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Development of a PRODELIC-Based Instrument for Assessing Students' Mathematical Literacy and Disposition

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Abstract: This study aims to develop and validate a PRODELIC-based instrument for assessing students' mathematical literacy and mathematical disposition, ensuring that the instrument demonstrates adequate validity and is suitable for evaluating these competencies in mathematics learning. This research method uses Design-Based Research (DBR) which consists of problem analysis, design and innovation development, cyclical repetition and implementation, and reflection evaluation. The research instrument is a validity instrument consisting of a validity assessment sheet for the PRODELIC learning model components and learning support tools. The data analysis used is qualitative and quantitative. The validity of the model, lesson plans, and worksheets was evaluated based on the assessment of experts and practitioners using the Aiken validity index. The results of the study showed that the Aiken's V value for all learning model component instrument items was in the range of 0.85 to 0.95, the lesson plan instrument was in the range of 0.9 to 0.95, and the worksheet was in the range to 1. These scores means that the model is valid and suitable for developing mathematical literacy and disposition. These findings indicate that the PRODELIC model and its supporting instruments are valid and suitable for mathematics learning aimed at developing students' mathematical literacy and disposition. Theoretically, PRODELIC contributes an integrated framework that combines Deeper Learning and Project-Based Learning, while practically, it provides teachers with a structured approach for designing mathematics instruction that promotes mathematical literacy and disposition.

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Introduction

Mathematical literacy and disposition are two crucial aspects of junior high school mathematics education, as both are correlated in strengthening students' mathematical abilities. In mathematical literacy, learning encompasses not only the ability to understand concepts and perform calculations, but also the ability to formulate, use, and interpret mathematics in various real-life contexts (OECD, 2018). Mathematical literacy is learning that fosters the ability to understand, interpret, and apply mathematical concepts and procedures in various contexts (NTCM, 2020). Students with good mathematical literacy are able to think critically, reason logically, and solve problems effectively and relevantly to the situations they face. Meanwhile, mathematical disposition learning builds students' self-confidence as individuals capable of thinking and acting mathematically, fostering self-confidence and perseverance in facing mathematical challenges (NTCM, 2020).

Indonesia's participation in the Programme for International Student Assessment (PISA) 2022 revealed persistent challenges in students' mathematical literacy. The average mathematics score declined from 379 in 2018 to 366 in 2022, placing Indonesia 70th among participating countries, with only approximately 18% of students reaching Level 2, the minimum proficiency threshold (OECD, 2023). This indicates that most Indonesian students still struggle with basic mathematical tasks, conceptual understanding, and applying mathematics to real-world problem-solving. Similar concerns have been reported by previous studies, including Leton et al. (2025) and Wijaya et al. (2024), which highlight students' difficulties in developing mathematical literacy and applying mathematical concepts meaningfully. In addition, students' mathematical disposition remains relatively weak, particularly in confidence, perseverance, and willingness to engage with challenging mathematical problems. These conditions underscore the need for adaptive, contextual, and in-depth learning strategies that strengthen both mathematical literacy and disposition through meaningful teacher–student interactions.

The low mathematical literacy of Indonesian students is associated with learning practices that remain conventional, insufficiently contextual, and less effective in engaging students actively (Widjaja et al., 2021; Supianti et al., 2025). The 2024 Independent Curriculum seeks to address these challenges through meaningful, contextual, student-centered, differentiated, and deep learning approaches that foster critical thinking, creativity, and character development. Mathematical disposition is also an important factor in students' success in understanding and applying mathematics. Low confidence and negative attitudes toward mathematics can limit students' willingness to engage with challenging problems (Jamiah, 2025; Deal et al., 2024). Conversely, students with stronger mathematical dispositions tend to demonstrate better reasoning and higher mathematical literacy, including the ability to solve PISA-type problems (Rahmawati et al., 2022). Therefore, improving mathematical literacy requires learning models that actively involve students, use contextual problems, and simultaneously strengthen their mathematical disposition.

Research findings related to the problem of low mathematical dispositions indicate that one of the causes of low mathematical dispositions is students' perceptions of mathematics, which still persists as a hated and unpleasant subject in school. Many junior high school students fail to enter high school math and science classes. This is not due to students' lack of ability, but rather to their negative dispositions or perceptions of mathematics (Kusmaryono et al., 2019). Beliefs about learning mathematics influence students' mathematical dispositions (Almerino et al., 2019).

