3.481>t_{tabel} = 2.00172. Further research can implement ethnomathematics-based *project-based learning* in geometry learning, especially flat-sided shapes, because this approach trains students to regulate themselves independently.

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