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Original Research

The Implementation of Project-Based Learning Assisted by GeoGebra-Based Ludomatika to Improve Students' Mathematics Learning Outcomes in Social Arithmetic

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Abstract

This study aims to improve students' mathematics learning outcomes in social arithmetic through the implementation of the Project-Based Learning (PjBL) model assisted by GeoGebra-based Ludomatika media in class VII-1 of SMP Negeri 11 Dumoga. This study employed a classroom action research (CAR) design conducted in the 2024/2025 academic year, involving 30 students of class VII-1 as research subjects. The study was conducted in two cycles, each consisting of planning, action implementation, observation, and reflection stages. Data were collected through tests and observations using essay tests and observation sheets for teacher and student activities. The results showed an improvement in students' learning outcomes following the implementation of learning assisted by GeoGebra-based Ludomatika. In addition, teacher activity increased from 77.77% in Cycle I to 83.33% in Cycle II, while student activity increased from 69.70% to 80.60%. These improvements indicate that the implementation of Project-Based Learning assisted by GeoGebra-based Ludomatika can support the improvement of students' mathematics learning outcomes in social arithmetic. Therefore, the use of this media can serve as an alternative to support the mathematics learning process in the classroom.

Keywords: Project-Based Learning; Ludomatika; GeoGebra; Mathematics learning outcomes; social arithmetic

1. Introduction

Education plays an important role in improving the quality of human resources. Through the educational process, students not only acquire knowledge but also develop the skills needed to address various problems in everyday life. Therefore, the learning process needs to be designed to encourage active student engagement and provide meaningful learning experiences. Mathematics is one of the subjects that plays an important role in education because it is closely related to logical and systematic thinking and problem-solving skills. However, in practice, mathematics is still often perceived as a difficult subject by some students. This condition may be influenced by the characteristics of the material, students' learning experiences, and the instructional approaches

used. Therefore, mathematics learning needs to be developed using approaches and media that can help students understand concepts and relate them to problems encountered in everyday life [1, 2].

One of the problems still encountered in mathematics learning is students' low learning outcomes. Learning outcomes can be influenced by various factors, including student characteristics, instructional strategies, the use of learning media, and student engagement during the learning process. The use of appropriate instructional models can provide students with opportunities to become more actively involved in the learning process and solve mathematical problems [3, 4].

Based on initial observations and interviews with the mathematics teacher at SMP Negeri 11 Dumoga, some students were found to experience difficulties in understanding and solving problems related to social arithmetic. These difficulties were particularly evident when students were required to connect mathematical concepts with problems related to everyday life. In addition, student activity during the learning process still needed to be improved because some students tended to receive information presented by the teacher, take notes, and solve problems based on the examples provided. This condition limited students' opportunities to explore concepts and actively solve problems.

This condition was also reflected in the students' daily test results on social arithmetic. The daily test results of class VII-1 students at SMP Negeri 11 Dumoga are presented in Table 1.

Table 1: Daily Test Results of Class VII-1 Students on Social Arithmetic

No.	Score	Category	Number of Students	Percentage
1	≥ 70	Completed	11	36.7%
2	< 70	Not completed	19	63.3%
Total			30	100%

Source: Daily test score records for social arithmetic of class VII-1 students at SMP Negeri 11 Dumoga.

Based on Table 1, 19 out of 30 students, or 63.3%, had not achieved a score of 70, while 11 students, or 36.7%, had achieved the score. The achievement criterion refers to the Minimum Mastery Criterion (KKM) for mathematics at SMP Negeri 11 Dumoga, which is 70. These data indicate that students' learning outcomes in social arithmetic still need to be improved.

Social arithmetic is closely related to various problems encountered in everyday life, such as selling prices, purchase prices, profits, losses, discounts, and percentages. Therefore, learning this topic needs to provide students with opportunities to understand concepts through contextual situations. The use of learning media can also help students gain more varied learning experiences and support their understanding of mathematical concepts [5, 6].

