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Research Article

Didactical Design Research (DDR) With Translation Module Development in Elementary Schools and Junior High Schools

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Abstract: The thinking process carried out by teachers occurs in three phases, namely before learning, during learning, and after learning. The results of the analysis of these processes have the potential to produce innovative didactic designs, and these three processes can be formulated as a series of steps to produce new didactic designs. This series of activities is formulated as Didactic Design Research (DDR). Didactic Design Research basically consists of three stages, namely: (1) analysis of the didactic situation before learning which is in the form of a Hypothetical Didactic Design including ADP, 2) metapedidactic analysis, and 3) retrospective analysis, namely an analysis that links the results of the analysis of the hypothetical didactic situation with the results of the metapedidactic analysis. From these three stages, an Empirical Didactic Design will be obtained which is not closed to being continuously refined through the three stages of DDR.

Keywords: Didactics; Modules; Students; Schools; Translation

1. Introduction

Didactic issues related to Translation material are very important to note in the context of basic education in mathematics (Suseelan et al., 2022; Rodríguez-Nieto et al., 2022). Translation covers various basic concepts and is not only a crucial part of the mathematics curriculum in elementary and junior high schools but also plays an important role in the development of students' logical thinking and spatial reasoning skills (Lepore, 2024), (Wicaksono & Korom, 2023). In the era of globalization and rapid technological development, understanding of mathematical concepts, especially in translation material, is becoming increasingly significant, not only in academic contexts but also in practical applications in the fields of art, engineering, architecture, culture and computer science (Abad-Segura et al., 2020; Lian & Xie, 2024). However, although this material is very fundamental, teaching Translation is often faced with various challenges that can hinder the understanding of elementary school students and junior high school students (Smagul, 2024), (Free et al., 2014). One of the main problems in Translation didactics is the understanding of abstract concepts. Many students have difficulty in imagining and understanding two-dimensional images that undergo transformation into three dimensions (Uttal & Cohen, 2012; Windows-Yule et al., 2024). The inability to visualize the changes that occur in geometric objects can cause difficulties in applying transformation concepts in real situations (Velázquez & Méndez, 2021; Yanik & Flores, 2009). For example, when students are faced with problems involving translation, they are often confused in determining the relationship and shift between the initial position and the final position of the object (Musk & Meij, 2024; Chen & Huang, 2024). This indicates the need for a more visual and interactive approach in teaching translation to help students overcome this challenge. In addition, monotonous and less varied teaching methods can also be the cause of students' low understanding of Translation (Hui et al., 2024; Liu & Liang, 2024).

The lack of use of innovative teaching aids, such as geometry software or manipulative tools, makes learning feel monotonous and reduces students' interest in studying the material further (Ahmed et al., 2024; Latini et al., 2024). In this context, it is important for teachers to

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develop more creative and fun teaching strategies, so that students not only receive information, but are also actively involved in the learning process (González-pérez & Ramírez-montoya, 2022; Santos et al., 2019). For example, the use of dynamic geometry software such as GeoGebra can provide opportunities for students to explore Translation more interactively, so that they can better understand the relationship between theory and practice (Inayatullah, 2010). In addition, the application of Constructivism Learning theory in teaching Translation also presents its own challenges (Wee et al., 2024; Bobbink et al., 2024). This approach believes that students construct their own knowledge through experience and interaction with the environment. However, in practice, not all students have the same background knowledge or equal ability in understanding geometric concepts. Therefore, teachers must be able to recognize these individual differences and provide an appropriate approach for each student. This is a challenge for teachers, especially in heterogeneous classes where students have varying levels of ability. This is where the importance of careful planning in learning design lies, so that each student can be involved and learn in a way that suits their respective characteristics (Song et al., 2024; Major et al., 2021).

