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Enhancing Students' Self-Determination through A Local Instruction Theory in Mathematics

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ABSTRACT
The struggle of junior high school students to grasp one-variable linear inequalities often stems from a lack of internal motivation and self-determination. Addressing this challenge, the present study explores the potential of a Local Instruction Theory (LIT)-based learning design to foster students' self-driven engagement in mathematics. Conducted in two instructional cycles with students in Lhokseumawe, Indonesia, the study employed a qualitative approach using a 24-item Likert-scale questionnaire measuring autonomy, competence, relatedness, and active willingness to learn. The results of the self-determination questionnaire analysis showed clear positive changes. The total number of subjects in this study was 57 students, of whom 31 participated in the first experimental phase (TE-1). Only 16% of students showed high self-determination. In contrast, in the second phase (TE-2) with 26 students as subjects in the first experimental phase (TE-1), only 16% of students demonstrated high self-determination. In contrast, in the second phase (TE-2), In the second phase (TE-2), the proportion of students with high self-determination increased from 16% to 35%, while the medium category decreased from 77% to 62% and the low category declined from 6% to 4%. These results highlight the promise of contextual, structured instruction supported by well-designed learning materials in cultivating students' intrinsic motivation. More broadly, this study offers a compelling direction for designing affective-centered math instruction. Future research is encouraged to integrate multiple data sources and expand LIT implementation across diverse mathematical domains

ABSTRAK
Kesulitan peserta didik sekolah menengah pertama dalam memahami materi Pertidaksamaan Linear Satu Variabel sering kali disebabkan oleh rendahnya motivasi internal dan kemandirian belajar. Menanggapi permasalahan tersebut, penelitian ini bertujuan untuk mengeksplorasi potensi desain pembelajaran berbasis *Local Instruction Theory* (LIT) dalam menumbuhkan keterlibatan belajar matematika yang bersifat mandiri. Penelitian ini dilaksanakan dalam dua siklus pembelajaran dengan melibatkan peserta didik di Lhokseumawe, Indonesia. Pendekatan penelitian yang digunakan adalah kualitatif dengan instrumen angket skala Likert sebanyak 24 butir yang mengukur aspek otonomi, kompetensi, keterhubungan, dan kemauan aktif untuk belajar. Hasil analisis angket *self-determination* menunjukkan adanya perubahan positif yang signifikan. Jumlah subjek penelitian sebanyak 57 peserta didik, dengan 31 peserta didik pada tahap eksperimen pertama (TE-1). Pada tahap ini, hanya 16%

peserta didik yang berada pada kategori *self-determination* tinggi. Pada tahap eksperimen kedua (TE-2) yang melibatkan 26 peserta didik, proporsi peserta didik dengan *self-determination* tinggi meningkat menjadi 35%, sementara kategori sedang menurun dari 77% menjadi 62% dan kategori rendah berkurang dari 6% menjadi 4%..Temuan ini menunjukkan bahwa pembelajaran kontekstual dan terstruktur yang didukung oleh bahan ajar yang dirancang secara sistematis mampu meningkatkan motivasi intrinsik peserta didik. Secara lebih luas, penelitian ini memberikan kontribusi terhadap pengembangan desain pembelajaran matematika yang berorientasi pada aspek afektif. Penelitian selanjutnya disarankan untuk mengintegrasikan berbagai sumber data serta memperluas penerapan LIT pada topik matematika lainnya.

