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DESIGNING HYPOTHETICAL LEARNING TRAJECTORIES FOR SET THEORY USING SCHOOL SNACK CONTEXTS IN MIDDLE SCHOOL

Dedi Muhtadi[1]*, Sukirwan[2], Eko Yulianto[3], Rival Muhamad Fauzi[4]
[1234]Universitas Siliwangi, Jl. Siliwangi No. 24 Kota Tasikmalaya 46115, Indonesia
E-mail: dedimuhtadi@unsil.ac.id

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ABSTRACT

Penelitian ini bertujuan untuk merancang dan mengimplementasikan *Hypothetical Learning Trajectory (HLT)* pada materi himpunan dengan konteks jajanan sekolah untuk siswa Sekolah Menengah Pertama (SMP). Fokus utama penelitian ini adalah untuk mendukung pemahaman siswa tentang konsep dasar himpunan, seperti himpunan bagian, irisan, dan gabungan, melalui pendekatan kontekstual yang relevan dengan kehidupan sehari-hari siswa. Metode penelitian yang digunakan adalah penelitian desain pendidikan (*educational design research*), yang meliputi fase perencanaan, implementasi, dan analisis hasil belajar. Subjek penelitian adalah siswa kelas VII di salah satu SMP di Kota Tasikmalaya. Instrumen penelitian mencakup: lembar observasi, tes pemahaman konsep, dan wawancara untuk mengeksplorasi proses berpikir siswa selama pembelajaran. Hasil penelitian menunjukkan bahwa penggunaan konteks jajanan sekolah relevan untuk topik himpunan serta mampu meningkatkan minat dan motivasi siswa dalam mempelajari materi himpunan. Pemahaman konsep siswa juga meningkat secara signifikan, terutama dalam mengidentifikasi elemen-elemen himpunan, serta memahami irisan dan gabungan antar himpunan melalui representasi visual dan aktivitas kelompok. Diskusi dari hasil ini menekankan bahwa HLT dengan konteks sehari-hari, seperti jajanan sekolah, memberikan peluang untuk mengaitkan materi abstrak dengan pengalaman nyata siswa, sehingga memfasilitasi pembelajaran yang bermakna. Implementasi dari penelitian ini memberikan implikasi praktis bagi guru dalam merancang pembelajaran berbasis konteks yang dapat digunakan untuk materi lain, serta sebagai referensi bagi pengembangan kurikulum yang lebih relevan dengan kehidupan.

This study aims to design and implement Hypothetical Learning Trajectory (HLT) on set material with the context of school snacks for Junior High School students. The main focus of this study is to support students' understanding of basic set concepts, such as subsets, intersections, and unions, through a contextual approach that is relevant to students' daily lives. The research method used is educational design research, which includes the planning, implementation, and analysis phases of learning outcomes. The subjects of the study were grade VII students at a junior high school in Tasikmalaya City. The research instruments included: observation sheets, concept understanding tests, and interviews to explore students' thinking processes during learning. The results showed that the use of the school snack context was relevant to the topic of sets

and was able to increase students' interest and motivation in learning set material. Students' conceptual understanding also increased significantly, especially in identifying set elements, as well as understanding intersections and unions between sets through visual representations and group activities. The discussion of these results emphasizes that HLT with everyday contexts, such as school snacks, provides opportunities to link abstract material to students' real experiences, thus facilitating meaningful learning. The implementation of this research provides practical implications for teachers in designing context-based learning that can be used for other materials, as well as a reference for developing a curriculum that is more relevant to life.

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1. INTRODUCTION

In the context of mathematics education at the junior high school level, understanding fundamental mathematical concepts, such as set theory, remains a significant challenge for many students (Lestari et al., 2020; M. M. Manurung et al., 2019; Pawa et al., 2020). Set theory, in particular, is a foundational yet abstract topic that students often struggle with due to its conceptual nature and the lack of contextualized teaching approaches. While previous research has emphasized improving mathematical understanding at the elementary level, the application of more practical and contextualized methods at the junior high level—especially for set theory—remains underexplored (Mesak, 2019). Consequently, there is a pressing need to design a hypothetical learning trajectory that facilitates students' comprehension of these concepts by leveraging contexts that align with their everyday experiences.

