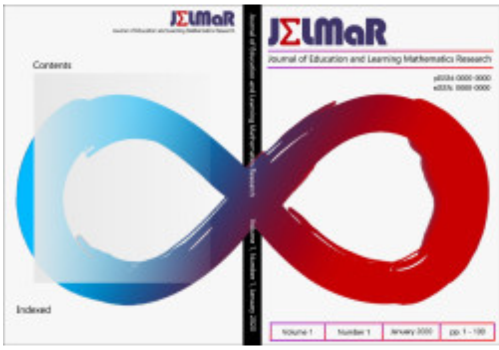

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Analyzing the Use of Snowball Throwing Model to Enhance Comprehension of Linear Functions: A Qualitative Study

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Abstract: *This study aims to explore the teaching and learning process of linear functions through the implementation of the Snowball Throwing learning model. A qualitative approach was employed, with data collected via observations, in-depth interviews, and documentation of the learning activities. The findings reveal that the Snowball Throwing model's syntax—including the delivery of material, group formation, group leader explanations, question writing and throwing, as well as group discussion and evaluation—creates an active and collaborative learning environment. This process encourages students to develop key indicators of mathematical conceptual understanding: the ability to restate the concept of linear functions in their own words, classify objects according to the concept's characteristics, and provide accurate examples and non-examples. Moreover, students demonstrate the ability to represent the concept in various mathematical forms, such as graphs and algebraic expressions, and apply the concept effectively in solving contextual problems. The interactive question-and-answer sessions and group discussions prove effective in strengthening conceptual understanding and clarifying misconceptions. This study recommends the use of the Snowball Throwing model as a participatory teaching strategy to enhance student engagement and improve the quality of mathematical conceptual understanding, particularly in the topic of linear functions.*
Keyword: conceptual understanding, linear functions, mathematical representation, problem solving, snowball throwing

INTRODUCTION

Mathematics plays a fundamental role in developing students' logical thinking and problem-solving skills. Among mathematical topics, linear functions are essential as they form the foundation for understanding more complex functions and real-world applications (Adu-Gyamfi & Bossé, 2014; Thonhongsa et al., 2024; Zandieh et al., 2017).However, many students face difficulties in grasping the concept of linear functions, which impacts their ability to solve related mathematical problems effectively (Hodnik Čadež & Manfreda Kolar, 2015).

One of the challenges in learning linear functions lies in students' low conceptual understanding, which results in rote memorization rather than meaningful comprehension (Aygör & Ozdag, 2012; Catarino & Vasco, 2014; Xu et al., 2010).This issue is often linked to traditional teaching methods that emphasize passive learning and limit student interaction (Ratna Herawati et al., 2024; Serhan, 2019). Therefore, there is a need for innovative learning models that foster active engagement and deeper understanding.

The Snowball Throwing model is a collaborative learning strategy designed to enhance student interaction through question-and-answer activities (Sartika et al., 2020). This model involves several steps such as group discussions, exchanging questions by throwing paper balls, and collaborative problem-solving, which encourage peer learning and critical thinking (Karlina & Amelia, 2019; Ofridaningsih et al., 2023).

Previous studies have shown that Snowball Throwing can improve student motivation and understanding in various subjects, including mathematics(Indraswari, 2022)). For example, Puspitarini et al. (2023) found that this model increased students' engagement and ability to explain mathematical concepts clearly. However, research specifically targeting linear functions using Snowball Throwing is still limited.

Understanding mathematical concepts involves several indicators: restating concepts in one's own words, classifying objects according to concept characteristics, providing examples and non-examples, representing concepts in various mathematical forms, and applying concepts to problem-solving (Ma'sum & Nurkolis, 2018).These indicators serve as benchmarks to assess students' conceptual understanding comprehensively.

Several researchers emphasize the importance of learning models that support these indicators by encouraging active participation and collaborative learning(Ofridaningsih et al., 2023). The Snowball Throwing model aligns with these principles by promoting dialogue, questioning, and peer feedback.