Didactic theory in Translation learning emphasizes the understanding of basic concepts of transformation such as translation, reflection, rotation, and dilation, as well as the importance of interaction between students and geometric objects in improving understanding (Johnston, 2012; Supriyadi et al., 2024). Translation not only functions as a tool to manipulate shapes, but also as a medium to develop students' critical and creative thinking skills. In this context, the constructivist approach becomes relevant, where students are invited to explore and discover the principles of transformation through direct experience and manipulation of real objects (Aravantinos et al., 2024). With problem-based learning, students can be invited to solve real-world situations involving transformation, such as graphic design or the movement of objects in space, which will increase their motivation and involvement in the learning process (Pan et al., 2023). The importance of using technology, such as dynamic geometry software, also cannot be ignored. This technology allows students to conduct experiments and visualize transformations interactively, which can help them understand how changes in position and shape occur in real time (Senatore & Piker, 2015). In addition, the integration of technology also makes it easier to reflect on the learning process, helping students to see mistakes and errors in understanding the basic concepts of transformation (Chiu, 2021; Radev, 2022). When students explore, they are also invited to collaborate with their friends, share ideas, and build knowledge together. This collaboration can enrich individual perspectives and understanding, as well as build essential social skills in the context of today's society. Didactic theory also emphasizes the importance of context in teaching Translation (Vásquez et al., 2024). By linking mathematical concepts to everyday situations, students can more easily understand the relevance of transformation in real life. For example, using examples of architectural design or fine art can make students see real applications of Translation. This aims to build meaning and foster students' interest in mathematics (Kit Ng et al., 2022). In this activity, the teacher acts as a facilitator who designs contextual and challenging learning activities, and provides constructive feedback on students' thinking processes. Furthermore, assessment in Translation learning must be directed not only at the final results, but also at the thinking processes that students go through (Mora et al., 2020; Nikolic et al., 2023). By using formative assessment, teachers can get a clearer picture of students' understanding, and identify areas that need improvement. Various assessments, such as portfolios, projects, or presentations, can also provide opportunities for students to express their understanding in different ways (Queiruga-Dios et al., 2021; Morris & O'Connor, 2023). Through this didactic approach, it is expected that students will not only be able to perform transformations mechanically, but also understand the meaning and application of each type of transformation in a broader context (Lesinskis et al., 2023; Deo & Hölttä-Otto, 2024). Ultimately, the goal of this didactic theory is to make Translation learning a significant and enjoyable experience, which not only improves students' mathematical abilities, but also their critical and creative thinking skills (Torres-Torres et al., 2024).

Translation is one of the important topics in mathematics learning, especially in geometry. Several previous studies have noted the didactics relevance in teaching Translation concepts, such as reflection, rotation, translation, and dilation. One study by Velázquez & Méndez (2021), emphasized that understanding geometry does not only depend on students' cognitive abilities, but also on the stage of geometric development they are facing. Students go through five levels of understanding in geometry, which suggests that teaching about Translation should be adjusted to the developmental stage of students. In another study Al-Batineh & Al Tenaijy (2024), highlighted the importance of using technology in Translation learning. He found that the use of interactive geometric software can deepen students' understanding of transformation concepts, because students can visually see the effects of each transformation carried out. By utilizing this technology, students not only recognize transformations in theory but can also apply their understanding through interactive exploration. This is in line with the constructivist approach which suggests that students learn more effectively when they are actively involved in the learning process. Yanik & Flores (2009), observed the difficulties that students often face in learning Translation, such as confusion between different types of transformations and difficulty in depicting the results of transformations on the plane. Orton suggested teaching strategies involving visual and manipulative approaches, such as the use of physical models and graphic illustrations, to help students understand and differentiate between different types of transformations. This approach proved effective in making it easier for students to absorb abstract geometric concepts. In addition, research by Vedrenne-Gutiérrez et al. (2021), showed that understanding the concept of Translation is not only important for success in mathematics, but also has applications in various disciplines, such as art, physics, and computer science. Kissane argued that integrating Translation into a broader context can increase student motivation and show the relevance of mathematics lessons in everyday life. In this case, teaching based on real-world contexts is considered more interesting to students and encourages them to be more actively involved in learning. Furthermore, research by Geurts et al., 2024), stated that communication and collaboration among students in Translation learning also play an important role. Group discussions can help students explain and discuss their understanding of transformation, making the learning process more constructive (Thomas et al., 2014). Overall, previous studies have shown that didactics in Translation learning involves various approaches, ranging from cognitive understanding to the use of technology and visual approaches, as well as the importance of real-world contexts and collaboration (Zhao & Wang, 2024; Rizvi et al., 2023). Thus, effective Translation teaching should consider these various aspects to achieve better understanding for students.