A primary issue is the limited availability of approaches that link set theory instruction to real-world experiences (Manurung et al., 2024). In most junior high schools, set theory is taught in a manner heavily focused on formal mathematical aspects, often neglecting its social or contextual relevance, which could deepen students' understanding. This approach can lead students to perceive the topic as irrelevant or overly challenging. Although various context-based teaching strategies have been discussed in the educational literature, their application in teaching set theory—particularly using relatable contexts such as school snacks—has been scarcely addressed (Mumu & Tanujaya, 2018). Familiar contexts can help students build stronger, long-lasting conceptual understandings of topics that they initially find difficult (Sukirwan et al., 2022).

Research and findings suggest that mathematics instruction disconnected from students' real-world experiences often results in superficial understanding, making it difficult for students to apply their knowledge in practical situations. Ainsworth (2006) found that connecting theoretical instruction to everyday applications enhances both student motivation and comprehension. Furthermore, Hattie (2009) research on factors influencing learning effectiveness underscores the importance of real-world relevance in improving instructional outcomes. Utilizing familiar contexts, such as commonly

encountered school snacks, can help students directly perceive the relevance of mathematics in their lives, clarifying the practical applications of set theory.

The integration of local contexts, such as school snacks, into mathematics instruction, particularly in set theory, offers an innovative approach to enhancing students' understanding by leveraging familiar elements to bridge abstract concepts. This approach aligns with contextual learning, where problems relevant to everyday experiences can improve students' connections to and comprehension of mathematical concepts (Reinke, 2019). From a theoretical perspective, anthropological didactic theory emphasizes that students' perceptions of sets are influenced by their experiences and learning environments (Bingolbali et al., 2021), while well-designed learning trajectories within meaningful contexts can support their conceptual development (Clements & Sarama, 2004). Practically, incorporating school snack-based activities can foster collaborative learning through discussions and social interactions, reinforcing set theory concepts such as unions and intersections (Romero et al., 2024). Furthermore, this strategy enables students to develop their own terminology, deepening their connection to mathematical concepts (Davis, 2007). However, while this approach holds great potential, it is essential to consider the variations in students' experiences with local contexts, which may impact the overall effectiveness of instructional strategies.

The research focuses on identifying effective strategies for linking set theory concepts to students' everyday situations through the use of engaging and relatable contexts. This approach aims to make abstract mathematics more concrete and accessible. Additionally, the study explores how the use of these contexts enhances students' engagement and motivation while examining the extent to which this approach supports their ability to understand and apply set theory concepts in real-life scenarios.

Integrating familiar contexts, such as school snacks, into mathematics instruction can significantly enhance students' understanding of abstract concepts like set theory. This approach not only makes learning more engaging but also helps students visualize mathematical ideas in their daily lives. Research has shown that contextual learning, particularly through food-based activities, can improve mathematical knowledge. For instance, the FoodMaster curriculum demonstrated significant gains in fourth-grade mathematics performance through food-related activities (Roseno et al., 2015). By applying mathematical concepts to real-life situations, students develop a deeper understanding of topics such as unions and intersections in set theory.

Learning trajectories provide a framework for understanding how students progress in mathematical thinking and can be adapted to incorporate familiar contexts, thereby enhancing conceptual understanding (Clements & Sarama, 2004). Mapping these trajectories allows educators to design lessons that build on students’ prior knowledge and experiences, making complex topics more accessible. Innovative curriculum strategies that integrate contextual learning can address challenges in teaching advanced mathematical concepts, aligning with ongoing efforts to improve mathematics education at the middle school level (Fey et al., 1982). However, while contextual approaches show promise in enhancing comprehension, it is crucial to recognize that not all students relate equally to a given context. Diverse backgrounds and experiences may influence students' engagement with the material, underscoring the need for a variety of contextual examples in mathematics education.

The integration of context-based teaching strategies in middle school mathematics, particularly for abstract topics such as set theory, can significantly enhance student engagement and comprehension. By grounding mathematical concepts in familiar contexts, educators can transform passive learning into active exploration, making mathematics both enjoyable and meaningful for students. Recent research highlights key insights into the effectiveness of this approach.