Despite these advantages, the effectiveness of Snowball Throwing in enhancing conceptual understanding of linear functions needs to be explored qualitatively, especially to capture the depth of students' thought processes and learning experiences (Creswell & Guetterman, 2019)

Therefore, this study aims to analyze how the Snowball Throwing model supports students in developing their understanding of linear functions based on the key indicators of mathematical concept comprehension. The qualitative approach will provide a detailed description of the learning dynamics and conceptual gains. Based on this background, the research problems are formulated as follows:

How is the implementation of the Snowball Throwing model in teaching linear functions conducted?

How does the Snowball Throwing model influence students' ability to restate, classify, and provide examples related to the concept of linear functions?

In what ways do students represent linear function concepts mathematically and apply them in problem-solving through the Snowball Throwing model?

What challenges do students face in understanding linear functions during the Snowball Throwing learning process?

METHOD

This study employed a qualitative descriptive approach to explore the implementation and impact of the Snowball Throwing learning model on students' conceptual understanding of linear functions. The research was conducted in an eighth-grade class at MTs Bahrul Maghfiroh with two purposively selected students based on their active participation and ability to articulate their understanding during the learning process. Data were collected through observations of the learning activities to document the implementation of the Snowball Throwing model and student interactions, semi-structured interviews with the selected students to gain insights into their conceptual understanding and learning experiences, and documentation such as student worksheets, written questions, and notes from group discussions to analyze students' conceptual expressions and problem-solving approaches. The learning process followed the syntax of the Snowball Throwing model, which included the teacher presenting the material, dividing students into small groups, group leaders explaining the material to their members, students writing questions about the material, rolling and throwing the questions as paper balls among peers, answering the received questions, group discussions to draw conclusions, teacher evaluations to assess understanding, and closing with feedback and assignments. Data analysis was conducted qualitatively using thematic analysis based on indicators of mathematical conceptual understanding, including the ability to restate concepts, classify objects, provide examples and non-examples, represent concepts in various mathematical forms, and apply concepts in problem-solving. Data validity was enhanced through triangulation of multiple data sources. Ethical considerations were addressed by ensuring participant confidentiality, voluntary participation, and obtaining informed consent prior to data collection.

RESULT AND DISCUSSION

Result

Subject 1 demonstrated a clear understanding of linear functions. During the interview, the student was able to articulate the concept by stating, *"I think linear functions are functions where the graph is a straight line. The equation looks like $y = mx + c$."* This statement was coded under Open Coding as "Understanding concept," indicating the student's ability to restate the mathematical concept in their own words. Further, Subject 1 classified functions effectively, correctly distinguishing linear from non-linear functions based on graph shape and equation structure, coded as Classification ability. For example, the student said, *"If the graph is a straight line and the equation is like $y = mx + c$, then it's linear."* In representing the concept, Subject 1 mentioned using graphs, tables, and algebraic expressions, which relates to the Representation skills code. The student noted, *"I draw the graph, write the equation, and sometimes make a table of values,"* reflecting a multi-representational understanding. Regarding problem-solving, Subject 1 applied slope and intercept concepts but expressed difficulty in verifying answers: "*Sometimes it is hard to check if my answer is correct."* This was coded as Problem-solving challenges, highlighting an area needing further support. Through Axial Coding, these open codes were grouped into categories reflecting key conceptual understanding indicators: conceptual understanding, classification, representation, and application. Selective Coding identified the core category as "Development of mathematical conceptual understanding facilitated by Snowball Throwing." The collaborative nature of the model encouraged peer discussion and helped deepen the subject's understanding, although verification skills required enhancement.

Subject 2 similarly expressed understanding of linear functions, emphasizing steady change and multiple representations: "*For me, linear functions are about relationships that change steadily, and I can make a table or graph to show that."* This again was coded as Understanding concept and Representation skills in open coding. In classification, Subject 2 correctly identified linear versus non-linear functions based on equation characteristics, reflected in the code Classification ability: "*If the function has squares or exponents, then it's not linear."* Subject 2 also showed proficiency in providing examples and non-examples, consistent with conceptual clarity. In problem-solving, Subject 2 followed procedural steps similarly but shared difficulty in verifying answers, which was again coded as Problem-solving challenges. Axial coding grouped these codes similarly under conceptual understanding, classification, representation, and application categories, while selective coding emphasized the model's role in enhancing collaborative learning and concept internalization, with verification remaining a challenge.