The urgency of teaching Translation in mathematics education is very high, considering that these concepts are an important foundation in the development of students' logical thinking and problem-solving skills. In the era of globalization and rapid technological advances, understanding Translation is not only relevant in academic contexts, but also has practical applications in various fields such as art, engineering, architecture, and computer science. However, although this material is fundamental, many students have difficulty in understanding abstract concepts, such as imagining changes in geometric objects in space. Therefore, it is important to develop an effective didactic approach that can help students overcome this challenge. The goal of teaching Translation is to improve students' understanding of basic concepts, as well as encourage them to be actively involved in the learning process. By using various and innovative methods, such as dynamic geometry software and visual approaches, it is hoped that students can more easily understand the relationship between theory and practice. In addition, the integration of real-world contexts in teaching can increase student motivation and show the relevance of the material in everyday life. Through collaboration between teachers, students, and parents, as well as the application of creative learning strategies, it is hoped that students' understanding of Translation can increase significantly. Thus, effective teaching in Translation will not only strengthen students' mathematical abilities, but also prepare them to face the challenges of an increasingly complex and technology-based world.

2. Literature Review

Geometry learning, particularly translation, plays a crucial role in developing students' spatial, logical, and representational thinking skills. Translation, as part of geometric transformation, requires not only procedural understanding but also conceptual understanding of changes in the position of objects in space (Shvarts et al., 2024). Various studies have shown that students often struggle to grasp the concept of translation due to its abstract nature and high visualization requirements. This difficulty is exacerbated by conventional learning approaches that lack space for active exploration. Constructivist theory is an important foundation for geometry learning, including translation (Cunha et al., 2025). This theory emphasizes that knowledge is actively constructed by students through experience, interaction, and reflection (Sundman et al., 2025). Translation learning should be designed so that students can directly explore changes in the position of objects, whether through visual media, concrete manipulatives, or digital technology. Several studies have shown that a constructivist approach can enhance understanding of geometric transformation concepts because students are directly involved in the process of discovering and constructing meaning.

In line with the constructivist approach, Didactic Design Research (DDR) has developed as a research framework that emphasizes the relationship between teachers, students, and learning materials. DDR views learning as a dynamic didactic system, where the learning design is not final but is continually refined through didactic situation analysis, metapedagogical analysis, and retrospective analysis (Ria & Fuadiah, 2023). In translation learning, DDR enables teachers to anticipate student learning obstacles and design activities tailored to their characteristics and needs. Previous research has shown that using a didactic design that considers didactic and pedagogical anticipation (ADP) can help minimize student misconceptions in understanding translation. For example, errors in determining the direction and distance of an object's displacement often arise due to a lack of adequate visual representation. Therefore, good learning design needs to integrate various representations, such as images, coordinates, real-world contexts, and interactive technology. Developments in educational technology have also made significant contributions to translation learning. Dynamic geometry software, such as GeoGebra, allows students to visualize transformations in real time, making the relationship between an object's initial and final position clearer. Various studies have reported that integrating technology into geometry learning can increase student motivation, engagement, and conceptual understanding. However, the effectiveness of technology is highly dependent on the didactic design used by the teacher. In addition to cognitive aspects, research also emphasizes the importance of social interaction and collaboration in translation learning. Group discussions, collaborative work, and mathematical communication help students clarify understanding and construct knowledge together (Aalst, 2009). Thus, effective translation learning focuses not only on the final outcome but also on students' thinking processes.

3. Research Method

The research method used in this study is a qualitative approach with a descriptive research design (Arnica et al., 2023) . This qualitative approach was chosen because this study aims to explore and understand in-depth the thought processes of teachers in designing and implementing learning, particularly in the context of mathematics education in junior high schools. With this approach, researchers can explore the experiences, perspectives, and challenges faced by teachers in the teaching process, as well as how they overcome obstacles that arise during learning.