One instructional model that can be used to increase student engagement is Project Based Learning (PjBL). PjBL is an instructional model that places projects as a central component of the learning process. Through projects, students can be involved in planning, problem solving, producing a product, and presenting their work. The implementation of PjBL provides opportunities for students to develop knowledge and skills through more contextual activities [7, 8].

PjBL can also be used to provide learning experiences that allow students to work individually or in groups. During the process, students do not merely receive information from the teacher but are involved in investigating and solving problems. Important stages of PjBL include determining questions or problems, planning the project, developing a schedule, monitoring project implementation, presenting the results, and evaluating and reflecting on the process and project outcomes [9, 10].

The implementation of PjBL in mathematics learning has been investigated in various studies. Nurfitriyanti reported that the implementation of the Project Based Learning model was associated with students' mathematical problem-solving skills [11]. Other studies have also shown that PjBL can be used to improve mathematical creative thinking and problem-solving skills [12]. In addition, the implementation of PjBL in mathematics learning has been examined in relation to students' conceptual understanding and learning outcomes [13, 14]. These findings indicate that PjBL has the potential to support more active mathematics learning oriented toward problem solving.

Learning media play an important role in supporting the mathematics learning process because they can help teachers deliver material more effectively while increasing student activity and engagement. The use of multimedia-based learning media in mathematics education has been shown to support learning management, increase student activity, and achieve classical learning mastery [15]. Teaching aids are often considered part of learning media because they are used as supporting tools to facilitate the learning process. In mathematics education, the use of teaching aids can help students understand abstract concepts, thereby making the learning process more effective and efficient [16].

The use of interactive media in mathematics learning can also increase student engagement and support the learning process. Diu et al. showed that the use of interactive multimedia in mathematics learning yielded very good results in terms of teacher competence, student activity, and student responses [17].

One digital medium that can be used in mathematics learning is GeoGebra. GeoGebra is dynamic mathematics software that can be used to represent and explore various mathematical concepts, including arithmetic, geometry, algebra, and calculus [18]. The use of GeoGebra can support the presentation of mathematical concepts in a more visual and interactive manner and can therefore serve as an alternative for developing mathematics learning media.

In addition to technology-based media, games can also be utilized as learning media. Ludo is a game that can be played individually or in groups and has relatively simple rules. These characteristics allow the Ludo game to be modified into a learning medium containing mathematical activities or materials [19]. One form of such modification is Ludomatika, a game-based instructional aid designed to support the mathematics learning process. The use of Ludomatika is expected to create a more engaging learning environment and increase student participation in learning activities [20].

In this study, GeoGebra-based Ludomatika is used as a learning medium in the implementation of Project Based Learning on social arithmetic. The integration of a project-based learning model with game-based and interactive media is expected to provide students with more active and contextual learning experiences. Students not only receive explanations of social arithmetic concepts but are also involved in learning activities that encourage them to apply these concepts to problem-solving situations.

Based on the problems identified among class VII-1 students at SMP Negeri 11 Dumoga and previous research on Project Based Learning, learning media, and mathematics instructional aids, this study was conducted to improve students' mathematics learning outcomes in social arithmetic through the implementation of the Project Based Learning model assisted by GeoGebra-based Ludomatika. Therefore, the action hypothesis of this study is that the implementation of Project Based Learning assisted by GeoGebra-based Ludomatika can improve the mathematics learning outcomes of class VII-1 students at SMP Negeri 11 Dumoga in social arithmetic.

2. Methods

This study employed Classroom Action Research (CAR), conducted during the even semester of the 2024/2025 academic year at SMP Negeri 11 Dumoga. The research subjects consisted of 30 seventh-grade students in class VII-1, comprising 14 male students and 16 female students. The study adopted the Kemmis and McTaggart model, which consists of four stages in each cycle: planning, action, observation, and reflection. The learning intervention applied Project-Based Learning (PjBL) assisted by GeoGebra-based Ludomatika. The study was conducted in two cycles, with improvements in the subsequent cycle based on the results of reflection from the previous cycle.

