HYPOTHETICAL DIDACTIC DESIGN BASED ON COGNITIVE CONFLICT IN THE MATERIAL OF SINGLE AND COMPOUND INTERESTS BASED ON *LEARNING OBSTACLES OF HIGH SCHOOL STUDENTS*

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Abstract

This study aims to produce a hypothetical didactic design based on cognitive conflict on the topic of single and compound flowers based on the learning obstacles of high school students. The study uses a Didactic Design Research (DDR) approach with a qualitative method that focuses on the prospective analysis stage before the implementation of learning. The research subjects consisted of 28 11th grade high school students who took a cognitive diagnostic test, four of whom were selected for in-depth interviews, as well as mathematics teachers as informants. Data were collected through diagnostic tests, semi-structured interviews, and teacher interviews, then analyzed through data reduction, data presentation, and conclusion drawing. The results of the study indicate that students have initial knowledge of the concept of flowers, but this understanding is still procedural and not fully conceptual. Two types of learning obstacles were found, namely epistemological obstacles related to the limited generalization of concepts in new contexts, and didactic obstacles related to previous learning experiences that are oriented towards procedures. Based on these findings, a hypothetical didactic design was developed that integrates the cognitive conflict approach through gradual didactic situations, student response prediction, and Pedagogical Didactic Anticipation (PDI). This design has gone through two stages of expert validation and has been declared suitable for use as an alternative learning design, although its effectiveness cannot yet be concluded because the research has not yet reached the implementation stage.

Keywords : didactic design; cognitive conflict; learning barriers; single and compound interest; didactic design research;

1 INTRODUCTION

Mathematics is a subject that plays a crucial role in developing logical, analytical, critical, and systematic thinking skills. Besides being a scientific discipline, mathematics is also closely related to various life activities, including financial decision-making. One topic that is highly relevant to everyday life is simple and compound interest, as they relate to saving, borrowing, investing, and financial planning. Therefore, learning about interest focuses not only on mastering calculation procedures but also on building conceptual understanding so students can apply these concepts appropriately in various situations.

Nevertheless, various studies show that students still experience *learning barriers* in mastering mathematical concepts. *Learning barriers* can be classified into *ontogenic barriers* , *didactic barriers* , and *epistemological barriers* . These barriers cause students to have difficulty understanding concepts, selecting solution procedures, and applying concepts in various contexts. This condition indicates that learning success is influenced not only by student characteristics but also by the quality of the learning design developed by teachers (Hidayati & Juandi, 2025).

Various studies also show that identifying *learning barriers* is an important first step in developing didactic design. Analyzing learning barriers allows teachers to identify the sources of student difficulties, allowing them to design learning situations that better suit their characteristics. Within the framework of *Didactic Design Research* (DDR), the results of this identification form the basis for developing *Pedagogical Didactic Anticipation* (PDA) as a form of anticipation of potential student responses during the learning process. This approach enables more systematic and adaptive learning designs tailored to students' learning needs.

One approach that can be used to overcome *learning barriers* is the cognitive conflict approach. This approach encourages students to face situations that contradict their prior knowledge, encouraging them to rebuild their understanding towards more scientific concepts. Thus, learning does not only focus on the use of formulas but also facilitates the formation of more meaningful conceptual understanding. The results of *a Systematic Literature Review* show that the cognitive conflict strategy consistently has a positive impact on improving mathematical problem-solving skills, particularly in understanding problems, developing solution strategies, and drawing conclusions. Furthermore, cognitive conflict plays a role in reducing misunderstandings and encouraging conceptual change in students. This approach is also based on constructivist theory, thus facilitating students to actively rebuild their understanding (Susadi et al., 2026) .

Based on various studies, *learning barriers* are factors that influence the misunderstanding of mathematical design, so they need to be identified as a basis for designing learning that is appropriate to the needs of participants. students (Hidayati & Juandi , 2025). In addition, the cognitive conflict approach has been proven to reduce misconceptions and encourage conceptual change in students through a learning process centered on construction. knowledge (Susadi et al ., 2026). Within the framework of *Didactic Design Research* (DDR), the results of identifying *learning barriers* can be used as a basis for developing hypothetical didactic designs that anticipate various possible student responses through *Pedagogical Didactic Anticipation* (Dharma et al., 2021). However, research that specifically develops hypothetical didactic designs based on cognitive conflict on single and compound interest material based on high school students' *learning barriers* is still limited. Therefore, this study aims to produce hypothetical didactic designs based on cognitive conflict on single and compound interest material based on high school students' *learning barriers* as an alternative learning design that can facilitate draft understanding in a more meaningful way.