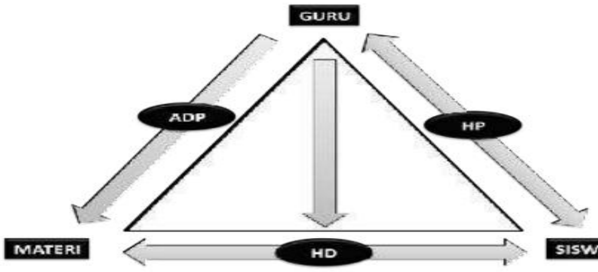

Figure 1. Didactic relationship (HD), pedagogical relationship (HP) and Didactic and Pedagogical Anticipation (ADP)

Data collection techniques were carried out through two observation methods: in-depth interviews and tests. In-depth interviews were conducted with several teachers experienced in teaching mathematics, particularly those related to the concept of translation. These interviews were designed to obtain information about the teaching strategies used, their understanding of didactic concepts, and the challenges they faced in implementing the lesson plans. The interview questions were open-ended, allowing respondents to provide broader and more in-depth answers. In addition, researchers also conducted direct observations during the learning process. These observations aimed to gain a more comprehensive understanding of the interactions between teachers and students, as well as the implementation of didactic strategies used in the classroom. During the observations, researchers recorded various aspects, including the teaching methods applied, students' responses to the material taught, and tests administered by this study to measure the effectiveness of the designed materials.

The data analysis technique was carried out using thematic analysis (Kania, 2024) , (Palmera & Senior-naveda, 2024) . The analysis process began with the transcription of interviews and observation notes which were then read thoroughly to understand the context and meaning contained therein. The researcher then identified the main themes that emerged from the data, which included aspects such as effective teaching strategies, learning barriers faced by students, and teacher reflections on the learning process. Each theme was further analysed to find patterns and relationships between the various elements. The results of this analysis were then compiled in the form of a narrative that describes the teacher's experiences and views, and provides insight into teaching practices that take place in the classroom. Teachers' thoughts are not only before learning, but also during and after learning. Learning activities involve three steps (planning, implementation, and description). Learning design research basically consists of three stages, namely: (1) pre-learning learning situation analysis in the form of learning design, (2) meta pediatric analysis, and (3) retrospective analysis, namely an analysis that links the results of the learning situation analysis with the results of the meta pediatric analysis. From these three stages, an experimental learning design will be obtained which will continue to be refined through the three DDR stages in this research.

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4. Results and Discussion

Results of the Analysis of the didactic situation before learning ADP Didactic Design

Meta Peda didactics is an approach to education that emphasizes the importance of the relationship between teachers, students, and learning materials. In this context, teachers act as facilitators who not only convey information but also develop materials that are relevant and engaging for students. This process involves a deep understanding of students' needs and characteristics, so that the materials developed can enhance their engagement and understanding. Thus, effective interactions between teachers, students, and materials are key to creating a productive and enjoyable learning environment, which ultimately supports the achievement of desired educational goals.

