

# Development of A Teaching Module For Measurement Concepts For Grade 2 Elementary School Based On Project Based Learning With An In-Depth Approach

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## Abstract.

*This study aimed to develop a Grade 2 mathematics teaching module on measurement (length, weight, and time) based on Project Based Learning (PjBL) with the Deep Learning Approach, and to determine its validity and initial practicality. The 4D model was used, limited to the Define, Design, and Develop stages. Four expert lecturers assessed validity and one Grade 2 teacher assessed practicality using a four-point Likert questionnaire. Validity scores were 94.44% (mathematics content), 97.22% (pedagogical/PjBL), 91.67% (language/media), and 84.72% (mathematics lecturer), all Very Valid. The teacher's rating was 83.33% (Very Practical). The module is theoretically valid and initially practical, but its effectiveness still needs classroom testing.*

**Keywords:** Teaching Module, Measurement, Project Based Learning, Deep Learning Approach.

## I. INTRODUCTION

Measuring length, weight, and time are basic mathematical concepts relevant to everyday life, but for lower-grade students, these concepts often feel abstract when presented only through symbols and standard units. Experience measuring with non-standard tools allows children to explore measurement intuitively before moving on to standard units (Chen et al., 2025).

The immersive learning approach is an educational transformation strategy that emphasizes meaningful, relevant, and enjoyable learning experiences (Abdul Mu'ti, 2025). This approach contains four components with different roles, the principles of Awareness, Meaningfulness, and Joy (BBM) as the foundation of the learning atmosphere, the learning experience of Understanding, Applying, and Reflecting (3M) as the flow of activities, the Pedagogical, Environmental, Digital, and Partnership (PLDK) framework as the support for implementation, and the Graduate Profile Dimension (DPL) as the intended achievement.

Mathematics is often considered an abstract subject that is difficult for early childhood learners who are still at the concrete operational stage to understand. Students are introduced to basic materials such as essential calculations and measurements, but the biggest challenge at this level lies in the low interest of students in learning mathematics (Mardiana et al., 2026: 61-67). In reality, the teaching modules developed by teachers risk being trapped in purely procedural and administrative aspects, where the focus of learning shifts only to pursuing the completion of physical products, so that the essence of an in-depth approach, such as the instillation of higher-order thinking skills and critical problem solving, is neglected as reflected in the teacher needs in this research needs analysis.

Previous research has shown that PjBL has the potential to improve mathematics learning outcomes in elementary schools (Ramadianti, 2021) and that PjBL-based mathematics learning modules or tools can be considered valid and practical (Afwa et al., 2023). However, these studies have not integrated PjBL syntax with in-depth learning components (BBM, 3M, and PLDK) on the measurement of length, weight, and time in second-grade elementary school. The novelty of this study lies in the explicit mapping of PjBL syntax, 3M learning experiences, and BBM principles to three object-based measurement projects around the school. Meta-analytic evidence also shows that the effects of PjBL on mathematics depend on the learning design and duration (Wang, Zhang, & Cheng, 2026), so designing projects specifically for measurement materials is necessary. This research gap underlies the importance of developing teaching modules in this study.

To solve this problem, an innovative learning tool is needed in the form of a Project Based Learning (PjBL)-based teaching module combined with an in-depth approach. Therefore, a learning model is needed that is able to present direct student involvement in real projects in the environment (Sumilat et al., 2025). PjBL emphasizes student activities in completing real projects that require active involvement, collaborative

work, critical thinking, problem solving, and communication. By facilitating the reconstruction of students' knowledge holistically, this study aims to: (1) determine the level of validity (feasibility) of the teaching module developed based on the results of assessment and validation by expert lecturers, and (2) determine the level of practicality of the teaching module developed based on the perceptions of lower-grade teachers.

## II. Literature Review

The “Deep Learning Approach” framework adopted by the Ministry of Primary and Secondary Education aligns conceptually with the deep learning movement, long researched internationally. A National Research Council report sponsored by the Hewlett Foundation identified cognitive, interpersonal, and intrapersonal competencies as core to meaningful learning (National Research Council, 2012). The components of the deep learning approach in Indonesia—DPL, BBM, 3M, and PLDK—can be viewed as domestic policy adaptations of these competencies. This research represents an initial effort to link these policies to the practice of basic mathematics learning.