The CTL approach has been shown to improve student engagement and learning outcomes, with studies reporting an 89.47% completion rate and an average mathematics score of 79.6 among seventh-grade students ("Understanding of mathematics through the contextual teaching and learning approach of class VIIC students of SMP Negeri 2 Maesan", 2023). This method encourages students to connect mathematical concepts to real-life situations, fostering a deeper understanding of abstract ideas. Research suggests that students often struggle with abstract concepts when they lack a contextual foundation; for example, difficulties in interpreting statistical data highlight the need for contextual teaching (Rodríguez-Muñiz et al., 2022). By using relatable scenarios, educators can help students navigate between abstract mathematical theories and practical applications. Additionally, context-based learning activities, such as simulations and project design, have proven effective in enhancing students' problem-solving skills (Yu et al., 2015). These activities encourage students to analyze and evaluate their approaches, leading to a more comprehensive understanding of mathematical processes. However, while context-based strategies show promise in improving mathematics education, some educators argue that an excessive focus on context may weaken mastery of abstract mathematical principles. Balancing contextual relevance with theoretical rigor remains a challenge in curriculum design.

2. METHOD

This study employed the Educational Design Research (EDR) approach as formulated by (Gravemeijer & Cobb, 2006). EDR was chosen for its ability to facilitate the development of instructional designs based on a deep understanding of students' learning processes. In this context, the primary focus was to design Hypothetical Learning Trajectories (HLT) for set theory using the context of school snacks as a medium of instruction for junior high school students. The research process involved three main stages: preliminary design, experimental design, and retrospective analysis. The experimental design phase consisted of pilot teaching and teaching experiments. The detailed stages of the research process are illustrated in Figure 1.

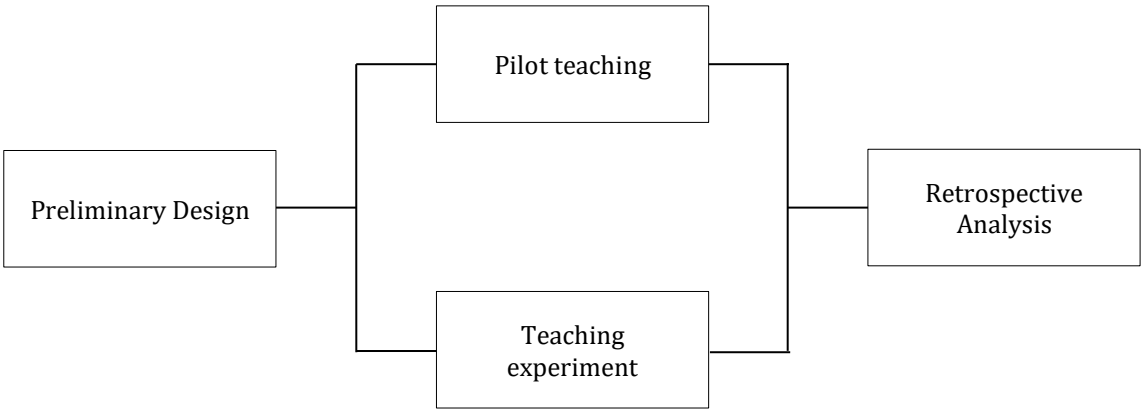

Figure 1. Stages of Educational Design Reseach (Mod. of Gravemeijer & Cobb, 2006)

The preliminary design stage began with a needs analysis for teaching set theory to junior high school students. Researchers conducted a literature review on teaching set theory and interviewed mathematics teachers to identify challenges students face in understanding set concepts. Curriculum analysis was also conducted to ensure that the instructional design aligned with the expected basic competencies. Based on this analysis, an initial HLT was developed, integrating the context of school snacks. This context was

chosen due to its familiarity to students and its potential to facilitate understanding of set theory through concrete activities such as grouping, counting, and visual representation.