INTRODUCTION

Mathematics instruction at the junior high school level plays a strategic role in developing students' logical and analytical thinking skills. One of the foundational topics in the curriculum is the linear inequality in one variable. This topic is not only conceptually essential but also serves as a basis for more advanced algebraic understanding. Unfortunately, various studies have shown that students often struggle to grasp the concept of linear inequality in one variable due to overly procedural instructional approaches that are insufficiently connected to real-life contexts (Widjaja et al., 2015). This condition affects students' weak conceptual understanding and low motivation to learn the topic. As an alternative solution, Local Instruction Theory (LIT) offers an approach that enables the design of learning activities based on students' local contexts. LIT is grounded in the principle that instructional design should be constructed from hypothesized learning processes in response to specific mathematical activities situated in meaningful and contextualized situations (Gravemeijer & Cobb, 2006). In its implementation, Local Instruction Theory (LIT) emphasizes not only the final learning outcomes but also the cognitive processes students undergo in constructing mathematical understanding through guided reinvention. Therefore, LIT is highly relevant for teaching linear inequalities in one variable, a topic that demands meaning-making rooted in students' concrete experiences.

Lhokseumawe, a city in Aceh Province, possesses distinctive cultural, social, and economic characteristics that can serve as authentic sources of mathematical learning contexts. However, in practice, mathematics instruction in schools remains predominantly abstract and lacks integration with students' real-life experiences. These local characteristics, if integrated into LIT-based instruction, have the potential to make learning more relevant and meaningful while also enhancing students' emotional and cognitive engagement (Rahmawati et al., 2022). This aligns with the principles of realistic, which positions students' real-life experiences as the starting point for the mathematics learning process. (Panhuizen & Drijvers, 2014;Denız & Uygur-Kabael, 2017; Jupri, 2018; Fauzana, Dahlan, & Jupri, 2020;).

In addition to cognitive aspects, mathematics instruction must also address students' affective dimensions, one of which is self-determination. The LIT-based learning design in this study addressed autonomy by allowing students to actively explore and choose solution strategies, competence by providing structured and progressively challenging tasks, and relatedness by encouraging collaboration and interaction through context-based group

activities. (Merdekawati et al., 2018; Niemiec & Ryan, 2009). Studies in the field of mathematics education, including research published in the *Supremum Journal of Mathematics Education (SJME),* have emphasized that self-determination is a crucial factor influencing students' persistence and positive attitudes toward mathematics learning, with gender and contextual factors also playing significant roles (Muhammad et al., 2024).When students perceive mathematical activities as relevant and meaningful to their lives, their self-determination increases, which in turn positively influences learning outcomes. Previous studies have shown that instructional strategies that provide purpose and value to tasks significantly enhance students' self-determination in the learning process (Howard et al., 2021)

While Local Instruction Theory has been discussed in mathematics education research, its application to linear inequalities in one variable with an explicit focus on students' self-determination remains underexplored, particularly at the junior high school level with strong local characteristics such as Lhokseumawe. This research gap is crucial to address so that instructional innovations do not solely focus on improving cognitive outcomes but also foster students' motivation and positive dispositions toward mathematics. Therefore, an approach that integrates LIT, linear inequalities in one variable, and self-determination theory within a single research framework is both theoretically and practically relevant (Samura et al., 2024).

The above conditions highlight the urgent need for a systematic effort to develop an instructional design based on Local Instruction Theory (LIT), structured around contextually grounded problems in the topic of Linear Inequalities in One Variable. This approach aims to foster active student engagement and enhance self-determination. Such development is expected not only to strengthen students' conceptual understanding of mathematics but also to cultivate autonomy, persistence, and intrinsic motivation in learning. By incorporating the socio-cultural context of Lhokseumawe, the resulting LIT model will be more contextualized and applicable for classroom implementation.

Based on these considerations, the present study aims to design a Hypothetical Learning Trajectory (HLT) and examine how it is refined through teaching experiments to produce a Local Instruction Theory (LIT) for teaching linear inequalities in one variable, as well as to investigate its potential in enhancing the self-determination of junior high school students in Lhokseumawe. This study is expected to contribute to the advancement of mathematics instruction grounded in contextual instructional design theory by clarifying how a hypothetical learning trajectory evolves into a local instruction theory while also enriching the literature linking LIT with self-determination theory in the context of mathematics education in Indonesia.