Based on these challenges, there is a need for a learning model that can simultaneously strengthen students' mathematical literacy and disposition through active, contextual, collaborative, and in-depth learning. Although Project-Based Learning (PjBL) provides opportunities for students to engage in authentic projects, collaborate, and apply mathematical knowledge to real-world contexts, it does not necessarily ensure systematic and sustained deep thinking throughout the learning process. Conversely, the Deeper Learning Cycle (DLC) emphasizes deeper understanding, critical thinking, reflection, and meaningful application, but provides less explicit structure for collaborative project completion and the production of authentic outcomes. Therefore, relying solely on either approach may not adequately address the combined needs of mathematical literacy and disposition.

To overcome these limitations, the PRODELIC (Project Deeper Learning Integrated Cycle) learning model integrates the strengths of PjBL and DLC into a structured learning cycle that combines authentic project activities with deeper thinking, collaboration, reflection, and application. As a newly developed integrated learning model, PRODELIC

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requires systematic validation to ensure that its learning components, syntax, instructional materials, and supporting instruments are valid, feasible, and theoretically consistent with the intended learning objectives. Therefore, this study focuses on developing and validating the PRODELIC learning model and its supporting instruments to determine their feasibility for promoting students' mathematical literacy and disposition. The validation process is essential to establish the quality of the developed model before its implementation and further effectiveness testing in junior high school mathematics learning.

Research Method

This study employs Design-Based Research (DBR), an iterative approach that bridges educational theory and practice by systematically designing, implementing, evaluating, and refining learning interventions in authentic educational settings (Reeves, 2012). Through repeated cycles of analysis, design, implementation, and reflection, DBR enables researchers to develop practical learning solutions while simultaneously generating and refining theoretical principles that inform educational practice (Reeves, Herrington, & Oliver, 2005; McKenney & Reeves, 2012).This approach offers a research framework in developing and testing innovations in theory and practice in an iterative cycle that aims to solve practical problems while generating theoretical knowledge that is more widely applied. This research was conducted at a junior high school in Indonesia, targeting eighth-grade students. The age of the class is 14 years approaching 15 years, in accordance with the PISA problem that still has low mathematical literacy skills at the age of 15 years and still weak mathematical disposition. The school has implemented mathematics learning using the Merdeka curriculum. Further consideration, the school has followed the government's encouragement in implementing a deep learning approach, making it suitable for the development of the PRODELIC learning model to support the success of mathematics learning. The research period was carried out for one semester in the 2025-2026 academic year.

The development procedure used in the development of the PRODELIC learning model is Design-Based Research (DBR), which consists of four stages: (1) Problem analysis, (2) Design development and innovation, (3) Cyclical repetition and implementation, and (4) Reflective evaluation. Before the initial PRODELIC learning model product was piloted, it was first validated by experts using instruments and revised based on input and suggestions from validators. After revision, it was validated again by validators to ensure that the initial PRODELIC learning model product, its learning tools, and the instruments used were suitable for piloting. Expert assessments, comments, and suggestions from experts in their respective fields were essential to ensure the developed PRODELIC learning model product was error-free and met the requirements.

Data collection techniques are an important step in Design Based Research (DBR) research in determining the quality and relevance of data collected continuously during the research process to ensure that each stage can be observed, analyzed and evaluated in depth. This data collection is carried out to obtain the information needed to understand the problem, develop solutions, and evaluate the validity of the PRODELIC learning model oriented to junior high school students' mathematical literacy and disposition abilities. Data collection for model validation involved expert assessment of the PRODELIC learning model, covering its syntax, learning objectives, the roles of teachers and students, and underlying learning principles. The validation process engaged two mathematics content experts, two instructional design/media experts, and four junior high school mathematics teachers acting as practitioners. Validity data analysis was developed based on input, suggestions, and comments from experts (validators). A developed product is considered

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valid if all aspects of the validity assessment are declared valid by the validators. Therefore, data analysis results that do not meet the valid category in this study will be used as considerations for revising the PRODELIC learning model and its learning tools before being tested. Retnawati (2015) stated that content validity involves experts in the field. The agreement obtained is valid if the experts believe the instrument measures mastery of the abilities defined in the domain or psychological construct being measured. To obtain this agreement, the validity index proposed by Aiken (1980) is used as follows:

$$V = \frac{\sum s}{n\,(c-1)}$$

Description:
V = rater agreement index regarding item validity
S = score assigned by each rater minus the lowest score in the category used ($s = r - l_o$)
r = rater-selected category score
l_o = lowest score in the scoring category
n = number of raters
c = number of categories a rater can choose.