To gain a deeper understanding of students' mathematical conceptual abilities and their problem-solving experiences, the study employed a systematic qualitative data analysis method. The coding process used in this study including open coding, axial coding, and selective coding. This process helps to systematically analyze interview data and link student responses to broader conceptual themes.

Open Coding involves identifying key phrases and statements from the interview transcripts. For example, when Subject 1 said, "I think linear functions are functions where the graph is a straight line," this was coded as *Understanding concept*. Similarly, difficulties in verifying answers were coded as *Problem-solving challenges*. These initial codes represent the raw data fragments related to students' thoughts and experiences.

Axial Coding groups these open codes into larger, more abstract categories. For instance, codes related to understanding the concept, classification, and representation were clustered under *Conceptual understanding*, as they all relate to how well students grasp and communicate the mathematical concept of linear functions. Codes about solving problems and verification challenges were grouped as *Application and verification issues*, reflecting students' abilities to apply knowledge and check their work.

Selective Coding synthesizes these categories into core themes that capture the essence of the research findings. The central theme emerging from the data is *Enhanced mathematical conceptual understanding* facilitated by the Snowball Throwing learning model. The collaborative and interactive steps of this model helped students internalize concepts and represent them in different ways, as evidenced by their ability to restate, classify, provide examples, and use multiple representations of linear functions.
However, a recurring challenge was the verification of problem-solving results. Both subjects mentioned difficulties in confidently checking their answers, indicating a need for instructional support to improve metacognitive skills like self-monitoring and evaluation.
This detailed coding and analysis show that while the Snowball Throwing model effectively promotes conceptual learning and peer collaboration, it should be complemented with activities that strengthen students' critical thinking and verification skills. Such a combined approach will foster a more comprehensive mathematical competence.

Table 1. The Coding Process

Open Coding	Axial Coding	Selective Coding	Example Quote
Understanding concept	Conceptual understanding	Enhanced mathematical conceptual understanding	"I think linear functions are functions where the graph is a straight line. The equation looks like y = mx + c." (Subject 1)
Classification ability	Classification	Enhanced mathematical conceptual understanding	"If the graph is a straight line and the equation is like y = mx + c, then it's linear." (Subject 1)
Representation skills	Representation	Enhanced mathematical conceptual understanding	"I draw the graph, write the equation, and sometimes make a table of values." (Subject 1)
Problem-solving challenges	Application and verification issues	Need for improvement in verification skills	"Sometimes it is hard to check if my answer is correct." (Subject 1)
Understanding concept	Conceptual understanding	Enhanced mathematical conceptual understanding	"For me, linear functions are about relationships that change steadily, and I can make a table or graph to show that." (Subject 2)
Classification ability	Classification	Enhanced mathematical conceptual understanding	"If the function has squares or exponents, then it's not linear." (Subject 2)
Representation skills	Representation	Enhanced mathematical conceptual understanding	"I use graphs and tables to explain the concept." (Subject 2)
Problem-solving challenges	Application and verification issues	Need for improvement in verification skills	"Sometimes verifying the answer is difficult." (Subject 2)

Discussion

The findings of this study reveal valuable insights into how the Snowball Throwing learning model supports students' conceptual understanding of linear functions. By examining the responses of two purposively selected students, it becomes evident that the model's collaborative and student-centered approach fosters deeper engagement with mathematical concepts, although certain cognitive hurdles—particularly related to verification—remain present.

The implementation of the Snowball Throwing model followed a structured progression that prioritized student interaction and active learning. The steps—from teacher explanation, group formation, peer discussion, to question exchanges—facilitated both social and cognitive engagement with the material. This structure aligns well with Vygotsky's sociocultural theory, which posits that learning is most effective when students construct knowledge collaboratively. The use of peer-generated questions during the "snowball" activity created opportunities for students to articulate, challenge, and consolidate their understanding of linear functions in a dynamic way.