METHOD

This study employed a descriptive qualitative approach aimed at portraying and analyzing how the development and implementation of Local Instruction Theory (LIT) in the teaching of one-variable linear inequalities can influence the self-determination of junior high school students in Lhokseumawe City. This approach was chosen because it allows the researcher to explore in depth the dynamics of students' motivation and learning attitudes within the context of contextualized mathematics instruction (Creswell, 2023).

The participants in this study were seventh-grade students from two junior high schools in Lhokseumawe, selected purposively (31 students and 26 students, respectively). The selection criteria included active engagement in the learning process and the willingness of both students and schools to participate in all stages of the research. The study was

conducted in two instructional cycles, each consisting of three sessions designed based on contextual learning principles and structured within the framework of Local Instruction Theory (LIT).

The instructional process was designed based on local contexts relevant to students' everyday lives and implemented through student worksheets, which served as a guide for contextual problem exploration and learning activities. Although student worksheets were used during instruction, this study did not employ tests or cognitive assessments as primary data sources, as the research focused on students' affective aspects rather than cognitive achievement. The main research instrument was a self-determination questionnaire, developed based on the theoretical framework of Self-Determination Theory (SDT) (Ampadu & Anokye-Poku, 2022; Vansteenkiste & Ryan, 2013). The questionnaire was designed to measure four indicators of self-determination: autonomy, competence, relatedness, and active willingness to learn. It was administered before and after the instructional cycles to examine changes in students' perceptions and attitudes toward the mathematics learning process.

This design-based research comprises three main phases: developing the preliminary design, conducting the teaching experiments, and performing a retrospective analysis (Gravemeijer & Eerde, 2016). Before elaborating on the three phases, it is important to define the concept of a Hypothetical Learning Trajectory (HLT). HLT is a design instrument in the form of a framework used by educators to plan and predict the sequence of learning steps that students are likely to follow in understanding a mathematical concept, based on hypotheses about the development of their conceptual understanding (Bakker, 2018). There are three main phases in the implementation of design research (Prahmana, 2016), are: (1) Retrospective Design; (2) Experiment Design; dan (3) Analysis retrospektif, **Figure 1**.

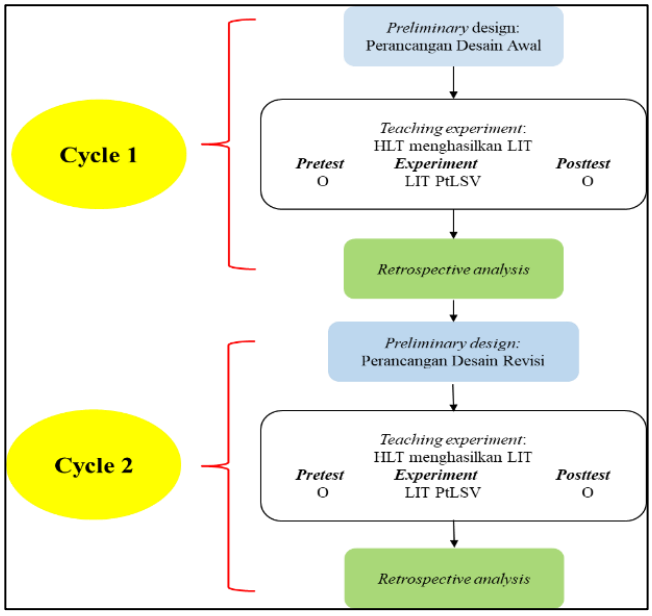

Figure.1 Research Design Structure

Data were collected through documentation of questionnaire results, field notes, and students' written reflections. Although the data were not subjected to statistical analysis, they served as valuable sources of information to understand patterns of change in students' self-determination throughout the learning process.

The data analysis technique employed in this study is descriptive and qualitative in nature. It involved examining the questionnaire results, observing changes in students' scores and written narratives, and relating these to the learning dynamics within each cycle. Student responses were thematically analyzed to identify emerging patterns indicating an increase in self-determination as a result of the contextually meaningful LIT-based instructional intervention.