After obtaining the V value, it is then categorized. The content validity categories using the Aiken Index are presented in Table 1.

Table 1. Content Validity Categories

Range	Category
< 0,4	Low
0, 4 ≤ V ≤ 0,8	Medium
> 0,8	High

The assessment is conducted by assigning a score between 1 (irrelevant) and 5 (relevant). The score range is 0 to 1.00 (Azwar, 2012). In other words, the closer the Aiken index value is to 1, the better the item is because it is more relevant to the indicator (Retnawati, 2016b).

Results and Discussion

Validity data analysis for the developed PRODELIC learning model was obtained based on input, suggestions, and comments from experts (validators) through a validation sheet converted into interval data. The developed PRODELIC learning model is considered valid if all aspects of the validity assessment are declared valid by the validator using five response options: very valid (5), valid (4), moderately valid (3), less valid (2), and invalid (1). Data analysis results that do not meet the validity category in this study will be used as considerations for revising the developed PRODELIC learning model before its pilot testing. Joyce & Weil (2009) state that communication is a way to communicate the basic procedures of each model and in efforts to implement it, including syntax, social systems, reaction principles, herding impacts, and instructional methods. The developed PRODELIC learning model is considered valid if the validator's assessment shows that the actual scores for each component of the learning model are at least in the minimally valid category.

Table 2. Percentage of Validity of the PRODELIC Learning Model

Evaluation Aspects	Validity Index (V)	Category	Criteria
Syntax	0,95	High	Valid
Social Systems	0,9	High	Valid
Reaction Principle	0,85	High	Valid

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Herding and Instructional Impacts	0,9	High	Valid

The calculation results show that the Aiken's V value for all instrument items ranges from 0.85 to 0.95. Based on the Aiken's V validity criteria, all instrument items fall into the high validity category. Therefore, it can be concluded that all instrument items in the PRODELIC learning model components are valid and suitable for use. The results of the research on the PRODELIC learning model component instruments have Aiken's V value between 0.85 and 0.95, which is included in the high category. This is in line with Aiken's (1985) statement that there is a strong agreement between the relevance and clarity of instrument items from experts related to the instrument being developed. Similar research related to instrument content validation was conducted by Retnawati (2016) where learning instruments with high validity will produce accurate and reliable data so that they can be used in the implementation stage of the learning model. The high validity of this instrument not only shows the quality of the instrument, but also strengthens the conceptual foundation of the PRODELIC learning model which is oriented towards mathematical literacy and disposition skills. Thus, the findings of this study confirm that the PRODELIC learning model component instruments are declared valid and ready to be used in further trials in the practicality and effectiveness testing phase of subsequent research.

Table 3. Percentage of Lesson Plan Validity using the PRODELIC Learning Model

Evaluation Aspects	Validity Index (V)	Category	Criteria
Content Suitability	0,9	High	Valid
Language Aspects	0,9	High	Valid
Time Allocation	0,95	High	Valid
Suitability of core activities to the syntax of the PRODELIC learning model	0,9	High	Valid
Graphic Aspects	0,9	High	Valid

Based on the results of content validity calculations using the Aiken's V index for the PRODELIC learning model-based teaching Lesson Plan instrument, assessed by five raters, all instrument items had V values ranging from 0.9 to 0.95. Overall, of the 16 items analyzed, all were in the high validity category, with Aiken's V values greater than 0.80. The analysis found no instrument items in the medium or low validity categories, thus all items were deemed suitable for use without revision. Therefore, the PRODELIC learning model-based teaching module instrument can be declared to have excellent content validity and has met the eligibility criteria based on expert judgment.