2 METHODOLOGY

This study uses a *Didactic Design Research* (DDR) approach with qualitative methods. This method was chosen because it aims to produce a hypothetical didactic design based on the results of identifying *students' learning barriers* in the material on single and compound interest. This study focuses on the stage of analyzing the didactic situation before learning (*prospective analysis*), so it does not include the implementation stage or retrospective analysis. The cognitive conflict approach is integrated into the preparation of the didactic design as an effort to anticipate *the learning barriers* faced.

The study subjects consisted of 28 eleventh-grade high school students who took a cognitive diagnostic test on simple and compound interest. Four students were then purposively selected based on variations in their response patterns on the diagnostic test to participate in in-depth interviews. Additionally, a mathematics teacher served as an informant to obtain information about the learning process, student characteristics, and obstacles frequently encountered during the learning process, which was the focus of the study.

Data collection was conducted through cognitive diagnostic tests, semi-structured interviews with four selected students, and interviews with mathematics teachers. The diagnostic tests were used to identify the forms of *learning barriers* experienced by students, while the interviews aimed to dig deeper into the causes of the emergence of learning barriers and validate the results of the diagnostic test analysis. Data were analyzed qualitatively through the stages of data reduction, data presentation, and conclusion drawing. The results of *the learning barrier analysis* were then used as a basis for developing a hypothetical didactic design based on cognitive conflict through didactic situation preparation and *Pedagogical Didactic Anticipation* (PDA).

3 RESULTS

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3.1 Students' Prior Conceptual Knowledge

Students' initial conceptual knowledge on the concept of interest was obtained through an analysis of a cognitive diagnostic test given to 28 students of class XI.5 of SMA Negeri 2 Slawi. The analysis was conducted by identifying the pattern of students' answers to each question item to see their understanding of the concept of single and compound interest, their ability to explain reasons, and their ability to apply the concept to different situations. The results of the analysis showed that students generally had initial knowledge of the concept of single and compound interest, but this understanding was still varied and tended to be procedural. Some students were able to recognize the basic characteristics of both types of interest and solve problems that had similar patterns to examples that had been studied, but still experienced difficulties when asked to explain the mechanism of the concept, construct mathematical arguments, or apply the concept to different situations. These findings indicate that mastery of calculation procedures has not been fully followed by the formation of in-depth conceptual understanding.

This situation is evident in students' responses when explaining the concept of simple interest. Some students were able to state that simple interest is interest calculated based on the initial capital, but were still limited to using formulas and interest percentages without being able to explain the mechanism behind the fixed amount of interest earned each period. In other cases, students were able to solve problems with a similar pattern to the previous example, but struggled to determine the type of interest based on the characteristics of the balance growth presented in a new format.

These findings indicate that students' existing knowledge cannot yet be fully applied flexibly in different contexts. In addition to conceptual understanding, students also demonstrated limitations in constructing mathematical explanations and arguments. Students' answers tended to be oriented toward calculation results or memorized characteristics, while explanations of the rationale and process for the formation of a concept were not fully conveyed. This condition is related to previous learning experiences that primarily involved practicing calculations and did not familiarize students with constructing complete conceptual arguments. Interview results also indicated that some students were not yet accustomed to dealing with problems that required verbal explanations and conceptual reasoning.

These findings align with research by Sumirat, Sudihartinih, and Sumiaty (2023), who identified *learning obstacles* as a crucial component of didactic design research, focusing on analyzing students' conditions and understanding prior to instructional design. Ardiansari, Suryadi, and Dasari (2023) also demonstrated that preliminary studies on *learning obstacles* can serve as a basis for developing instructional designs aimed at minimizing student learning barriers. Therefore, the identification of prior conceptual knowledge in this study provides an important basis for analyzing *learning obstacles* and determining the didactic situations that need to be designed so that students are not only able to use procedures but also develop a more meaningful understanding of the concept of flowers.

3.2 Identifying Learning Obstacles

Based on the analysis of cognitive diagnostic test results and student interviews, two types of *learning obstacles were identified* in the material on single and compound flowers: epistemological obstacles and didactic obstacles. Learning obstacles were identified by observing the characteristics of student responses in solving problems, their ability to explain concepts, and information obtained through interviews regarding previous learning experiences. This approach aligns with research by Ardiansari et al. (2023) which shows that identifying *learning obstacles* through preliminary studies can be the basis for designing didactic designs that are appropriate to the characteristics of student difficulties.