Data were collected through observation and tests. Observation was used to obtain data on teacher and student activities during the learning process, while tests were used to measure students' learning outcomes on the topic of social arithmetic. The instruments consisted of a teacher activity observation sheet, a student activity observation sheet, and an essay test. The test was developed based on the predetermined learning objectives and indicators.

The teacher activity observation sheet consisted of 18 aspects covering introductory activities, core activities based on the six stages of PjBL, and closing activities. Each aspect was assessed using a scale of 1–4, namely

1 = poor, 2 = fair, 3 = good, and 4 = very good. The percentage of teacher activity was calculated using the following formula:

$$P_g = \frac{S_g}{S_{g,\max}} \times 100\%, \tag{1}$$

where P_g is the percentage of teacher activity, S_g is the total score obtained, and $S_{g,\max}$ is the maximum score.

Student activity observations covered five aspects: the ability to use GeoGebra-based mathematical teaching aids, the ability to analyze and solve mathematical problems, the ability to work collaboratively in groups, the ability to present the results of their work, and the ability to understand mathematical concepts. Each aspect was assessed using a scale of 1–5, namely 1 = very poor, 2 = poor, 3 = fair, 4 = good, and 5 = very good. The percentage of student activity was calculated based on the ratio between the score obtained and the maximum score, as follows:

$$P_s = \frac{S_s}{S_{s,\max}} \times 100\%, \tag{2}$$

where P_s is the percentage of student activity, S_s is the total score obtained, and $S_{s,\max}$ is the maximum score.

Learning outcome data were analyzed descriptively by calculating the mean score and classical completeness. The students' mean score was calculated using:

$$\bar{X} = \frac{\sum X}{N}, \tag{3}$$

where $\bar{X}$ is the mean score, $\sum X$ is the total score of all students, and N is the number of students.

Students were considered to have achieved mastery if they obtained a score of at least 70, in accordance with the applicable Minimum Completeness Criterion (KKM) at SMP Negeri 11 Dumoga. Classical completeness was calculated using the following formula:

$$K = \frac{n_t}{N} \times 100\%, \tag{4}$$

where K is the percentage of classical completeness, n_t is the number of students who achieved a minimum score of 70, and N is the total number of students. The intervention was considered successful if at least 80% of the students achieved learning mastery. The percentage of learning achievement was categorized as very high ($\geq$ 80%), high (60%–< 80%), moderate (40%–< 60%), low (20%–< 40%), and very low ($\leq$ 20%).

3. Results and Discussion

3.1 Research Results

This classroom action research aimed to improve students' mathematics learning outcomes on the topic of Social Arithmetic through the implementation of the Project Based Learning (PjBL) model assisted by GeoGebra-based Ludomatika teaching aids. The research was conducted in two cycles. Each cycle consisted of two learning meetings and one test at the end of the cycle. Each meeting lasted for 2×40 minutes. The research data were obtained through observations of teacher and student activities and learning outcome tests administered at the end of each cycle.

3.1.1 Results of Teacher and Student Activity Observations in Cycle I

Teacher activity was observed during the learning process to determine the implementation of learning using the PjBL model assisted by GeoGebra-based Ludomatika. Based on the 18 observed aspects, a total score of 56 out of a maximum score of 72 was obtained, resulting in a teacher activity percentage of 77.77%. This result was still below the predetermined success indicator of at least 80%.

Student activity was also observed during the two meetings in Cycle I. The results of the observations of the five aspects of student activity are presented in Table 2.

In general, student activity increased from the first meeting to the second meeting. The average student activity in Cycle I reached 70% and was classified as moderate. This condition indicates that students were beginning to adapt to project-based learning and the use of teaching aids, but their involvement had not yet reached the success indicator of 80%.

Table 2: Results of Student Activity Observation in Cycle I

Student Activity Aspect	Meeting 1	Meeting 2	Average
Ability to use GeoGebra-based teaching aids	0%	73%	37%
Ability to analyze and solve problems	80%	83%	82%
Ability to work cooperatively in teams	67%	80%	73%
Ability to present the work results	73%	77%	75%
Ability to understand mathematical concepts	77%	87%	82%

Several obstacles were identified in Cycle I, including students who paid insufficient attention to the learning process, were not actively asking or answering questions, lacked confidence in expressing their opinions, and had not yet fully understood the PjBL learning stages and the use of GeoGebra-based Ludomatika.