Learning tools in the form of lesson plans need to be validated to ensure that they truly reflect the expected competencies, aligned with the objectives, learning steps, and principles of the model used. This is in line with Cohen, Manion, & Morrison (2018), who argued that valid learning tools will enhance learning in accordance with the developed theoretical design. The accuracy of instrument items is crucial so that each planned step supports the expected learning process. Similar research conducted previously by Widyaastuti and Kurniawan (2020) showed that learning tools with innovative models tend to achieve high validity when developed. Thus, high validity of the lesson plan confirms that a learning tool has met quality standards, without additional revision, and is ready for implementation.

Based on the results of the content validity analysis using the Aiken's V index on the Student Worksheet instrument based on the PRODELIC learning model assessed by five validators, it was found that all instrument items had V values in the range of 1.00. Most items obtained a V value of 1.00, which indicates perfect agreement among validators regarding the relevance and feasibility of the instrument items. Thus, student worksheet

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instrument items were declared to be in the high validity category and were suitable for use without revision. This indicates that the Student Worksheet instrument developed has met the criteria for excellent content validity based on expert judgment.

Table 4. Percentage of Validity of Student Worksheet using the PRODELIC Learning Model

Evaluation Aspects	Validity Index (V)	Category	Criteria
The relationship between content and curriculum competency standards	1	High	Valid
The alignment of content with the characteristics of the PRODELIC learning model	1	High	Valid
The alignment of construction aspects	1	High	Valid
The alignment of instructional technical aspects.	1	High	Valid

The student worksheet developed using the PRODELIC model demonstrated very good content validity, reflecting strong alignment among the worksheet content, learning objectives, PRODELIC syntax, and learning activities. The high validation results can be attributed to the systematic integration of Project-Based Learning (PjBL) and Deeper Learning principles. The Project and Researching stages engage students in authentic, contextual problems, requiring them to interpret information, formulate problems, and apply mathematical concepts, which directly supports mathematical literacy (OECD, 2023). The Organize, Design, and Execute stages promote collaboration, reasoning, strategy selection, and problem solving, while also fostering confidence, perseverance, and engagement with challenging tasks.

The Lessons and Improve stages encourage reflection, evaluation, and revision, supporting deeper conceptual understanding and mathematical disposition. Finally, the Communicate stage requires students to explain and justify their mathematical reasoning, strengthening mathematical communication and literacy. Thus, the worksheet's validity reflects not only expert agreement but also the coherence between PRODELIC's theoretical foundations and its intended learning outcomes. This systematic alignment is consistent with principles of educational design research, which emphasize theoretical consistency and practical relevance in developing instructional products (Nieveen, 2007; McKenney & Reeves, 2012). Therefore, the worksheet is considered feasible as a supporting tool for PRODELIC-based mathematics learning.

Conclusion

Based on the results of the content validity calculation using the Aiken's V index on the PRODELIC learning model component instruments, the Aiken's V value for all instrument items is in the range of 0.85 to 0.95. This value is in the high validity category, so it can be concluded that all instrument items are considered valid and suitable for use. Furthermore, for the lesson plan instrument of the PRODELIC learning model, it has an Aiken's V value between 0.90 to 0.95 and for the Student Worksheet in the range of 1. Thus, all instrument items are included in the very high validity category, so the instrument is declared to have strong suitability and feasibility for use in the development and implementation of learning.

Recommendation

Based on the high validity of the PRODELIC learning model and its supporting instruments, junior high school mathematics teachers and curriculum developers are encouraged to apply the PRODELIC syntax by integrating Deeper Learning and Project-Based Learning. Teachers can design authentic and contextual projects that engage students in researching, organizing information, designing and executing solutions, reflecting on learning, improving their work, and communicating mathematical reasoning. This approach can be oriented toward strengthening mathematical literacy while fostering mathematical disposition through collaboration, perseverance, reflection, and confidence in solving challenging problems. Schools can support its implementation by providing adequate learning resources, collaborative learning environments, and teacher professional development.

Future studies should examine the effectiveness and practicality of the PRODELIC model through larger-scale implementation involving diverse junior high school contexts. Further research may also investigate its impact on mathematical literacy and disposition using experimental or quasi-experimental designs and explore how each PRODELIC syntax contributes to students' learning outcomes. Continuous refinement of the model and its instruments is recommended based on implementation findings and feedback from teachers and students.

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