RESULTS AND DISCUSSION

After the implementation of the learning design based on Local Instruction Theory (LIT) for the topic of Linear Inequalities in One Variable across two instructional cycles, measurements of students' self-determination levels were conducted to gain insights into the development of students' affective aspects within a contextually and participatively designed learning environment. This measurement was carried out using a questionnaire instrument systematically developed based on the framework of Self-Determination Theory (Deci & Ryan, 2000; Ryan & Deci, 2000). The questionnaire aimed to assess the extent to which the LIT-based learning design could foster students' independence, self-confidence, and emotional and social engagement in the mathematics learning process. The instrument consisted of 24 Likert-scale items with five response levels, ranging from "strongly disagree" to "strongly agree." These statements represented four core indicators of self-determination: autonomy, competence, relatedness, and active willingness to learn. These indicators were selected as they reflect essential psychological dimensions contributing to the development of students' self-determination during the LIT-based mathematics instruction.

Each indicator was measured through six items, balanced between positively and negatively worded statements to minimize social desirability bias and enhance data reliability. The item construction underwent a content validation process involving experts in mathematics education and educational psychology to ensure that each item accurately represented the intended psychological construct. The results of this validation were also used to revise wording and structure, ensuring clarity for junior high school students without compromising theoretical integrity.

This study does not aim to perform inferential statistical analysis but rather to describe trends in students' self-determination development through a descriptive qualitative approach. The questionnaire data, collected from 31 students during the first teaching experiment (TE-1), were analyzed to evaluate changes in each indicator. Mean scores for each indicator were analyzed and categorized based on established assessment criteria, as presented in **Table 1**.

Table 1. Results of the Self-Determination Questionnaire in TE-1

Self-Determination Indicators	Student Count by Category		
	Low	Moderate	High
Autonomy	3	25	3
Competence	2	27	2
Relatedness	1	21	9
Active Willingness to Learn	0	23	8

Based on **Table 1** the analysis of the self-determination questionnaire for grade TE-1 students, the majority of students were categorized as moderate across all indicators, with a

visible trend toward improvement in the high category. This was particularly evident in the indicators of relatedness and active willingness to learn. These findings can be interpreted through the lens of Self-Determination Theory (SDT), which emphasizes three basic psychological needs as the foundation of intrinsic motivation: autonomy, competence, and social relatedness (Yengkopiong, 2025) . In the autonomy indicator, the majority of students (25 students) fell into the moderate category, indicating that the learning environment had begun to provide space for students to make decisions and take active roles. However, the presence of three students in the low category suggests that not all students have yet experienced psychological freedom in controlling their own learning process—a condition that is crucial for the development of intrinsic motivation according to Self-Determination Theory (SDT).

To better explain the mechanism underlying these findings, the Local Instruction Theory (LIT) implemented in this study was intentionally designed to address the basic psychological needs proposed by Self-Determination Theory. Autonomy was supported through context-based problem situations that allowed students to explore multiple solution strategies and actively participate in decision-making during the learning process. Competence was fostered through a structured learning trajectory in which tasks were sequenced from simple to more complex, enabling students to experience gradual success. Meanwhile, relatedness was enhanced through collaborative activities and classroom discussions, where students interacted with peers and teachers while working on problems grounded in familiar local contexts. These design features explain why improvements were observed across the self-determination indicators.

The competence indicator, which reflects the extent to which students feel capable of completing mathematics tasks, also showed a dominance of the moderate category (27 students). This suggests that although most students have developed a sense of confidence, they are still in a transitional stage toward achieving optimal performance. An increase in the social relatedness indicator (with nine students in the high category) indicates that students are beginning to perceive positive relationships with their teachers and classmates. This is significant because, in SDT, healthy social relatedness serves as a key motivational driver that fosters active participation and a desire to continue learning.