The use of PjBL in measurement topics aligns with a meta-analysis that found that project-based learning improves mathematics learning outcomes with a moderate effect (Cohen's  $d = 0.529$ , approximately 0.275 after publication bias correction), and is strongest at implementation durations of 1–8 weeks ( $d = 0.666$ ) (Wang, Zhang, & Cheng, 2026). In a multicomplementary study, the effect of PjBL on mathematics (Hedges'  $g = 0.68$ ) was the lowest among the compared subject areas, although still quite large (Dogan et al., 2026). These findings suggest that the effect of PjBL depends on the subject area and learning design. Therefore, designing a specific project for the material with a duration of three 70-minute meetings is relevant to study.

Research on measurement cognition in early childhood emphasizes the importance of imaginative play experiences and concrete representations as a bridge to abstract understanding. The Conceptual PlayWorld study of early elementary school children demonstrated that imaginative play approaches can support children's understanding of informal length measurements (Chen, Disney, & Li, 2025). Although this module was not designed like PlayWorld and the context is different, these findings align with the argument that children in the concrete operational stage require visual representations and intense motor activity.

From a methodological perspective, the 4D development model used in this study is derived from Thiagarajan et al. (1974, as cited in Trisnawati & Sundari, 2021), who divides the learning device development process into Define, Design, Develop, and Disseminate stages. This model can be adapted into three development procedures: Define, Design, and Develop, as conducted in this study (Trisnawati & Sundari, 2021). The educational product quality criteria used to assess module feasibility include validity, practicality, and effectiveness, referring to the educational design research framework (Plomp & Nieveen, 2013; Cela-Ranilla et al., 2025). According to Cela-Ranilla et al. (2025), who refer to Plomp and Nieveen, validity relates to the verification and conceptual clarity of the content and issues studied, while practicality relates to the functionality of the product prototype and its suitability for users and the context of its application.

## III. Research Methods

This research is a type of research and development (Research and Development) (Sugiyono, 2021) that aims to produce a product in the form of a teaching module for the concept of measurement for grade 2 elementary school based on Project Based Learning with an in-depth approach. The development model used is the 4D model (Define, Design, Develop, Disseminate) developed by Thiagarajan et al. (1974, as cited in Trisnawati & Sundari, 2021). However, this research is methodologically limited to the third stage (3D), namely the Development stage without conducting the Disseminate stage and direct trials with students due to time, energy, and funding limitations.

The Define stage involves curriculum analysis, student characteristics analysis, concept analysis, and teacher needs analysis. Curriculum analysis is conducted to identify learning outcomes and objectives related to the measurement material for grade 2 elementary school. Student characteristics analysis is conducted to determine the initial abilities, characteristics, and needs of students in mathematics learning. Concept analysis is conducted to identify measurement concepts that will be developed in the module. Meanwhile, teacher needs analysis is conducted through a questionnaire and initial interview with one grade 2 elementary school teacher

at one of the elementary schools in Tomohon city to determine the need for teaching tools that are appropriate to student characteristics and Project Based Learning (PjBL)-based learning with an in-depth learning approach. The questionnaire includes aspects of the teaching tools currently used, difficulties in teaching measurement material, experience implementing PjBL, and the expected module format.

The design phase focuses on developing the module format, structure, and content, integrating Project-Based Learning (PjBL) syntax, and developing assessment instruments. At this stage, an in-depth approach is integrated into the module through four pillars: DPL, BBM, 3M, and PLDK, tailored to the characteristics of mathematics learning in measurement.

The development stage focused on assessing the theoretical validity and initial practicality of the module. Validation was conducted by four expert lecturers, including a mathematics material expert, a pedagogical/PjBL expert, a language/media expert, and a mathematics lecturer. Initial practicality was assessed by a second-grade elementary school teacher as a practitioner. The assessment instrument used a four-point Likert scale questionnaire. Data were analyzed descriptively by calculating the percentage of the scores obtained against the ideal maximum score. This study did not conduct direct trials with students, so the results are limited to theoretical validity and initial practicality based on expert assessments and teacher perceptions.