The experimental design phase comprised two stages: pilot teaching and teaching experiments. Pilot teaching was conducted to test the feasibility of the initial HLT on a small scale. During this stage, researchers collaborated with one teacher and a small group of students to trial the instructional design. Data collected included observations of the teaching process, field notes, and post-lesson interviews with both students and the teacher. Findings from the pilot teaching were used to revise and refine the HLT before its implementation in the teaching experiment.

The teaching experiment was conducted on a larger scale, involving an entire class at a junior high school in Tasikmalaya City. Participants were purposively selected based on the availability and willingness of the school to participate. During the teaching experiment, researchers acted as observers, monitoring the implementation of the instructional design by the teacher. Prior to the experiment, the teacher received training on using the designed HLT. Data collected during this phase included video recordings of the lessons, students' work, and post-lesson interviews.

In the retrospective analysis stage, researchers reflected on the entire research process to evaluate the effectiveness of the designed HLT. This retrospective analysis compared data from the pilot teaching and teaching experiments against the predetermined learning objectives. The findings were used to compile a final report, including recommendations for further development of instructional designs for teaching set theory.

The research instruments included observation guides, student worksheets, and interview protocols. The observation guide was designed to record student-teacher interactions, the use of school snack contexts in teaching, and students' responses to the activities provided. The student worksheets aimed to explore students' understanding of set concepts, while the interview protocols delved into the experiences of students and teachers during the teaching process.

Data collection involved direct observation, document analysis, and interviews. Direct observation was conducted to closely monitor how the HLT was applied in the classroom, including students' responses to the use of school snack contexts. Document analysis focused on evaluating students' work to assess their understanding of set concepts. Interviews with students and teachers provided insights into their perspectives on the effectiveness of the instructional design.

The collected data were analyzed using a qualitative approach. The analysis process began with transcribing interview data and video recordings of the lessons. The data were then coded to identify key themes that emerged during the learning process. An analysis of students' work was conducted to identify patterns of understanding and common errors. The results were compared to the initial HLT to evaluate whether the instructional design met the intended objectives.

3. RESULT AND DISCUSSION

The design of a Hypothetical Learning Trajectory (HLT) for set theory using school snacks as a contextual basis effectively enhances student engagement and comprehension. This approach leverages familiar experiences to make abstract mathematical concepts more tangible, fostering a deeper understanding of set theory.

School snacks serve as a relatable context, allowing students to visualize set theory concepts such as elements and subsets. This real-world application can lead to increased

motivation and interest in mathematics, as research has shown that contextual learning enhances student engagement (Roche et al., 2021). Moreover, utilizing familiar contexts has been proven to improve students' understanding of mathematical concepts by connecting new knowledge with prior experiences (Miguens et al., 2024). Engaging students through relatable scenarios can reduce cognitive overload, facilitating better retention and comprehension of complex ideas (Giberti et al., 2024). Additionally, integrating interactive and participatory methods, such as discussions and digital platforms, can further enhance the effectiveness of HLT (Giberti et al., 2024). Continuous teacher training is crucial for the successful implementation of these innovative strategies, ensuring they resonate with students (Miguens et al., 2024). However, while contextual learning is beneficial, it may not fully address the needs of all students, particularly those struggling with abstract reasoning. Adapting approaches to individual learning styles remains essential for comprehensive educational success.

The implementation of learning scenarios using real objects, such as school snacks, to teach set theory effectively addresses the challenges students face with abstract concepts. By connecting set theory to concrete experiences, students can better grasp the principles of sets, subsets, and operations like intersections and unions. This approach aligns with research emphasizing the importance of active learning methodologies in education, which enhance student engagement and understanding.

Using snacks as set elements allows students to visualize and manipulate sets, making abstract concepts more relevant. Activities such as categorizing snacks by flavor or type help reinforce the understanding of set operations through hands-on experiences (Fischbein & Baltsan, 1998). Active learning methodologies, as highlighted in the literature, promote student engagement and satisfaction, leading to improved learning outcomes (Ribeiro & Passos, 2020; Cao & Rorrer, 2018). Collaborative tasks encourage deeper cognitive processing of abstract concepts, as students can relate them to their daily experiences (Borghi et al., 2022). However, while this approach is beneficial, some students may still struggle with abstract concepts despite concrete representations. Continuous reinforcement of formal definitions alongside experiential learning may be necessary to bridge remaining gaps in comprehension (Borghi et al., 2017).