As for the indicator of self-regulation, no students were found in the low category, and eight students were classified in the high category (Thoyyibah et al., 2024). This is a positive signal that some students have developed the ability to manage their behavior and emotions independently, one of the core manifestations of a growing sense of self-determination. Strong self-regulation reflects the internalization of motivation, where students are driven not only by external factors but also begin to integrate learning goals into their personal values (Pertiwi & Juandi, 2022).

Overall, these results suggest that the design of the Local Instruction Theory (LIT), which considers students' contexts and needs, has supported the fulfillment of the basic psychological needs emphasized in SDT and has gradually strengthened students' self-determination in learning mathematics. Accordingly, the results of students' self-determination levels in the second experimental phase (TE-2), involving 26 students, are presented in **Table 2**, which summarizes the average scores by indicator and their corresponding categorical values.

Based on the questionnaire results in the second experimental phase (TE-2), as presented in **Table 2**, there was an improvement in several indicators of students' self-determination compared to the previous phase (TE-1). In the indicator of social relatedness, 17 out of 26 students were in the high category, with none in the low category. This suggests

that the implemented learning approach successfully created a supportive learning environment that fostered positive social relationships among students and between students and the teacher. According to Self-Determination Theory, the fulfillment of the need for warm and supportive social connections is a critical aspect in enhancing students' intrinsic motivation to learn (Siacor & Ng, 2024;Yang et al., 2025;Wang et al., 2025) .

Table 2. Results of the Self-Determination Questionnaire in TE-2

Self-Determination Indicators	Student Count by Category		
	Low	Moderate	Low
Autonomy	2	18	6
Competence	11	9	6
Relatedness	0	9	17
Active Willingness to Learn	0	16	10

More specifically, the observed enhancement in students' self-determination can be attributed to several interrelated components embedded within the Local Instruction Theory (LIT) design. First, the incorporation of local and meaningful contexts positioned mathematical tasks closer to students' everyday experiences, allowing learners to perceive mathematics as relevant and purposeful rather than abstract and detached. This contextualization supported students' sense of autonomy, as they were encouraged to explore, interpret, and construct solutions based on familiar situations, which in turn increased their engagement and ownership of learning.

Second, the guided reinvention approach articulated in the learning trajectory played a crucial role in fostering students' competence. By gradually structuring tasks from informal reasoning toward more formal mathematical representations, the LIT design provided appropriate scaffolding that enabled students to experience successive mastery. Such experiences of successful problem-solving strengthened students' confidence in their mathematical abilities and reduced dependence on direct teacher instruction.

Furthermore, the emphasis on collaborative problem solving and sustained teacher–student interactions contributed to the development of social relatedness. Working in small groups allowed students to articulate ideas, negotiate meanings, and validate their reasoning with peers, while responsive teacher guidance created a supportive learning climate. These social interactions reinforced students' feelings of being valued and connected within the classroom community. The iterative refinement of these instructional components during the second teaching experiment (TE-2) further optimized their effectiveness. Adjustments in task sequencing, contextual clarity, and facilitation strategies enhanced the alignment between instructional design and students' learning needs. Consequently, these improvements help explain the observed shift of students from the medium and low self-determination categories toward the high self-determination category, indicating that a well-refined LIT-based learning environment can systematically support the fulfillment of autonomy, competence, and relatedness needs in mathematics learning. Furthermore, the self-regulation indicator also showed positive development, with 10 students falling into the high category and the rest in the moderate category. This indicates that most students demonstrated the ability to manage their time, set goals, and direct their own learning independently throughout the mathematics learning process. This finding is consistent with the view that self-regulation is an integral part of effective and sustainable learning (Gaeta et al., 2024). Meanwhile, for the autonomy indicator, although the majority of students

remained in the moderate category (18 students), the number of students in the high category increased to six, while only two students were in the low category. This improvement reflects progress in students' sense of freedom and independence in managing their own learning processes. This is a highly positive outcome, as autonomy is one of the core pillars in fostering self-directed and internally oriented motivation (Zhu et al., 2024).