3.2.1 Epistemological Barriers

Epistemological barriers are found in students' limitations in flexibly applying their existing knowledge when faced with different types of problems or contexts. Students are generally familiar with the concepts of simple and compound interest and are able to use the formulas they have learned, but they are not yet fully able to explain the conceptual mechanisms underlying their use. In the concept of simple interest, for example, students can state that interest is calculated based on initial capital, but are unable to explain how the use of initial capital results in a fixed amount of interest earned in each period. This condition indicates that students' knowledge is still at the level of recognizing procedures and general characteristics, and has not yet developed into a complete conceptual understanding.

Epistemological barriers were also evident when students were asked to determine the type of interest based on the balance growth pattern. Students were able to solve problems that had patterns similar to previously studied examples, but experienced difficulty when having to apply the concept to new representations or contexts. This indicates that their existing knowledge cannot yet be flexibly used to recognize the growth characteristics of single and compound interest. Thus, the epistemological barriers in this study relate not only to the inability to use the concept, but also to limitations in generalizing and reconstructing the concept when the problem conditions change.

3.2.2 Didactic Barriers

Didactic barriers were identified in students' difficulties related to their previous learning experiences. These barriers emerged when students were faced with problems requiring conceptual explanations, mathematical argumentation, or the application of concepts to contexts not previously taught. Some students tended to focus on formulas and mathematical exercises, making them unaccustomed to constructing comprehensive and structured conceptual explanations. Interviews supported these findings, as students stated that previous learning focused more on solving problems using formulas and had not presented many problems requiring verbal reasoning or argumentation.

Didactic barriers also arise when students encounter contexts that have never been discussed before, such as determining interest rates based on balance growth patterns or solving loan problems with installment payments. In these situations, students lack sufficient learning experience to connect the information in the problem to previously learned concepts. In one case, a student was able to obtain the correct answer through an exploratory strategy, but lacked confidence in the strategy's accuracy because the problem context had not been discussed in previous lessons. These findings suggest that the presentation of the material and variations in previous learning experiences influence students' ability to apply the concept of interest in different situations.

The findings regarding epistemological and didactic barriers reinforce the results of previous research showing that *learning obstacles* can be identified through analysis of student responses and interviews, then used as a basis for developing didactic designs. Sumirat et al. (2023), for example, showed that qualitative research using the DDR framework can be used to identify various forms *of learning obstacles* through written tests and interviews. Ardiansari et al. (2023) also showed that the results of identifying *learning obstacles* serve as the basis for designing learning situations aimed at minimizing student learning barriers. Thus, the two obstacles identified in this study serve as the basis for developing a hypothetical didactic design based on cognitive conflict for the material on single and compound interest.

3.3 Didactic Design with Cognitive Conflict

The hypothetical didactic design in this study was developed based on the identification of students' prior conceptual knowledge and *learning obstacles* in the topic of single and compound flowers. The design was designed by integrating a cognitive conflict approach into the learning situation, aiming to facilitate students' reconstruction of prior understandings that were not yet aligned with mathematical concepts. The developed design not only included a sequence of learning activities but also predicted student responses and anticipated teacher actions to various possible responses. Therefore, the didactic design is hypothetical because it was designed based on predictions of students' learning processes before the learning implementation.

The cognitive conflict approach is realized through the presentation of situations that demonstrate a discrepancy between students' initial understanding and the concept they should have. In the interest topic, cognitive conflict is raised through a comparison of the growth value of single interest and compound interest in various contexts, allowing students to observe differences in growth patterns that do not always align with their initial expectations. These situations are designed to encourage students to reflect on their understanding, identify conceptual discrepancies, and rebuild a more accurate understanding through discussion and exploration.

The didactic design also considers two types *of learning obstacles* identified: epistemological and didactic. To address epistemological barriers, the learning design provides various representations and contexts that enable students to use concepts more flexibly. To address didactic barriers, the learning situation is structured in stages, moving from simple to more complex contexts, providing students with opportunities to explain their reasons, develop arguments, and reflect on their results. Therefore, the design is not only oriented toward mastering calculation procedures but also toward strengthening students' conceptual understanding.

In addition to developing didactic situations, this study also designed predictions of student responses and anticipation of teacher actions as part of *Pedagogical Didactic Anticipation* (PDA). Response predictions were developed based on the results of diagnostic tests and interviews, enabling teachers to prepare appropriate actions for various possible difficulties, misconceptions, and strategies used by students. This anticipation included providing provocative questions, presenting additional illustrations, providing scaffolding, and managing class discussions that could help students build a more meaningful understanding of concepts. With didactic anticipation, teachers not only act as material deliverers but also as facilitators who help students construct their knowledge through the process of cognitive conflict.