3.1.2 Student Learning Outcomes in Cycle I

The test administered at the end of Cycle I showed that, out of 30 students, 17 students obtained a score of at least 70, while 13 students did not achieve this score.

Table 3: Student Learning Test Results in Cycle I

Score	Number of Students	Percentage	Description
≥ 70	17	56.67%	Complete
< 70	13	43.33%	Incomplete
Total	30	100%	

Based on Table 3, the classical mastery level in Cycle I was 56.67%. This result had not yet reached the predetermined success indicator, namely at least 80% of students achieving a minimum score of 70. Therefore, the action was continued to Cycle II.

Based on the reflection results from Cycle I, several improvements were implemented in Cycle II. The teacher provided more intensive motivation to passive students, improved communication with students to build their confidence, and provided more structured explanations regarding the PjBL stages and the use of GeoGebra-based Ludomatika. The teacher also provided guidance during group activities so that students could participate more effectively in the learning process and collaborate in completing the assigned tasks.

3.1.3 Results of Teacher and Student Activity Observations in Cycle II

After improvements were implemented based on the reflection results from Cycle I, teacher activity in Cycle II increased. Based on the 18 observed aspects, a total score of 72 out of a maximum score of 72 was obtained, resulting in a teacher activity percentage of 83.30%. This result met the minimum success indicator of 80%.

Student activity in Cycle II also increased. The results of observations of the five aspects of student activity are presented in Table 4.

Table 4: Results of Student Activity Observation in Cycle II

Student Activity Aspect	Meeting 1	Meeting 2	Average
Ability to use GeoGebra-based teaching aids	70%	80%	75%
Ability to analyze and solve problems	67%	83%	75%
Ability to work cooperatively in teams	83%	87%	85%
Ability to present the work results	83%	83%	83%
Ability to understand mathematical concepts	80%	90%	85%

Based on these data, the average student activity in Cycle II reached approximately 81%. This result indicates that students became more active in using the teaching aids, working cooperatively in groups, completing tasks, and presenting their work. The percentage also exceeded the predetermined success indicator of 80%.

3.1.4 Student Learning Outcomes in Cycle II

The learning outcome test administered at the end of Cycle II showed an increase in student learning mastery compared with Cycle I.

Table 5: Student Learning Test Results in Cycle II

Score	Number of Students	Percentage	Description
≥ 70	25	83.33%	Complete
< 70	5	16.67%	Incomplete
Total	30	100%	

The classical mastery level in Cycle II was calculated as follows:

$$K = \frac{25}{30} \times 100\% = 83.33\%. \tag{5}$$

Based on Table 5, 25 out of 30 students achieved a minimum score of 70. The classical mastery percentage of 83.33% exceeded the success indicator of 80%. Based on the success criteria used in the study, this result was classified as very high.

These results indicate that student learning mastery in Cycle II had achieved the predetermined success indicator. Therefore, the research was concluded in Cycle II.

3.1.5 Comparison of Results between Cycle I and Cycle II

The comparison of the research results between Cycle I and Cycle II is presented in Table 6.

Table 6: Comparison of Research Results between Cycle I and Cycle II

Component	Cycle I	Cycle II	Increase
Teacher activity	77.77%	83.30%	5.53 percentage points
Student activity	70%	81%	11 percentage points
Student learning mastery	56.67%	83.33%	26.66 percentage points

Table 6 shows that teacher activity, student activity, and student learning mastery increased from Cycle I to Cycle II. Teacher activity increased by 5.53 percentage points, while student activity increased by 11 percentage points. Student learning mastery increased by 26.66 percentage points, from 56.67% in Cycle I to 83.33% in Cycle II.