Meanwhile, the competence indicator exhibited a relatively diverse distribution, with 11 students falling into the low category, 9 in the moderate category, and 6 in the high category. Although the number of students in the high category was not yet dominant, this suggests that a group of students has begun to develop self-confidence in their ability to understand the material and complete mathematical tasks independently. The presence of students in the high category serves as an initial indicator that the implemented instructional strategy is beginning to foster students' self-confidence and academic self-efficacy.

Furthermore, the considerable number of students in the moderate category indicates that most students are on the right developmental path and are transitioning positively in building their self-perceived competence. This suggests that the designed instruction has provided sufficient space for students to explore, evaluate, and enhance their mathematical understanding, in line with the scaffolding principle of constructivist learning. Over time, and with continued reinforcement, this group has strong potential to progress into the high category in future learning phases.

These findings support the view that the development of competence is a gradual process requiring consistent, successful experiences, a supportive learning environment, and positive reinforcement of students' efforts (He et al., 2025). Therefore, although not all students have reached the high category, the observed developmental trajectory reflects a positive and constructive trend toward enhancing self-determination, particularly in the competence aspect.

After analyzing the results of the self-determination questionnaire separately for the TE-1 and TE-2 classes, a comparative analysis was conducted to examine differences in students' self-determination levels between the two teaching experiments. This comparison was intended to capture not only overall changes but also shifts across the low, moderate, and high self-determination categories. By examining the percentage distribution of students within each category, the analysis provides a more nuanced understanding of how students' motivational profiles evolved over the course of the instructional implementation.

Specifically, the comparison between TE-1 and TE-2 enables the identification of meaningful patterns that indicate whether students experienced a shift from lower to higher levels of self-determination following the refinement of the learning design. By examining changes in the distribution of students across the low, moderate, and high categories, this analysis captures the dynamic nature of students' motivational development rather than viewing self-determination as a static outcome. Such shifts provide insight into how students gradually internalized learning goals as the instructional approach became more aligned with their learning needs and classroom experiences.

Furthermore, changes in the proportion of students within each category serve as empirical indicators of the effectiveness of the instructional intervention in fostering students' motivation. An increase in the number of students in the high self-determination category, accompanied by a decrease in the low or moderate categories, suggests that the learning approach supported a deeper internalization of motivation. This pattern indicates that students' engagement was not merely situational or driven by external demands but increasingly regulated by internal values and personal relevance. Consequently, these findings imply that the refined instructional design in TE-2 was more successful in

promoting sustained motivational growth and supporting students' progression toward higher levels of self-determination.

Moreover, this comparative analysis provides empirical support for evaluating the role of iterative instructional improvements in fostering self-determination. The results offer evidence of whether adjustments made during TE-2, such as improved task sequencing, clearer contextualization, and enhanced facilitation strategies, contributed to more optimal satisfaction of students' autonomy, competence, and relatedness needs. Consequently, this analysis forms a critical basis for assessing the success of the implemented learning approach in promoting students' progression toward higher levels of self-determination in mathematics. learning visually illustrates the change in students' self-determination levels between TE-1 and TE-2; a comparative graph of the percentage of students in each category, low, moderate, and high, is also presented. This visual representation aims to highlight the trend of shifting self-determination levels following the second-phase intervention. It enables a more concrete observation of the increased proportion of students in the high category and the corresponding decline in the low and moderate categories. The comparative percentages are illustrated in **Figure 2**.