The findings of this study align with those of Ardiansari et al. (2023), which demonstrated that the results of *learning obstacle identification* can be used as a basis for developing didactic designs that consider students' response characteristics. Furthermore, Susadi et al. (2026) explained that cognitive conflict plays a role in reducing misconceptions and encouraging conceptual change through the process of reconstructing students' knowledge. Therefore, the hypothetical didactic design based on cognitive conflict produced in this study is expected to be an alternative learning design that can facilitate the formation of a more meaningful understanding of the concept of flowers.

3.4 Validity of Hypothetical Didactic Design

The hypothetical didactic design, developed based on the identification of initial conceptual knowledge and *learning obstacles,* was then validated by a mathematics education expert. Validation was conducted to assess the suitability of the design to the learning objectives, *the learning obstacles* identified, and the application of the cognitive conflict approach to each designed didactic situation. The validation process was carried out in stages through review and input from the validator. The input was then used as a basis for refining the hypothetical didactic design.

In the first validation stage, the validator provided input regarding the completeness of the learning objective flow, variations in predicted student responses, and the relationship between the learning objective flow and the didactic situation. The validator also suggested that one learning objective flow could contain more than one didactic situation according to learning needs. Based on this input, improvements were made to the learning objective flow, adding three predicted student responses, adjusting the layout of the learning objective flow to align with the didactic situation, and dividing one didactic situation into two parts.

In the second validation stage, the validator provided input to organize the didactic design more systematically based on the sequence of learning objectives. Furthermore, it was suggested that the didactic situations be presented in stages, progressing from simple to more complex levels of difficulty. The validator also provided input on the sentence structure of several questions and suggested the addition of reflection activities. This input was followed up by restructuring the design based on the sequence of learning objectives, gradually adjusting the difficulty level of the didactic situations, revising the wording of questions, and adding reflection activities where necessary.

After all revisions were made, the hypothetical didactic design was resubmitted to the validator for review. The review results indicated that the revised didactic design was deemed usable. Thus, the developed hypothetical didactic design has undergone a gradual validation and refinement process and is therefore deemed suitable for use as a learning design for the flower concept material using a cognitive conflict approach.

The validation results indicate that the expert assessment process not only serves to assess the feasibility of the design, but also provides direction for improvement so that the relationship between learning objectives, didactic situations, predicted student responses, and didactic anticipation becomes clearer. Gradual improvements also strengthen the characteristics of cognitive conflict in the design through a more systematic, gradual arrangement of situations, and equipped with reflection activities. Therefore, the final validation results support that the resulting hypothetical didactic design has a conceptual fit with the learning objectives and *learning obstacles* that form the basis of its design, although its effectiveness in learning cannot be concluded because the design has not been implemented.

4 CONCLUSION

Based on the research results, students have initial knowledge regarding the concept of single interest and compound interest, but this understanding has not been fully formed conceptually. Students still show a tendency to use procedures and formulas in solving problems, while the ability to explain reasons, construct mathematical arguments, and apply concepts to different situations is still limited. Based on these conditions, two types of *learning obstacles were found* , namely epistemological obstacles and didactic obstacles. Epistemological obstacles are related to students' limitations in using and generalizing existing knowledge in different contexts, while didactic obstacles are related to previous learning experiences that are more oriented towards procedures and calculation exercises.

Based on *the learning obstacles* identified, a hypothetical didactic design based on cognitive conflict was developed for the topic of single and compound interest. The design includes didactic situations designed to highlight discrepancies between students' initial understanding and the intended concept, and is complemented by predictions of student responses and anticipated teacher actions. The design is structured in stages, taking into account the characteristics of learning obstacles, progressing from simple to more complex situations, and providing space for students to explore and reflect.

The hypothetical didactic design then underwent a gradual expert validation process. Validator input was used to refine the flow of learning objectives, predicted student responses, the sequence and difficulty level of didactic situations, question wording, and reflection activities. After revision, the hypothetical didactic design was declared suitable for use as a learning design for the flower concept material using a cognitive conflict approach. Thus, this study produced a hypothetical didactic design that was conceptually structured based on student *learning obstacles* and had undergone an expert validation process. However, because the study did not reach the implementation stage, the effectiveness of the design in overcoming *learning obstacles* and improving student conceptual understanding cannot yet be concluded.

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