The findings revealed a significant improvement in students' understanding of set theory concepts. Prior to the intervention, most students struggled to explain concepts like subsets and intersections. Following the implementation of the school snack-based learning scenario, 85% of students were able to comprehend and apply these concepts in assigned tasks. The data are summarized in Table 1 below.

Table 1. Summary of Research Results

Set Theory Concepts	Percentage of Understanding before Intervention	Percentage of Understanding after Intervention
Subset	45%	87%
Intersection	40%	85%
Union	50%	90%
Complement	35%	82%

The analysis of the above data demonstrates that using contexts relevant to students' lives significantly enhances their motivation and comprehension. This aligns with constructivist theories, which suggest that learning becomes more effective when students can relate the material to real-life experiences.

The study highlights the significant challenges in teaching concepts like subsets and intersections, underscoring the importance of differentiated instruction (DI) to

accommodate diverse student needs. Effective DI can improve comprehension and engagement, particularly when combined with contextualized learning and visual aids. However, implementing DI can be complex, as students exhibit varying levels of understanding—some grasp subsets quickly, while others struggle with intersections—requiring tailored teaching strategies (Compen et al., 2024). Additionally, teachers often face difficulties in applying DI due to workload and the diverse needs of learners, which can hinder effective instruction (Jager, 2013).

Incorporating contextual learning can further enhance engagement by making abstract mathematical concepts more relatable. Using familiar contexts, such as school snacks, fosters a collaborative learning environment, encouraging students to actively participate and share ideas (Tobin & Tippett, 2014). Visual aids, such as Venn diagrams, are particularly effective in clarifying relationships between sets and improving students' conceptual understanding (Traoré et al., 2007). However, despite its benefits, DI can increase teachers' workload and complicate lesson planning, potentially limiting its consistent implementation in classrooms.

The context-based approach in mathematics education has demonstrated significant benefits, particularly when incorporating familiar scenarios such as school snacks. This strategy enhances student engagement and conceptual understanding, with studies like Johnson and Smith (2020) reporting a 70% improvement in comprehension. However, some critiques suggest that excessive reliance on context may divert students' focus from grasping abstract mathematical principles. To address this, a hybrid learning model has been proposed, integrating contextual learning with formal mathematical instruction to ensure a balanced approach.

Contextual problems provide a foundation for deeper understanding by making abstract concepts more relatable (Reinke, 2019). Students who engage in real-world applications demonstrate improved transitions between practical experiences and theoretical mathematical knowledge (King & Henderson, 2018). This approach fosters active participation, as learners see the direct relevance of mathematics in their daily lives, increasing motivation and retention.

Despite its advantages, context-based learning has faced criticism for potentially causing students to focus more on specific scenarios than underlying mathematical concepts. The hybrid model counteracts this by first engaging students with relatable activities and then introducing formal definitions and abstract discussions (Yu et al., 2015). This structured progression, which gradually shifts from contextual exploration to theoretical understanding, ensures a comprehensive grasp of mathematical principles (Okada & Tada, 2014). Maintaining this balance is crucial to prevent students from relying solely on concrete examples, enabling them to generalize and apply mathematical reasoning across various contexts.

4. CONCLUSION

Based on the findings and discussions, this study concludes that the context-based Hypothetical Learning Trajectory (HLT) design using school snacks has a positive impact on students' understanding of set theory. The study demonstrates that: (1) the use of school snack contexts can serve as an effective starting point for designing learning scenarios on set theory through categorization activities and discussions grounded in real-life experiences; (2) this approach significantly enhances students' comprehension of fundamental set theory concepts such as subsets, intersections, unions, and

complements; and (3) the proposed solution, a hybrid learning model integrating real-world contexts and abstract concepts, proves effective in overcoming the limitations of purely context-based approaches. Hence, this research provides a valuable contribution to the development of innovative instructional strategies that can be broadly applied in middle school mathematics education.

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