3.2 Discussion

The results showed an increase in learning activity and student learning outcomes following the implementation of the Project Based Learning model assisted by GeoGebra-based Ludomatika on the topic of Social Arithmetic. The improvement was reflected in the observations of teacher and student activities as well as student learning mastery across the cycles.

In Cycle I, teacher activity reached 77.77%, while student activity reached 70%. These results indicate that the implementation of PjBL had not yet proceeded optimally. Some students remained passive, lacked confidence in asking questions and expressing their opinions, and were not yet accustomed to project-based learning stages and the use of GeoGebra-based Ludomatika. This condition was also reflected in student learning mastery, which reached only 56.67%.

The reflection results from Cycle I served as the basis for improvements in Cycle II. The teacher provided more intensive assistance to students, particularly those who were less active, explained the PjBL stages and the use of the teaching aids again, and provided motivation to increase students' confidence in participating in learning activities. These improvements were followed by an increase in teacher activity to 83.30% and student activity to approximately 81%.

The improvement in learning activity was also accompanied by an increase in student learning outcomes. Learning mastery increased from 56.67% in Cycle I to 83.33% in Cycle II. Thus, an increase of 26.66 percentage points occurred, and the classical mastery indicator of 80% was achieved.

The implementation of PjBL provided students with opportunities to participate in group activities, complete tasks or projects, use teaching aids, and present their work. These activities provided a more active learning experience and encouraged student involvement in the learning process. This finding is consistent with Puspasari [19], who reported that Project Based Learning can be used to improve students' independence and academic achievement through activities involving the development of innovative mathematics teaching aids.

The use of GeoGebra-based Ludomatika in this study also provided students with opportunities to interact directly with the learning media. Students did not merely receive explanations from the teacher but were involved in activities involving the use of teaching aids, discussion, problem solving, and presentation of their work. This condition can contribute to creating a more active learning environment and providing students with a more concrete learning experience.

Nevertheless, the improvement in learning outcomes in this study should not be attributed solely to the use of GeoGebra-based Ludomatika. The improvement occurred alongside the implementation of the PjBL model, improvements in teacher activity, increased student activity, and instructional improvements based on reflection at each cycle. Therefore, the findings of this study are more appropriately interpreted as an improvement in learning outcomes following the implementation of the overall instructional intervention.

Based on the research findings, the implementation of Project Based Learning assisted by GeoGebra-based Ludomatika can serve as an alternative learning approach for improving students' mathematics learning outcomes on the topic of Social Arithmetic. The success of the intervention was demonstrated by the achievement of 83.33% classical mastery in Cycle II, which exceeded the predetermined success indicator of 80%.

4. Conclusion

Based on the research results and discussion, it can be concluded that the implementation of the Project Based Learning (PjBL) model assisted by the innovative mathematics teaching aid Ludomatika based on GeoGebra can improve students' mathematics learning outcomes on the topic of Social Arithmetic in Grade VII-1 at SMP Negeri 11 Dumoga. The improvement was reflected in teacher activity, student activity, and student learning mastery from Cycle I to Cycle II.

Teacher activity increased from 77.77% in Cycle I to 83.30% in Cycle II, representing an increase of 5.53 percentage points. Student activity also increased from 70% in Cycle I to 81% in Cycle II, representing an increase of 11 percentage points. These improvements indicate that the learning process using the PjBL model assisted by GeoGebra-based Ludomatika became more optimal in Cycle II.

Student learning outcomes also improved. In Cycle I, 17 out of 30 students achieved a minimum score of 70, resulting in a classical mastery level of 56.67%. In Cycle II, the number of students achieving mastery increased to 25, with a percentage of 83.33%. Thus, the classical mastery level increased by 26.66 percentage points. The mastery percentage in Cycle II exceeded the predetermined success indicator of 80%.

With the achievement of a classical mastery level of 83.33% in Cycle II, the research action was considered successful and the study was concluded in Cycle II. These results indicate that PjBL assisted by GeoGebra-based Ludomatika can serve as an alternative learning approach to support the improvement of students' mathematics learning outcomes on the topic of Social Arithmetic.

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Conflicts of Interest

The authors declare no conflict of interest.

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