Subject 1 demonstrated strong conceptual understanding by accurately restating the meaning of linear functions and effectively representing them through tables and graphs. These abilities align with indicators of mathematical conceptual understanding, including restating concepts, classifying objects, providing examples and non-examples, presenting various representations, and applying concepts in problem-solving (Anggoro & Prabawanto, 2019; Park & Oliver, 2008)). Moreover, Subject 1 correctly classified linear and non-linear functions and provided valid examples and non-examples. This reflects the effectiveness of the early stages of the Snowball Throwing model—particularly during material delivery and peer explanation—in enabling the internalization of fundamental concepts through social interaction (Crawford, 1996; Schmittau, 2005; Walshaw, 2017)

However, difficulties emerged during the verification stage, where Subject 1 struggled to reassess and confirm the accuracy of solutions. This suggests a need to strengthen metacognitive reflection in the evaluation and conclusion phases of the model (Jong, 2019; Lysaker, 2020).Subject 2 exhibited similar patterns of understanding. They expressed a clear conceptual grasp of linear relationships and used graphs and tables confidently, fulfilling indicators of concept restatement, representation, and application. The student also demonstrated the ability to classify mathematical objects and distinguish linear equations from non-linear ones. These abilities were likely enhanced through the question generation and peer interaction activities integral to the Snowball Throwing model (Indraswari, 2022)

Again, challenges appeared during verification, where answers were not always reassessed thoroughly. This confirms that while the Snowball Throwing model promotes active engagement and encourages question-driven learning—especially through the question writing and snowball activity stages—it may benefit from explicit scaffolding to support students' self-monitoring and evaluative skills (Gidalevich & Kramarski, 2019; Wedastuti et al., 2022). The collaborative framework of the model enables students to verbalize their reasoning and hear alternative explanations, deepening understanding. However, the lack of structured metacognitive guidance limits students' ability to independently assess and refine their solutions.

The coding process further confirmed these patterns. Open coding revealed recurring themes such as concept understanding, classification skills, representational ability, and problem-solving behavior, while also identifying a consistent difficulty in verification. These were grouped through axial coding into broader categories—conceptual understanding, classification, representation, and application. Selective coding then highlighted a central theme: the Snowball Throwing model enhances conceptual acquisition and peer interaction but does not fully support metacognitive regulation, particularly during solution verification.

These results are consistent with existing research. Ofridaningsih et al. (2023) found that cooperative learning models significantly improve students' mathematical comprehension, especially when paired with contextual engagement. Similarly, Ma'sum & Nurkolis (2018) emphasized that peer-based discussion fosters conceptual depth and clarity. The Snowball Throwing model's interactive design, where students formulate and respond to peer questions, clearly promotes learner agency and ownership of understanding (Puspitarini et al., 2023). Nevertheless, as Perdana & Isrokatun (2019)) points out, effective mathematical problem-solving requires both strategic reasoning and reflective monitoring—components that remain underdeveloped in the current implementation.

In conclusion, while the Snowball Throwing model proves highly effective in supporting the restatement, classification, representation, and application of linear function concepts, it offers limited scaffolding for verification and self-evaluation. Addressing this gap through the integration of structured metacognitive strategies—such as guided reflection, peer review, or self-assessment tools—could significantly enhance the model's impact on comprehensive mathematical understanding.

CONCLUSION

This study explored the implementation and impact of the Snowball Throwing learning model on students' conceptual understanding of linear functions, focusing on four key research questions.

First, regarding the implementation, the Snowball Throwing model was effectively carried out in a structured sequence involving teacher explanation, group collaboration, peer question formulation, and snowball-style exchanges. This structure promoted active participation and social interaction, creating a student-centered learning environment that encouraged engagement with mathematical concepts.

Second, the model significantly influenced students' abilities to restate, classify, and provide examples related to the concept of linear functions. Both participants successfully restated the definition of linear functions in their own words, classified functions based on their structure, and provided appropriate examples and non-examples. These findings suggest that the model supports the internalization of conceptual knowledge through collaborative learning and repeated exposure to peer-generated content.

Third, in terms of representation and application, students demonstrated the ability to express linear functions through tables, graphs, and equations. They also showed competence in applying these concepts in problem-solving scenarios, reflecting a deepened understanding fostered by the interactive elements of the model, particularly peer discussion and active questioning.

Fourth, the study identified verification as the primary challenge students encountered. While they could perform the required steps to solve problems, they struggled with evaluating and confirming the accuracy of their solutions. This highlights a gap in the model's support for metacognitive processes, suggesting that future implementations should incorporate structured reflection or self-assessment phases to strengthen students' verification and evaluation skills.

Overall, the Snowball Throwing model proves effective in enhancing students' conceptual understanding, though its integration with metacognitive strategies remains a key area for development.

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