The validators consisted of four lecturers: a mathematics subject matter expert, a pedagogical/PjBL expert, a language/media expert, and a mathematics expert. The practitioner was a second-grade elementary school teacher with teaching experience. The assessors were not involved in the module development. The validity instrument consisted of 18 items covering the aspects of Material and Curriculum Suitability, Project Based Learning (PjBL) Characteristics, Implementation of an In-Depth Approach, Design, Language, and Readability. The practicality instrument consisted of 18 items covering the aspects of ease, time efficiency, availability of tools/materials, and attractiveness. Each item was assessed on a scale of 1-4 (1 = not appropriate, 4 = very appropriate). The mathematics subject matter expert validator focused on assessing conceptual accuracy, the suitability of the measurement material content to learning objectives, and the presentation of the material based on the characteristics of second-grade elementary school students. Meanwhile, the mathematics expert lecturer focused on assessing the mathematical concept accuracy, the suitability of the material and questions to learning outcomes and objectives, and the level of question difficulty. The different assessment focuses were intended to obtain complementary input in assessing the feasibility of the developed teaching module.

The feasibility percentage is calculated using the formula  $P = (X / X_i) \times 100\%$ , with X as the obtained score and  $X_i$  as the ideal maximum score. The percentage results are then matched against the established feasibility and practicality criteria. The percentage results are interpreted using the criteria in Table 1 (adapted from Riduwan, 2016).

**Table 1. Validity Criteria and Practicality Criteria**

| Percentage   | Validity Criteria | Practicality Criteria |
|--------------|-------------------|-----------------------|
| 81.25-100%   | Very Valid        | Very Practical        |
| 62.50-81.24% | Valid             | Practical             |
| 43.75-62.49% | Quite Valid       | Quite Practical       |
| 25.00-43.74% | Invalid           | Impractical           |

The four components of in-depth learning were operationalized into questionnaire items as follows. DPL was operationalized through indicators of module suitability with graduate profile achievements and mathematics learning outcomes. BBM was operationalized through indicators of meaningfulness of measurement project activities and a pleasant learning atmosphere. 3M was operationalized through items of understanding measurement concepts, application of concepts to real projects (length, weight, and time), and reflection on learning outcomes at the end of the project. PLDK was operationalized through indicators of suitability of pedagogical practices (PjBL syntax), project connectivity with the school environment, and learning partnerships. The digital component was not specifically operationalized because second-grade elementary school learning emphasizes concrete objects and simple measuring tools. Media and simple measuring tools are assessed as part of the concrete learning experience.

#### IV. Results and Discussion

##### Research result

Curriculum analysis shows that Phase A learning outcomes in the measurement element serve as a reference in developing the module. Student analysis, which includes identifying prior knowledge, interests, and learning needs, indicates that grade 2 students generally understand the basic concepts of long-short, heavy-light, and long-short through direct comparisons of objects or events, but are not yet familiar with how to measure objects that cannot be compared visually. Students are interested in activities that involve physical activity and concrete media. They need experience measuring with non-standard measuring tools, guidance in arranging measuring tools closely and straight for consistent results, and an understanding of why measurement results can differ between individuals. Concept analysis identifies the measurement concepts of length (comparing, measuring, and estimating with non-standard units such as spans, fathoms, footsteps, and paper clips), weight (comparing and weighing using a hanger scale with non-standard units such as marbles), and time (reading analog clocks and comparing activity durations). A teacher needs analysis conducted through a questionnaire and initial interview with a second-grade elementary school teacher revealed that the teaching materials currently used focus more on administrative requirements and do not systematically incorporate project-based learning steps. Teachers also experience difficulty creating concrete and engaging measurement activities for students. Therefore, teachers need alternative teaching materials that systematically integrate project-based learning (PjBL) to facilitate an in-depth learning approach, in a practical and easy-to-understand format.

In the Design stage, the module is composed of module identity, student identification, subject matter, Graduate Profile Dimensions, learning design, three meetings with a time allocation of 70 minutes per meeting (each containing one project), assessment, enrichment and remedial, and reflection, equipped with LKPD and evaluation sheets in the appendix. The PjBL syntax used includes six steps, namely basic questions, designing project planning, preparing a schedule, making projects, testing results, and evaluating learning experiences. The three projects are designed using objects around the school according to the measurement topic. The project names for each topic are presented in Table 2.