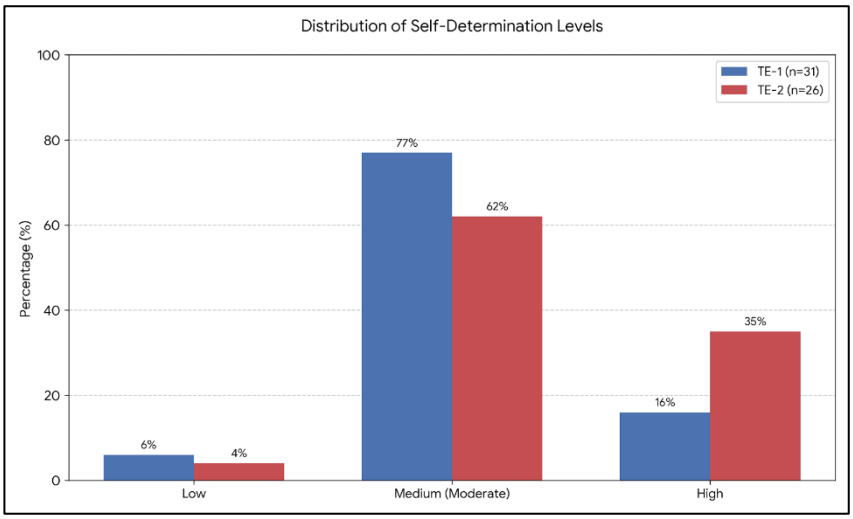

Figure 2. Percentage Distribution of Self-Determination Levels

Based on the self-determination questionnaire results presented in percentage form, a noticeable shift in students' levels of self-determination can be observed between the TE-1 and TE-2 stages. In TE-1, which involved 31 students, 6% of students were categorized as low, 77% as moderate, and only 16% as high. In contrast, in TE-2, which included 26 students, the percentage of students in the low category decreased to 4%, the moderate category declined to 62%, and there was a significant increase in the high category to 35%. This shift indicates that the instructional intervention implemented in TE-2 was more effective in supporting students' autonomy, competence, and intrinsic motivation. The increase in the high self-determination category suggests that a greater proportion of students became actively engaged and self-driven in their learning, while the reduction in the low and moderate categories implies a positive transition toward higher motivational states. These findings imply that the refined instructional design, grounded in the Local Instruction Theory framework, has the potential to foster more sustainable and meaningful student engagement in mathematics learning.

CONCLUSION

Based on the qualitative analysis of self-determination questionnaire data collected after the implementation of the Local Instruction Theory (LIT) in teaching Linear Inequalities in One Variable, this study concludes that LIT-based instruction contributes meaningfully to the enhancement of junior high school students' self-determination. The findings indicate clear improvements across the four assessed indicators.

Specifically, students demonstrated greater autonomy through increased initiative in engaging with learning tasks and making independent decisions during problem-solving activities. Improvements in competence were reflected in students' growing confidence in completing tasks, applying strategies correctly, and persisting when encountering difficulties. The relatedness indicator improved as students showed more positive interactions with peers and the teacher, suggesting the emergence of a more supportive and collaborative learning environment. In addition, students' active willingness to learn increased, as evidenced by higher levels of participation, attentiveness, and sustained engagement throughout the instructional cycles.

Despite these positive outcomes, the study is limited by its reliance on self-report questionnaire data as the sole source of evidence. The absence of observational data or in-depth interviews restricts a deeper understanding of how students experienced the learning process and how specific instructional components influenced their motivation. Future research is therefore encouraged to employ data triangulation by incorporating classroom observations, interviews, and learning artifacts. Further investigations could also examine the application of Local Instruction Theory to other affective variables, such as self-efficacy, learning persistence, or self-regulation, as well as its implementation in more advanced mathematical topics and across different educational levels.

The data reveal an increase in the proportion of students with high self-determination in TE-2 compared to TE-1, indicating that the instructional intervention implemented during TE-2 contributed to strengthening students' motivational aspects that support self-determination. This improvement also reflects a positive shift from the moderate to the high category, suggesting the success of the learning strategy in fostering students' psychological development, particularly in terms of autonomy, competence, and social relatedness.

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