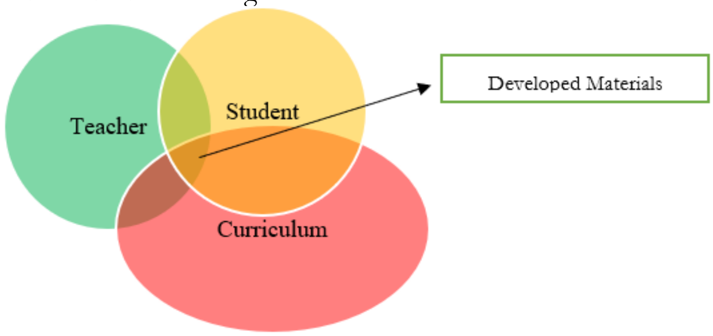

Figure 2. Modified Didactics

Design Results Before Revision

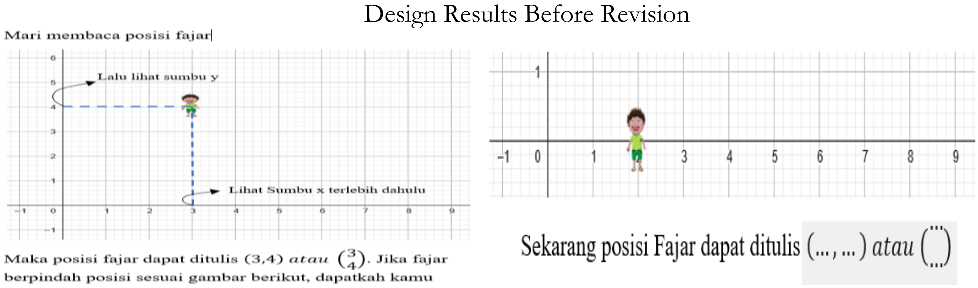

Figure 3. Design Results Before Revision

Design Results After Revision

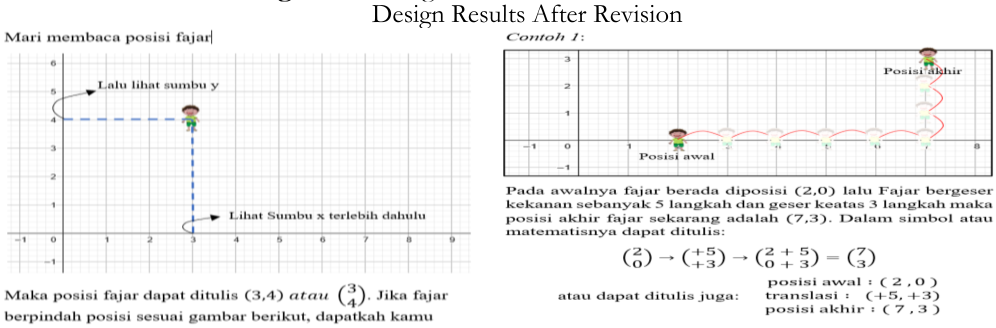

Figure 4. Design Results After Revision

Figures 3 and 4 show glaring learning design errors that can hinder the effectiveness of the learning process. Figure 3 demonstrates a lack of interaction between instructor and learners, which can lead to boredom and a lack of engagement. Learning designs that do not actively engage learners often result in shallow understanding and low motivation. Meanwhile, Figure 4 illustrates the use of materials that are irrelevant to learners' needs, which can lead to confusion and frustration. When learning materials do not align with students' context or interests, they tend to lose focus and are unable to connect new information to existing knowledge. These errors demonstrate the importance of designing interactive and relevant learning experiences to actively engage learners and gain deep understanding. Good learning design must consider learners' needs and characteristics to achieve optimal results.

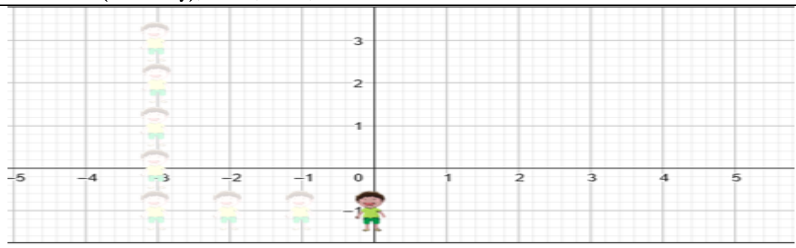

Figure 5. Illustration of Problem Three

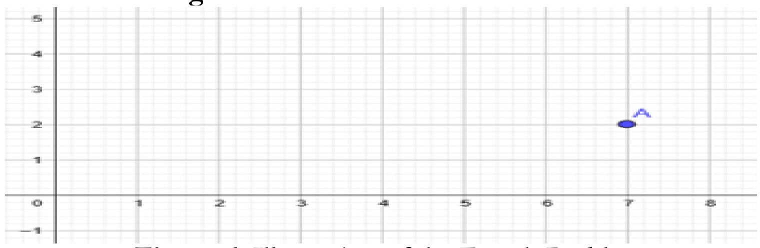

Figure 6. Illustration of the Fourth Problem

In analysing the learning design errors reflected in Figures 5 and 6, several aspects need to be considered. Figure 5 demonstrates a lack of student engagement in the learning process. A non-interactive design can leave students feeling isolated and unmotivated, hindering their understanding of the material. This highlights the importance of creating a learning environment that encourages active participation. Furthermore, Figure 6 illustrates the problem of unclear information delivery. A lack of clarity in instructions or material can lead to confusion among students. Effective learning design must ensure that information is delivered in a way that is easy to understand, using appropriate language and relevant examples. Without clarity, students may not be able to follow the learning flow effectively. Finally, Figure 6 highlights the lack of variety in teaching methods. Using a single, monotonous approach can quickly lead to student boredom and loss of interest. Good learning design should incorporate a variety of methods, such as group discussions, project-based learning, and the use of technology, to cater to students' diverse learning styles. By integrating this variety, learning becomes more engaging and effective.