**Table 2. Project Name in Module**

| Topics | Project Name        |
|--------|---------------------|
| Long   | Size Hunter Board   |
| Heavy  | Scale Hunter Table  |
| Time   | Rainbow Plate Clock |

The development of the teaching module resulted in a draft (prototype) containing learning objectives, project-based activity steps with PjBL syntax integrated with in-depth approach indicators, measurement materials, project LKPD, and assessment instruments. Theoretical feasibility was assessed at the Develop stage through validation by four expert validators: a mathematics material expert, a pedagogical/Project Based Learning (PjBL) expert, a language/media expert, and a mathematics lecturer. Furthermore, the module's initial practicality was assessed by a second-grade elementary school teacher as a practitioner. The results of the assessments by the expert validators and practitioners are presented in Table 3.

**Table 3. Summary of Validation Results and Practicality of Teaching Modules**

| Assessor Subject                                 | Score Obtained | Maximum Score | Percentage | Criteria       |
|--------------------------------------------------|----------------|---------------|------------|----------------|
| Mathematics Material Expert Validator            | 68             | 72            | 94.44%     | Very Valid     |
| Pedagogical Expert Validator/PjBL                | 70             | 72            | 97.22%     | Very Valid     |
| Language/Media Expert Validator                  | 66             | 72            | 91.67%     | Very Valid     |
| Mathematics Expert Lecturer                      | 61             | 72            | 84.72%     | Very Valid     |
| Grade 2 Elementary School Teacher (Practitioner) | 60             | 72            | 83.33%     | Very Practical |

According to the criteria in Table 1, the validation results indicate that the teaching module received a Very Valid rating from four validating lecturers. Meanwhile, the initial practicality assessment by second-grade elementary school teachers resulted in a Very Practical rating of 83.33%. These results indicate that the teaching module meets the theoretical validity criteria and has initial practicality based on teacher assessment. However, these results do not yet prove the module's effectiveness in improving student learning outcomes because it has not been tested directly in the classroom.

As an illustration of the product being developed, the following are several examples of Student Worksheets (LKPD) for projects contained in Project Based Learning (PjBL) teaching modules with an in-depth learning approach.



**Fig. 1.** Example of LKPD for a length measurement project using non-standard units

In addition to length measurement activities, the teaching module also contains LKPD for weight measurement projects through activities to compare the weight of objects.



**Fig. 2.** Example of a project LKPD comparing the weight of objects

The teaching module also includes time measurement activities through the LKPD project of drawing clock hands according to the specified time.

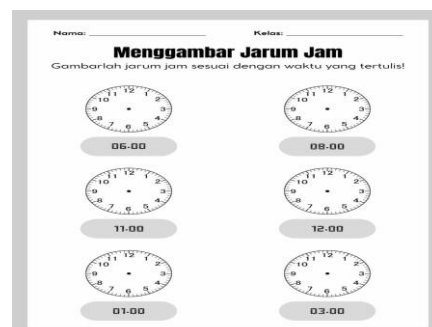


**Fig. 3.** Example of a LKPD project on drawing clock hands according to time.

## Discussion

The results of the study indicate that the teaching module for the concept of measurement for grade 2 elementary school based on Project Based Learning (PjBL) with an in-depth learning approach received a Very Valid assessment from four expert lecturers and Very Practical based on the initial assessment of a grade 2 elementary school teacher. These results indicate that the module has met the criteria for theoretical validity and obtained a good initial practicality assessment based on teacher perceptions. However, these results cannot yet be used as proof of the module's effectiveness because it has not been directly tested on students.

Based on the validation results, mathematics material experts gave a score of 94.44% with a Very Valid category. This result indicates that the module received an excellent assessment from the mathematical material aspect. The material on measuring length, weight, and time is structured through activities close to students' daily lives. The use of concrete objects and non-standard units in measurement activities is designed to help students recognize measurement concepts through direct experience. This design is in line with Chen et al. (2025), who emphasized the importance of concrete experiences in supporting children's understanding of informal length measurements.

In the pedagogical/PjBL aspect, the module obtained a percentage of 97.22% with a Very Valid category. This assessment indicates that the project-based learning design received a very good assessment from the pedagogical aspect and its suitability with PjBL. The six steps of PjBL syntax in the module are combined with the learning experience of Understanding, Applying, and Reflecting (3M). The basic question stage is directed to help students understand the problem, the planning stage to project creation is directed to apply the measurement concept, while the results testing and evaluation stages of the learning experience are directed to reflect on the process and results of the activity. This mapping is a form of integration of the PjBL design with the learning experience in the in-depth learning approach. However, teachers need to provide adequate guidance during the project. Umboh et al. (2025) found that the benefits of PjBL are influenced by self-efficacy.

The integration of an in-depth learning approach is also realized through the principles of Conscious, Meaningful, and Joyful (BBM), as well as the support of the Pedagogical, Environmental, Digital, and Partnership (PLDK) framework. Within the module, project activities are designed to relate to the school environment and students' daily experiences. The use of concrete objects and measurement activities is expected to help students connect mathematical concepts to real-life situations. The three projects in Table 2 provide the context for learning activities that connect measurement material with project activities.

In the language/media aspect, the module obtained a percentage of 91.67% with a Very Valid category. These results indicate that the module received excellent ratings for its language and media presentation. The use of language, images, student worksheets, and material presentation were designed with the characteristics of second-grade elementary school students in mind. These aspects still need to be refined in future products, particularly to ensure that the activity instructions are easily understood by students.

Meanwhile, the mathematics expert lecturer gave a rating of 84.72%, categorized as Very Valid. This assessment complements the validation results from the mathematics material expert by paying attention to the accuracy of mathematical concepts, the suitability of the material and questions to learning objectives, and the level of difficulty of the questions according to the focus of the instrument used. Overall, the four validation results ranged from 84.72% to 97.22% and were categorized as Very Valid. These results support the conclusion that the module has theoretical feasibility based on expert assessment, but do not in themselves prove that the module is effective in improving student learning outcomes.

In terms of practicality, the second-grade elementary school teacher's assessment gave a score of 83.33%, categorized as Very Practical. This assessment provides an initial overview of the module's practicality based on the teacher's perception as a potential user. Although it received a Very Practical category, the results need to be interpreted proportionally because the assessment involved only one teacher and was not supported by direct classroom trials. Therefore, this assessment result indicates initial practicality based on teacher perception, not empirical practicality proven through learning implementation.

Overall, these results align with the educational product quality framework, which prioritizes validity, practicality, and effectiveness as key considerations in developing learning tools (Plomp & Nieveen, 2013). In this study, the evidence obtained was limited to theoretical validity and initial practicality. Further research is

needed to test the module's implementation, obtain student responses, and assess its effectiveness on learning outcomes through direct trials in learning.

## V. Research Limitations

This study has several limitations that need to be considered when interpreting the results. First, the module validation involved four expert lecturers and one practicing teacher, so the assessment results are still limited to the experts' assessments and the teachers' perceptions. Second, the questionnaire instrument used has not undergone empirical reliability testing. Third, the study has not conducted a direct trial with students, so the reported practicality is still an initial assessment from teachers and is not supported by data on learning implementation, student responses, or observations of module use in the classroom. Fourth, the study has not tested the module's effectiveness on student learning outcomes. Fifth, practicality was assessed by only one teacher from the school, so the results cannot be generalized. Therefore, the results of this study should be interpreted as evidence of the theoretical validity and initial practicality of the product, not as evidence of empirical effectiveness. Future research is recommended to conduct a direct trial with students and test the instrument's reliability and the module's effectiveness in learning.

## VI. Conclusions and Suggestions

Based on the results of the development research, the teaching module for the concept of measurement for grade 2 elementary school based on Project Based Learning (PjBL) with an in-depth learning approach obtained excellent validation results from four expert lecturers. The validation percentage ranged between 84.72% and 97.22% with the category of Very Valid. Meanwhile, the assessment of grade 2 elementary school teachers as practitioners obtained a percentage of 83.33% with the category of Very Practical. These results indicate that the teaching module meets the criteria of theoretical feasibility and has initial practicality based on teacher perceptions.

The developed teaching module contains measurement material combined with project activities and an in-depth learning approach, namely the Measurement Hunter Board, Scale Hunter Table, and Rainbow Plate Clock. The presentation of the material, activity steps, and Student Worksheets are designed to support concrete and contextual mathematics learning for second-grade elementary school students. However, because the research was limited to the Develop stage and no direct trials were conducted with students, the effectiveness of the module on learning outcomes cannot be concluded empirically.

Based on these results, teachers can consider this teaching module as an alternative learning tool for mathematics measurement. Future researchers are advised to involve students in limited trials and field trials, test the instrument's reliability, and evaluate the learning implementation and the module's effectiveness on student learning outcomes.

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