Meta didactic Analysis Results

Overall, the learning design mistakes seen in these three images indicate the need for more attention to student engagement, clarity of information, and variety of teaching methods to create better and more effective learning experiences.

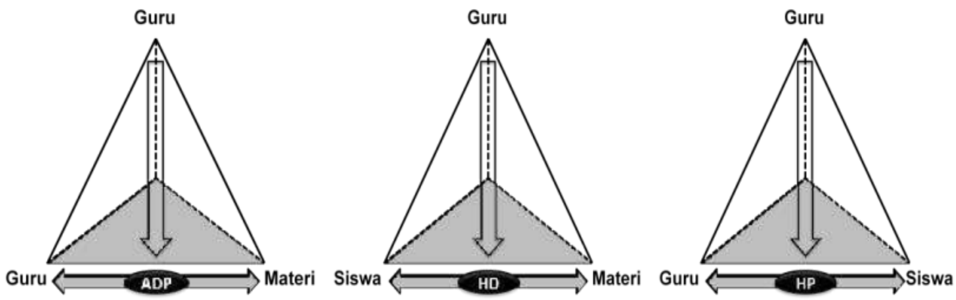

Figure 7. Meta didactics Seen from the Side of ADP, HD, and HP

Meta didactics, viewed from the perspective of ADP (Learning Design Analysis), HD (Design Outcomes), and HP (Learning Outcomes), provides a comprehensive framework for understanding and developing effective learning processes. ADP focuses on an in-depth analysis of learning needs and contexts, ensuring that the resulting design is relevant and appropriate to the characteristics of learners. In this stage, it is important to consider various factors, such as learning objectives, available resources, and the teaching methods to be used. Next, HD includes the implementation of the analysed design, where the selected strategies and methods are applied in practice. At this stage, evaluating the effectiveness of the design is crucial to ensure that learning objectives are achieved. If the design is not implemented well, the expected outcomes may not be achieved, leading to dissatisfaction with both learners and instructors. Finally, HP focuses on the final outcome of the learning process, namely the extent to which learners can master the expected competencies. Good learning outcomes reflect the success of the two previous stages, namely analysis and design. Thus, these three elements of ADP, HD, and HP must be interconnected and function harmoniously to create an effective and meaningful learning experience. Mistakes in any one aspect can result in failure to achieve the desired educational goals.

Results of Retrospective Analysis of Didactic Situations with Meta didactics

The results of the retrospective analysis are an important stage in didactic design research that links the results of the didactic situation analysis with the results of the meta didactic analysis. In this context, the retrospective analysis serves to evaluate and reflect on the learning process that has been implemented, as well as identify the relationship between the learning design that has been implemented and the results achieved by students. This process begins by collecting data from the previously analysed didactic situation, which includes various aspects such as interactions between teachers and students, the teaching methods used, and students' responses to the material taught. This data is then compared with the results of the meta didactic analysis, which provides a framework for understanding how elements in the learning design interact with each other and influence learning outcomes. In the retrospective analysis, it is important to consider the context and characteristics of the students involved. For example, if the analysis of the didactic situation finds that students are having difficulty understanding the concept of translation, then the meta didactic analysis can help identify factors that may be causing these difficulties. This could include inappropriate teaching methods, irrelevant materials, or a lack of student engagement in the learning process. By understanding these relationships, teachers can reflect on their teaching practices and look for ways to improve the effectiveness of future instructional designs.

Furthermore, retrospective analysis also provides an opportunity for teachers to evaluate the teaching strategies that have been implemented. For example, if learning outcomes indicate that students have successfully mastered the expected competencies, teachers can analyse the elements in the learning design that contributed to this success. Conversely, if the results are unsatisfactory, teachers can use this analysis to identify areas that need improvement. This reflection process is not only beneficial for teachers but also for broader curriculum development and educational policy. In the ever-evolving educational context, retrospective analysis also allows teachers to adapt to changing student needs and expectations. By considering the results of meta didactic analysis, teachers can develop approaches that are more responsive to learners' needs. For example, if the analysis shows that students are more interested in project-based learning, teachers can design more interactive and collaborative activities to increase student engagement. This aligns with the principle that effective learning must consider student characteristics and interests. Finally, the results of retrospective analysis can serve as a basis for developing better didactic designs in the future. By linking the results of the didactic situation analysis with the results of the meta didactic analysis, teachers can create a cycle of continuous improvement in their teaching practices. This process not only improves the quality of learning but also supports the achievement of broader educational goals. Thus, retrospective analysis plays a crucial role in creating a productive and enjoyable learning environment, ultimately supporting the holistic development of student competencies.

Discussion

Based on the analysis of the pre-learning didactic situation, it was found that students experienced various learning obstacles, including epistemological, didactic, and ontogenetic ones. These obstacles primarily arose in understanding the concept of object displacement, determining the direction and distance of translation, and linking visual representations to algebraic forms or coordinates. This finding aligns with previous research that stated that geometric transformations are abstract material and require high spatial visualization skills. In the initial didactic situation analysis stage, the learning design used by teachers tended to focus on conveying procedures and example problems, with relatively low student engagement. Learning activities did not fully provide space for students to explore the concept of translation independently. This condition resulted in the emergence of misconceptions, such as errors in determining the translation vector and the inability to explain the meaning of displacement conceptually. This finding reinforces the view that learning designs that lack contextualization and minimal visual representation have the potential to hinder student understanding. Based on the analysis, a hypothetical didactic design was developed equipped with Didactic and Pedagogical Anticipation (DAP). This design emphasized the use of exploratory activities, visual representations, group discussions, and real-world contexts to help students develop an understanding of the translation concept. During the implementation phase, the meta didactic analysis revealed a shift in the teacher's role from an information centre to a learning facilitator. Teachers were more active in guiding discussions, asking stimulating questions, and responding to students' thinking strategies throughout the learning process.

The retrospective analysis revealed that the developed didactic design significantly reduced student learning barriers. Students demonstrated improved abilities in determining the direction and distance of translation, explaining the process of object displacement, and connecting visual representations with mathematical symbols. Furthermore, students appeared more actively engaged in the learning process and were able to justify their answers. This demonstrates that translation learning is understood not only procedurally but also conceptually. Another important finding is that teachers' reflection through the DDR phase contributed to improving the quality of learning. Teachers became more sensitive to student responses and were able to flexibly adjust learning strategies. Thus, the resulting didactic design is empirical and open to continuous improvement. Overall, the results of this study confirm that the DDR approach is effective in developing translation learning that is more meaningful, contextual, and oriented towards students' thinking processes.

5. Conclusion

The conclusion of this study is that the translational learning design in junior high schools demonstrates that an effective didactic approach is crucial for improving students' understanding of abstract mathematical concepts. The teacher's thinking process, which occurs in three phases before, during, and after learning, is key to designing meaningful learning experiences. In the planning phase, teachers need to consider the context and needs of students, and design relevant and challenging activities. During implementation, it is important for teachers to act as facilitators who encourage collaboration and group discussions, so that students can share understanding and build knowledge constructively. Formative assessment is also a crucial aspect, where teachers assess not only the final results but also students' thinking processes, thus providing constructive feedback. Furthermore, the integration of real-world contexts in teaching can increase student motivation and demonstrate the relevance of the material to everyday life. The use of various innovative teaching methods, such as technology and visual approaches, is expected to help students overcome difficulties in understanding geometric concepts. Thus, good learning design should include a variety of methods to meet various student learning styles, making learning more engaging and effective. Overall, this research emphasizes that effective translation instruction will not only strengthen students' mathematical abilities but also prepare them to face the challenges of an increasingly complex and technology-driven world. Through collaboration between teachers, students, and parents, along with the application of creative learning strategies, students' understanding of fundamental concepts can be significantly improved.

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Data Availability Statement: All data in this study is confidential, because it relates to the privacy of the school where the research was conducted.

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